Introduction: An Objective Kind of Freedom

Version 1.0 1/15/05

Part I: Foundation

§ 1 The Question of Freedom and Scientists Who Say "No"

We know we are free but there seems to be no place for freedom in a scientific view of reality. This statement poses the "Question of Freedom" that some scientists answer by declaring that freedom is an illusion.

I propose an ***alternative scientific view*** that incorporates freedom. The alternative view is like coming upon a well-known territory from a new and quite different position. Many features are recognizable but they are arranged differently and there are differences everywhere. Freedom that is hidden in the conventional view can be seen from the alternative viewpoint, if only partially.

The alternative view is an indirect, limited view and shortcomings are included in its description. I hold that every view attainable by human intelligence is a limited view and that all have the same general shortcomings as well as particular shortcomings. Important matters are hidden in both the conventional and the alternative views and appear to be hidden in all views attainable by human beings. Only part of freedom can be seen in the alternative view. The most important part of freedom is not being seen, even indirectly, and I conclude that views of important parts of freedom may not be attainable. Notwithstanding the shortcomings, much of freedom can be seen in the alternative view.

As a starting point, I state a "folk definition of freedom," or how I think freedom might be defined by an intelligent person who has carefully considered the question, but without benefit of education beyond high school. Under the folk definition, freedom means: a person considers two or more alternative courses of action; the person chooses and takes one course of action to realize a purpose and/or to satisfy a desire; the choice is based on likely rewards, costs and risk of losses; other alternative courses of action are excluded by the choice; and the person enjoys any rewards and bear any costs and losses. Shopping for dinner is a familiar example.

To sharpen the issue, I state a version of "the conventional scientific view" that denies that freedom has any meaningful reality, including, of course, freedom as stated in the folk definition. In brief, it is said that physical laws comprehend the activity of physical matter. That is, any and all activity of physical matter is properly described by a compact body of physical laws, stated and applied according to physics. Each physical law can be stated in mathematical formulations and the formulations work together to describe the activity of physical matter. Everything that involves physical matter is described by the formulations and if there is anything not described by the formulations, the omission is inconsequential. By "formulations," is meant something similar to current formulations but that have been "finalized" to exactly state matters not presently known with exactitude. The nature of the formulations is that there can not be anything to substantiate "freedom." Hence, "freedom" cannot be consequential.

In other words, the conventional scientific view states that there is no known influence on the activity of physical matter other than that stated in physical laws and there is no place for any new influence. Physical laws incorporate (1) ***mechanisms***, causal relationships expressed through the mathematics of differential equations and (2) ***chance***, expressed through the mathematics of probability and statistics. Supposedly, all physical phenomena are exhaustively described by mechanisms and chance.

Adherents of the conventional view anticipate the completion of a unified science, supposedly still in development. At the center of the expected unified science is physics that will comprehend a unified reality. Physics is expressed in mathematics. A correspondence between the unities means that the structure of mathematics has a comprehensive, determinative relationship with the structure of reality – "isomorphism" is the strongest possible such relationship. In other words, the structure of mathematics comprehends the structure of reality. E.g., "The philosopher Kant thought that the internal logic of nature corresponded to the internal logic of the human mind, and this was why nature was comprehensible." H.R. Pagels, *The Cosmic Code: Quantum Physics As the Language of Nature* (1982). [In my view, Kant had quite different thoughts, but Pagels states a "conventional view."]

A scientific view is chiefly concerned with facts. I state, as a fact, that every intelligent person experiences freedom every day, as freedom is defined in the folk definition. I state, as a fact, that each person knows of his or her freedom through direct personal experience. I state, as facts: each person knows that each other person has direct personal experience of freedom; each person knows of knowledge of freedom on the part of other persons; such knowledge is commonly known; and such common knowledge is built into human interaction and activity, e.g., bargaining, gossiping or driving on the freeway (e.g., "defensive driving").

If a "scientific view" ignores the facts about freedom, than that view is, at best, incomplete. It is a false argument that a view, such as a scientific view, that ignores and denies facts can, at the same time, have comprehensive power.

Many scientists, acknowledging the primacy of personal experience, affirm freedom; but they see no way to incorporate freedom into their views and they remain silent. The arena of discourse is occupied by scientists who deny freedom and their denials provide a useful introduction to the Question of Freedom because a denier must somehow avoid confronting the facts of freedom while acknowledging that the question is troublesome.

In a 1971 bestseller, *Beyond Freedom and Dignity*, Harvard University's then premier psychologist, B. F. Skinner, saw nothing more in freedom than "escape and avoidance." Skinner referred to a "literature of freedom" (said to contain a "philosophy of freedom") that "has been designed to induce people to escape from or attack those who act to control them aversively." The only serious example is from Rousseau (1712-1778). According to Skinner, the literature of freedom stands on nothing more than "states of mind and feelings," obviously beneath serious consideration. The "literature" is thus conveniently wrapped up and tossed away. (Chapter 2.)

Skinner declares: "Man is a machine," although a very complex machine that is adjusted by the environment. Notions of freedom need to be "abolished." "What is being abolished is autonomous man–the inner man, the homunculus, the possessing demon, the man defended by the literatures of freedom and dignity. ¶ His abolition has long been overdue. Autonomous man is a device used to explain what we cannot explain in any other way. He has been constructed from our ignorance." (Chapter 9.)

I do not understand Skinner's suggestion that a life devoid of freedom or dignity is somehow "beyond" some less enviable condition and I see no demonstrable benefit to be gained by "abolishing" beliefs in freedom and dignity. The evidence I see is to the contrary. I suspect that Skinner was trying to echo the title of Nietzsche's *Beyond Good and Evil* and to make radical declarations imitating those of an original creator. If so, Skinner's ear was false because Nietzsche denounced "the prevailing mechanical doltishness which makes the cause press and push until it 'effects' its end." (Kaufmann translation, § 21.) "[P]hysics, too, is only an interpretation and exegesis of the world (to suit us, if I may say so!) and ***not*** a world-explanation." (*Id*., at § 14, emphasis in original.)

Skinner does not mention Nietzsche or existentialist philosophers in his dismissal of the "literature of freedom" and the "philosophy of freedom." Elsewhere in *Beyond Freedom and Dignity*, there is a quotation from one important work on freedom – Karl R. Popper's *The Open Society and Its Enemies* (*ad interim* copyright 1946, revised ed. 1950). Popper wrote that a person, knowing of a social "norm" against stealing, can "decide to adopt this norm" or not. (*Open Society*, 1950 ed. at 65; Skinner quotes the 1946 edition.) Popper holds to "moral decisions" that are measured against "norms" based on nature and society and developed through reason. Moral decisions are more than "physico-chemical processes." Popper believed, for example, that "the historical Socrates [was] compelled by his conscience as well as by his religious beliefs, to question all authority [and] searched for the norms in whose justice he could trust." See *Open Society*, 1950 ed. at 62-67.

Skinner opposes Popper's position, because, according to Skinner, it's all just a matter of "contingencies." The "contingencies" have "negatively reinforced" stealing through punishment and/or the "contingencies" have "positively reinforced" honesty, apparently through verbal statements of approval. "The 'norm' is simply a statement of the contingencies;" ethics are defined by "the customary practice of a group;" and "justice is often simply a matter of good husbandry." (Skinner, 106-110).

However "contingencies" are defined, Skinner's view is not new. Popper saw something similar in Plato's application to human society of lessons learned from the breeding and training of dogs and other domesticated animals. (Popper at 52 *et. seq.*) Skinner, too, declares that we are housebroken to honesty and that we are honest for no other reason. According to Skinner, human beings are a species of domesticated animal.

In *The Open Society and Its Enemies,* Popper stated in the preface that "in this book harsh words are spoken about some of the greatest among the intellectual leaders of mankind ... [who]

supported the perennial attack on freedom and reason." Skinner comes under Popper's indictment of those with an "immodest belief in one's superior intellectual gifts, the claim to be initiated, to know with certainty, and with authority." (At p. 413.)

When he wrote, Popper was defending freedom against Marxism-Leninism-Stalinism, which used "Pavlovian" conditioning to enforce doglike obedience. Notwithstanding modernizing improvements, Skinner too is subject to Popper's critique of "this authoritarian intellectualism, this belief in the possession of an infallible instrument of discovery, or an infallible method, this failure to distinguish between a man's intellectual powers and his indebtedness to others for all he can possibly know or understand, this pseudo-rationalism [that] is often called 'rationalism,' but it is diametrically opposed to what we call by this name." (*Id*.)

Enormously influential during the 1960's, Skinner's theories are no longer esteemed in academia. His successors in eminence continue his attack on freedom. In his bestseller published in 1991, *Consciousness Explained,* at p. 431, philosopher Daniel Dennett declared that "all the phenomena of human consciousness [are] 'just' the activities of a virtual machine realized in the astronomically adjustable connections of a human brain." It's "obvious and unobjectionable" to say: "Of course we're machines!"

Dennett addressed freedom in an earlier work, *Elbow Room: The Varieties of Free Will Worth Wanting*, where he claims he showed why we should "abandon[] the hopelessly contradiction-riddled myth of the distinct, separate soul." (*Consciousness Explained* at 430.) In its place, we can insert "the social utility of the myth of free will." (*Elbow Room* at 166.) This is, apparently the kind of "free will worth wanting." All others, according to Dennett, are semantic confusions to be relieved by soothing assurances that notions of freedom have no meaning. There is nothing to worry about and there never was anything to worry about. Things are the way they have to be and you can have a "myth of free will" if it feels nice to you.

A human "virtual machine," even one with "astronomically adjustable connections," fits like a locknut onto the bolt of computer science. Mathematics, it is said, proves that a computer is a "universal" machine that can "represent" every other machine and so, just throw the switch and out pop true conclusions. (See Penrose, *The Emperor's New Mind* for a thorough but popularized discussion.)

"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 choice." (Leading MIT Artificial Intelligence pioneer Marvin Minsky's *Society of Mind* (1986), § 30.6.)

But, according to Minsky, buggy old people still need the ***illusion of freedom***. "No matter that the physical world provides no room for freedom of will. ... Too much of our psychology is based on it for us to ever give it up. We're virtually forced to maintain that belief, even though we know it's false–except, of course, when we're inspired to find flaws in *all* our beliefs, whatever may be the consequence to cheerfulness and mental peace." (*Id*., § 30.7.)

Minsky's cheerfulness and mental peace were apparently not disturbed by asking himself: "If I am so befuddled that I am forced to maintain a false belief about freedom of the will, how can I can confidently classify everything that happens in the universe into two categories?"

The notion that human intelligence can comprehend "[e]verything that happens in our universe" has its basis in "universal" laws and, especially, the paradigmatic "universal law of gravitation." These "universal" laws are said to prove that there is a "mathematical scheme which governs the structure of the universe." (Penrose, *The Emperor's New Mind* at 431-433.) This leaves "no room for 'free will' since the future behavior of a system seems to be totally determined by the physical laws." But there remain so many ***mysteries*** that "It seems to me to be quite plausible that CQG [Penrose's proposed Correct Quantum Gravity theory] might be a deterministic but non-computable theory." Alas, such mystery, even one veiling wonderful quantum gravity from outer space, is still "deterministic" and does not actually have anything to do with freedom. Penrose must "anticipate something much more subtle" before freedom can be considered. One candidate is a "*many-worlds* view of quantum mechanics." Despite a "multitude of problems and inadequacies that it presents us with, it cannot be ruled out as a possibility."

In sum, the Question of Freedom states a conflict between universal human experience of freedom and a "modern scientific view" where the possibility of freedom is excluded by a "mathematical scheme which governs the structure of the universe" but where belief in freedom, although delusional, is also compulsory. Even those who scorn freedom recognize the conflict.

What can be done to make sense of this?

§ 2 The example of ping-pong: exercising freedom with every stroke

I answer the Question of Freedom with a Yes. My answer is by way of construction, namely, the construction of a Model for activity of intelligence using brains that exercise freedom.

The construction is based on an alternative scientific view that has freedom at the center. The alternative view makes no comprehensive statement, e.g., there is no statement about "everything that happens in our universe." Rather, the alternative view says that our intelligence is ***unable*** to make such comprehensive statements. I hold that our intelligence is not strong enough to make true statements about important matters in Reality. ***Hence***, we are free. I acknowledge that the force of reason behind this conclusion may not be immediately clear.

Instead of comprehensive statements, my construction has the character of a ***contraption***; and the overall construction can be called Kovsky's Consciousness Contraption or, "the Contraption." Using "the Contraption," I propose to construct actual functioning devices – "Ideal Brains" – from electronics components and to state design principles for the components and device operations. Such purposes are not realized in these Researches, but I suggest ways I think they might be realized. See also related archival materials *Technology of Freedom*. If such purposes or something similar are ultimately realized by others, I believe it will be at the laboratory bench, beginning with real but simplistic units and proceeding by incremental steps.

In the largest view, the Contraption is supposed to ***imitate activity of intelligence engaging Reality***. In this view, a person uses his or her intelligence to "engage Reality" and the Contraption seeks to imitate such engagement. As with a child playing follow-the-leader, imitating an exercise of freedom sometimes requires an exercise of freedom. The Contraption's activity is based on operating principles that include the possibility of freedom, as appropriately defined.

Notions of imitation are foreign to the conventional scientific view but are central in the alternative view. In the alternative scientific view, we aren't smart enough to understand "everything that happens in the universe" and, as to some particular matters, we are unable to see enough to navigate by reference to an overall understanding. Lacking comprehensive or overall knowledge, we must often employ ***particularized knowledge*** that is applicable with certainty to only a small class of phenomena and that becomes risky when applied elsewhere. Particularized knowledge, e.g., knowledge involving tools, is often constituted by a series of acts or by structures of possible acts in the nature of "tool-uses" that a person can perform. Imitation is the most common way to learn such particularized knowledge.

In describing engagement between intelligence and Reality, I emphasize examples and metaphors based on ***travel in a terrain***. Examples for detailed discussion include "walking in the wilderness" and "driving on the freeway." I follow and imitate principles of thermodynamics or thermal physics where a Carnot Heat Engine travels on and maps a mathematical surface defined by an equation of state. It is even possible to think of a computer as traveling in a "terrain" that is a mathematical space (see Penrose, supra.)

To generalize and extend the metaphor, a person engaging Reality may be traveling in terrain where some areas are flat, clear and solid and where anyone can walk in any direction as he or she pleases; other areas are impassable and no one can go there; and there are areas in a middle "difficult" range where travel is problematic but where there are ***pathways***. The middle ground is my chief focus. In the middle ground, travel is possible in some ways, but we are confined to pathways and cannot roam as we wish. Exercises of freedom are required to get to difficult places and to plan efficient travel.

Pathways have been developed through the collective effort of humanity. If I am looking for a new pathway into difficult terrain, I can do so only by extending pathways developed by others. I learn those pathways by following others on the pathways, i.e., by imitating others in their activities.

Directions about pathways of knowledge are often given in person – by a teacher – so the student follows and imitates the steps, either practical or conceptual. Other benefits include interactive teacher-student communication and the teacher's personal expressiveness. Written directions – books – are often sufficient for someone knowledgeable about basic pathways in the subject matter or knowledgeable about the basic pathways of several related subject matters.

In the alternative scientific view, it is not possible, by mathematics or otherwise, to transcend the human condition that must sometimes learn through imitation. The surest knowledge is often particular knowledge, in the nature of a pathway; and large-scale maps are often unavailable or troubled by systematic uncertainty and/or error.

In this Introduction to the Researches, I state general principles of the alternative view that are in the nature of a philosophy and philosophy of science and that support (even require) an investigation of consciousness through means of a Contraption. I also survey the components of the Contraption and describe how they fit together to provide my constructed answer to the Question of Freedom. The purpose of the Introduction is to provide an overall survey of the alternative view in a ***single sweep***. Technical conceptions are stated in words and images.

As an exemplary subject matter for investigation into personal freedom, I focus on ***ping-pong***. Ping-pong is not an example for all purposes, but it goes a long way. A chief advantage is that everybody knows about ping-pong.

The focus of investigation is the ping-pong ***stroke***. I suggest that, in the Thermal Model of brains, ***a stroke of a Structural Engine produces a ping-pong stroke***, including production of the particular perceptions, muscular acts and intentions involved in the ping-pong stroke.

In a "natural science" view of freedom occurring in ping-pong, a ping-pong game is constituted by (made up of) a ***sequence of strokes***, and a stroke occurs each time a player strikes the ball in play. The definition of "in play" includes services, the stroke that starts a point; I focus on volleys, strokes after the service. During a volley stroke, the player is acting purposefully (to win!) and spontaneously (here comes the ball!). I generally identify an exercise of freedom as "purposeful, spontaneous action" and I hold that a ping-pong stroke is produced by a ***person exercising freedom***. During a stroke, a player performs a ***particular exercises of freedom***. By exercising freedom, the players ***construct or produce a game*** of ping-pong, stroke by stroke, point by point.

Accordingly, a ping-pong stroke is an exemplary exercise of freedom. A stroke is centered around the ***paddle-impact***, identified by the momentary, audible contact ("click") between the paddle and the ball. Each stroke is separate and distinguishable from each other stroke. The strokes are collected into a compact, well-defined class of strokes. A particular individual stroke is a concrete instance. In ping-pong, freedom comes conveniently packaged for investigation.

I next present concepts and methods about ping-pong strokes as a class. I refer facts to a "representative ping-pong stroke." A "representative" of a class is a concept supposed to be like a concrete instance of the class without actually being one and to incorporate features common among members of the class. In thinking of a representative, it is useful to conceive of an "Ideal Representative" that carries out the functions of representation to the fullest and without any shortfall. ***An Ideal Representative incorporates important matters that are "the same" or***

maintained in common with each and every member of the class so that making a substantive statement about the representative makes "the same" statement about each and every member with "the same" validity.

Not all useful representatives are ideal representatives. A useful representatives may differ markedly from particular class members and there may be some particular class members that are poorly represented by a useful representative. It is possible to evaluate useful representatives qualitatively as strong or weak depending on how they perform when measured against an Ideal Representative. As a practical matter, the tests of strength (based on the boldface definition, supra) are identification of "the same" something important needed to support "the same" statements and determinations about the presence and importance of "the same" matters maintained in common by class members.

Sometimes it is possible to construct a strong representative, but sometimes not. There is no representative meal, weak or strong. In other words, there is nothing substantial that can be said about meals in common - the makeups and circumstances of meals are just too wildly diverse and disorganized. (A meal is identified by continual chewing and swallowing of nutriments that is externally organized into a compact time.)

It is possible to conceive of a representative citizen of the United States of America, at least to stand in contrast to a representative citizen of the Peoples Republic of China, but, because of the many varieties of American citizens, no strong representative of the USA can be formed. At an extreme of strength, every three-pronged AC power plug used in the USA (the kind of power plug that you stick in the wall) should be "the same," containing a fixed arrangement of three metal prongs. There is nothing important other than "the same" three prongs in "the same" arrangement and every AC power plug ***is*** a representative, and a strong one, because that's how AC power plugs are designed. Sometimes there is choice involved: When filing a class action, a lawyer will choose "representatives" of the class that have strength in several capacities.

I suggest that "the same" important matters are found in all ping-pong strokes and, therefore, a representative ping-pong can be constructed. That is, I can and do conceive of a representative ping-pong stroke. Moreover, I presume that you have a conception with sufficient similarities to mine so that the representative is strong enough for purposes here. (For my visual conception of a representative ping-pong stroke, I imagine an animation of a series of photographs I saw in a book where a "pro" demonstrates the simplest forehand drive shot.)

We are concerned with operating principles of brains and the statement of a basis for freedom in such operations. For that concern, the facts about ping-pong strokes fall into three classes: (1) objects and perceptions; (2) muscular acts and (3) purpose and intentions. These facts can be referred to a representative.

The first class of representative-stroke-facts collects ***objects and perceptions*** involved in the representative ping-pong stroke. I use the word "objects" in a fashion that is quite broad and the word applies to, e.g., physical material objects; persons; words, text and meanings; natural laws, juridical laws (enforced by courts of law) and geopolitical states. In the Objective Person Psychological Model, an object is experience that has been simultaneously (1) stabilized and (2) set off or ***explicated*** (e.g., by isolation or a boundary); and (3) that has details that can be identified with details of other objects. Objects can include both general and particular details, e.g., abstract and concrete as in "the red 1988 Ford with excessive exhaust-pipe emissions (smog)." Objects are organized into structures; and perceptions can be organized with respect to the structures and objects. One practical point of the arrangement is to organize perceptions for immediate involvement in action.

A major source for information about objects in ping-pong is ***The Laws of Table Tennis*** found at the website of the International Table Tennis Federation, http://www.ittf.com. The Laws define terminology; describe the equipment; require, authorize and/or prohibit certain acts during play; and prescribe procedures for play. "Everyone has to agree" to The Laws of Table Tennis to play. That's what makes ping-pong possible. Of course, laws can be relaxed or changed by private agreement but The Laws are necessary for any such modifications.

The second class of representative-stroke-facts collects ***muscular acts*** involved in the representative ping-pong stroke. It is a fact of ping-pong that nearly all strokes made by a player with substantial experience can be identified as belonging to a particular ***stroke style*** such as the drive, the block, the flip, the loop, the chop, the push and the smash. See http://tabletennis.about.com/library/glossary/bl-glossary.htm for descriptions of these stroke styles. For example, in a loop, the player quickly raises the paddle to meet the ball in flight, "just skimming the ball on the way up," and thus seeks to return the ball to the adversary with hopefully-surprising spin; there is little attempt to speed up the ball by forceful impact and the loop is "more subtle" than a drive (direct shot, forceful but controlled, e.g., to stay low near the table) or a smash (more powerful than a drive and with control sacrificed for maximum speed).

A person's muscular acts involved in a particular activity are organized by the concept of ***repertoire***. For example, it is possible to state a repertoire of stroke styles for ping-pong, e.g., R = {drive, block, flip, loop, chop, push, smash}. The repertoire is open for additional stroke styles and may include practical receptacles, e.g., "miscellaneous" or "freaky."

The third class of representative-stroke-facts collects ***purposes and intentions*** involved in the representative ping-pong stroke. In these Researches purposes and intentions are involved in the primal engagement between intelligence and Reality. The most important fact is that there is a ***sustained purpose*** that is presumed to be constant throughout the activity and that is a basis for ***transient particular intentions***. I borrow a legal definition and say that an ***intention is a mental determination to realize a purpose through particular means and particular acts***.

A player is always motivated by a ***purpose to win the game***. The players have ***competing*** purposes to win and the competition is a central "hook" on which everything hangs: take away the competition and there is nothing of substance left to a game of ping-pong. There is, therefore, the always-overarching goal of winning the game, that I call a ***sustained purpose***.

A player's sustained purpose to win the game is present during every stroke. In addition, there are ***transient intentions*** that are similar in experience to the sustained purpose but that last only a short time. For example, a player may have the transient intention that the then-current stroke send the ball to impact the adversary's side of the table close to an outside edge near the net. After that stroke has ended and a new stroke is being prepared, the former transient intention disappears and a new transient intention forms. A transient intention need not be clear and some transient intentions cannot be expressed in words, feeling more like a need to focus action, e.g. (if it were to be expressed in words) "gotta get the paddle on this..."

The foregoing analysis defines three classes of representative-stroke-facts that I shall refer to in a summary fashion as (1) objects, (2) acts and (3) intentions. Each class of facts has been briefly structured as set forth above. There are ***parallel structures*** that the three classes have in common. In each structure, there is a general conceptual class where the particular members are direct experiences. Objects organize perceptions; repertoire organizes acts; purpose organizes intentions. The structure of objects can be developed in great detail, e.g., by keeping records of games. Structures of acts and intentions are also subject to some development.

I suggest that, in my natural science view of ping-pong strokes, a player is simultaneously accessing three streams of experiential material: objects, acts and intentions. During a stroke, the player selects from each of the three streams and combines the selections by producing the particular stroke, with its particular object-based perceptions, particular stroke style out of the repertoire and particular intention as an expression of sustained purpose.

The foregoing description divides the player's activity into "selects" and "combines" but this a shortcoming based on an inability to describe more precisely. "Selecting" and "combining" are going on at the same time.

Consider an ***ideal ping-pong stroke*** where, as the "ideal" condition, ***all three structures are clearly defined***. An ideal ping-pong stroke might be produced by a ping-pong expert responding to a "set up" shot by an assistant that is delivered so that the response will be ideal in the sense defined above, i.e., clear definition of structures. The expert will have the sustained purpose of "scoring" off the assistant through execution of an "ideal" exemplar of a stroke style with "ideal" placement against the assistant so as to prevent the assistant from being able to return. Clarity of structures is seen after the stroke has been completed but is not assured during the stroke – every performance is risky. I presume that a particular intention arises during the stroke and shapes the stroke. For example, if the assistant unforeseeably moves while the expert is producing a ping-pong stroke, the expert may shape the stroke to send the ball in a direction based on that move – and the stroke will be different if the assistant's move is different.

After consideration of an ideal ping-pong stroke and possibilities for further analysis, I conclude that, from a natural science viewpoint, ***a ping-pong stroke is irreducible***. That is, I know of no way to state how a particular ping-pong stroke is produced and there does not appear to be any way to divide the problem into parts. It can be described in some generic, clumsy way as "selecting" and "combining," but there is nothing in these words that particularizes selections and combinations for a particular stroke. The structure of objects and the repertoire of stroke styles suggest that some guidances can be stated ("if the ball is in a slow, high bounce, go for the smash"), but there is no general means of organization and there seems no way to figure the purpose and intentions into any guidance. In other words, ***there is something going on to produce the ping-pong stroke but it is hidden from view.***

There is an additional, important feature: whatever is going on to produce the ping-pong stroke is working with ***remarkable speed***. A player has only a few tenths of a second to produce a ping-pong stroke, during which, presumably, the complex co-ordinations previously described are taking place. Under a computational view, the smallest unit of time conceivable for activity of a brain cell, a ***neuron***, is about 1 millisecond. If a computer clock had a cycle time of 1 millisecond and had only a few tenths of a second to act, that would mean that there would be only a few hundred clock cycles, not enough time to load, execute and follow through more than a handful of instructions – a shortfall of many orders of magnitude.

To state the conclusion in a more detailed way, each of the three streams of matters (objects, acts and intentions) has its own structure, as indicated above. Material from the three streams is being combined with remarkable speed, but no way appears to organize the three structures together, fast or slow. I cannot conceive of how structures of objects–perceptions, repertoire–stroke_styles and purpose–intentions get organized together to produce a particular stroke so quickly. It would seem that the whole repertoire of stroke styles must needs be accessed before a particular stroke is selected and something similar with the structure of objects. It is more difficult to state how purpose and intentions figure in; but figuring them in, supposing such figuring to be possible, is not likely to simplify the situation.

There are three streams (objects, acts, intentions) that "somehow" get combined. We can't see how but there it is: Chris put a lot of spin on the ball with a flip but Jerr anticipated the bounce and returned with a killer drive to the opposite corner.

I suggest that the production of the stroke ***as a whole*** is an exercise of freedom but that the central part of the stroke cannot be seen. The ping-pong stroke presents the Question of Freedom in individualized, concrete actuality. ***Freedom is hiding at the center of each ping-pong stroke***.

The inquiry into freedom is defeated at this point. Note, however, that considerable progress has been made. Ping-pong has been structured into a sequence of strokes where each stroke involves an exercise of freedom; and, if the centers cannot be seen, they have at least been organized within a clear setting; and common external features, expressed in and through a "representative," are suggestive of further investigations.

§ 3 Looking for freedom hiding at the center of a ping-pong stroke

In this section, I apply suggestions of child psychologist Jean Piaget (1896-1980) about "concept formation" in children to investigate the nature of the "hiding" surrounding freedom inside ping-pong strokes. Piaget is the "father of constructive psychology" that teaches "we construct our experiences," based on Reality.

To sum up the prior subsection: the production of a particular ping-pong stroke requires a player to combine objects, acts and intentions; and, indeed, players accomplish such combinations and produce strokes; but we cannot conceptually follow the threads of a combination or trace connections in any systematic way. We have a conception ***that*** a ping-pong stroke is going on, namely, we know that the combination is being produced; but we cannot form a conception of ***how*** it is going on.

Contrast our inability to conceive of how we produce a ping-pong stroke with knowledge of how bicycles work. I presume that every intelligent adult knows "how" bicycles work. A person presses on a pedal with his or her foot; the force is passed through the pedal crank to the pedal gear, thence to the chain, thence to the rear wheel gear and finally through the rear wheel to push the tire against the pavement and propel bicycle and rider forward. There is a ***continuous passage of force*** from the person's foot – through parts of the mechanism – to the pavement (with gears adjusted to provide the best mechanical advantage); and the ***continuity*** is the key.

A person need not study texts to learn how bicycles work. People learn how bicycles work by riding them, looking at them and working on them. Many a person turns a bicycle upside down so that the wheels are uppermost and the frame rests on the seat and handles. While the bicycle is in such a position, hold the rear wheel with one hand and move a pedal crank with the other. Co-ordinate the motions of the hands. Watch the chain first stretch and then relax and see how the parts touch and move one another. Ahhh.

In bicycles, there is a clear path from knowing ***that*** a bicycle works to knowing ***how*** a bicycle works. That step is taken by acquiring knowledge through direct experience. In the case of a bicycle that knowledge is based (1) on a concept, that of force, and (2) on a principle of continuity so that the force is passed on from one part of the system to another and so forth. The basis of knowledge is activity of muscles and senses that enables intelligence, e.g., to play with bicycles.

As demonstrated above, when we attempt to investigate the representative ping-pong stroke by following a similar path, we can get a certain distance and no farther. Call this "the blocked path to full understanding." There is a block between knowing ***that*** a ping-pong stroke is produced by combining object/act/intention and knowing ***how*** that stroke is produced. We have no concept to apply like "force" is applied in bicycles.

The world's brightest men and women have worked on these problems for many years and have not provided answers. J. A. S. Kelso, *Dynamic Patterns: The Self-Organization of Brain and Behavior* (MIT 1995) is, in my opinion, exemplary of the best attempts and the statement of a conventional view of brains that is as close to my own alternative view as I have found. I use *Dynamic Patterns* in these Researches as a particular target for criticism directed in general at the conventional view of brains, but I hope that the criticism expresses my respect for the author and for those working with him.

Kelso was a student of H. Haken, who coined the name "synergetics" for his interdisciplinary investigations of the "notion of self-organization." According to Kelso, "the key concepts of synergetics ... are order parameters, control parameters, instability and slaving... the brain is *fundamentally* a pattern-forming, self-organized, dynamical system poised on the brink of instability. By operating near instability, the brain is able to switch flexibly and quickly among a large repertoire of spatiotemporal patterns, It is, I like to say, a 'twinkling' system, creating and annihilating patterns according to the demands place on it. When the brain switches, it undergoes a nonequilibrium phase transition, which according to Haken's theory, is the basic mechanism of self-organization in nature." (*Dynamic Patterns* at xvii, emphasis in original.)

There is much in this passage that resonates with my own approach, e.g., "phase transition" that is a central concept here. I even borrow "twinkling." But I do not adopt the ***mechanics*** approach where "the brain" is "a dynamical system" characterized by identifiable "order parameters, control parameters, ... slaving" etc.

Kelso's reference to a "***nonequilibrium*** phase transition" (emphasis added) is especially important. It is factual that matter comes in different forms, called ***phases***. The simplest example is water that comes in the form of vapor or steam, liquid water and solid ice (and snowflakes). The concept of phase is also applied to different arrangements of metal atoms in alloys such as steel (discussed below in § 7) and to different activity patterns in human behavior. In behavior, a phase transition is a shift from one form or mode of activity to another form or mode of activity. "Equilibrium" and "nonequilibrium" refer to the way in which the transition occurs and, most important, whether the transition is ***reversible***, e.g., whether the person can easily go backward. ***Equilibrium phase transitions are reversible; but nonequilibrium phase transitions are irreversible***. (The reversibility concept also applies to activity other than phase transitions.)

As set forth in § 7 below ("We Cook Up Our Experiences"), I hold, along with Kelso, that important activity of brains is modeled as "nonequilibrium phase transitions." But I further hold that nonequilibrium phase transitions are not comprehensible by the physics of ***mechanics*** on which Kelso relies. The alternative view is grounded in ***thermodynamics***, an ***independent branch*** of physics that approaches problems in ways that are quite different from those of mechanics. ***Equilibrium phase transitions***, on the other hand can be modeled better by mechanics than by thermodynamics.

From the standpoint of thermodynamics, Kelso is chiefly directing his attention at ***equilibrium*** phase transitions, e.g., where: "*Both modes coexist* for the *same* parameter value." *Dynamic Patterns* at 56 (emphasis in original). Such coexistence is a statement of an equilibrium condition. See also 45-52, describing an experiment where a person kept pace with fingers while a governing sound was repeated with a "frequency [that] was systematically increased every few seconds ... ***in small steps***," (emphasis added) thus stating a process where equilibrium is restored after each step. However, Kelso does not distinguish between equilibrium and non-equilibrium phase transitions and does not seem to attach any importance to the distinction.

From the alternative viewpoint, the difference between nonequilibrium phase transitions and equilibrium phase transitions is a most important difference. To summarize a chief conclusion of the Researches set forth in § 12, I suggest that an Ideal Brain, while engaging an aspect of Reality and while operating by means of reversible (equilibrium) phase transitions to which that aspect of Reality provides support, can structure or map that aspect of Reality and can, under such conditions and by such means, even structure some aspects of Reality in ways that are comprehensive and/or "mechanical." I further suggest that comprehensive and/or mechanical structuring cannot occur as to a matter where engagement between the Ideal Brain and Reality involves irreversible (nonequilibrium) phase transitions on the part of the Ideal Brain, as many matters like ping-pong do; and I suggest that successful activity by intelligence under such circumstances typically requires an exercise of freedom. These conclusions apply both to a first person engaged in activity and also to another person engaged in understanding the activity of the first person.

To return to ping-pong, I compare the attempted – but blocked – path to development of a full concept of a ping-pong stroke to another path of development, namely, that taken by children in the development of intelligence through normal maturation, as described by Piaget.

At about age 7, a person has only limited skills in forming concepts and applying them to tasks of ordinary life. A child of that age uses a style of concept formation called ***juxtaposition***. Details are not organized but simply "***stuck together***." Later, a growing child develops additional means of concept formation, called ***synthesis***, that culminates in the mental activity of an adult where details are organized into ***structures of relationships***. "We can say that childish conceptions are the result of the juxtaposition and not of the synthesis of a certain number of elements which are still disparate and will only gradually come into relation." Piaget, *Judgment and Reasoning in the Child* (orig. pub. 1924, English reprint 1968) at 157.

I draw upon Piaget's analysis and I abstract material from it for my purposes. I set up "juxtaposition" and "synthesis" as ***two kinds of concept formation***. First there is concept formation through juxtaposition, where features are experienced as being simultaneously present but without more. Through additional concept formation, synthesis, a concept formed by juxtaposition is infused with relations and becomes embedded in a structure of relationships with other concepts.

I suggest that, in addressing the Question of Freedom in the form of a ping-pong stroke, we can employ and apply a "juxtaposition" style of concept formation but we cannot employ and apply "synthesis," at least as to the hidden center of the stroke where objects, acts and intentions are combined. As a result we see facts about objects, acts and intentions (along with their separate structures) as no better than stuck together; we cannot see relationships interconnecting the classes of facts or their structures. This suggestion accounts for being able to see "that" there is an exercise of freedom but not being able to see "how" that exercise occurs and also leads toward an account in § 4 ("In the Blind Spot of the Mind") for this state of affairs. Piaget provides detailed support for these suggestions.

According to Piaget, a person's intelligence develops in a continuous progression from birth to adulthood. Every child traces essentially the same path of development, taking each of the same steps in the same order. There are three major Periods and various stages within the Periods that are defined with some specificity (but subject to variation and/or dispute).

The First Period extends from birth to about age 2 and is marked by Sensory-motor activity. Major activities involve coordinating vision, hearing and touch with muscular action to make "practical" sense of the surrounding world. The Second Period builds on the First Period, extends to age 7 or 8 and is marked by "Egocentric activity" that includes "juxtaposition" concept formation. The Third Period builds on the prior Periods, develops into adulthood and is marked by "Operational activity" that uses "synthesis" concept formation. See Piaget, *Play, Dreams and Imitation in Childhood* (New York, 1962) ("Conclusions") and generally, H. E. Gruber & J. J. Vonèche, *The Essential Piaget* (1995).

"Juxtaposition" concept formation occurs during Period II as part of Egocentric activity. Piaget does not use the word "egocentric" to refer to character pathology or social dysfunction. Later stating that the word was ill-chosen, Piaget defined it in *Judgment and Reasoning in the Child* at 1 as meaning, "that the child thinks for himself without troubling to make himself understood nor to place himself at the other person's point of view."

"Egocentric" thinking or "egocentricity" is part of normal growth. "For instance, the child at this age (between 6 and 8 years) will tell the story without putting the different sequences of the story in the right order. Rather, she will tell the story in the order in which she remembers the different passages, which is neither logical nor historical." (Gruber & Vonèche at 66.)

Egocentricity is bound up with a style of thought where distinctions we take for granted are confused. Piaget studied children's use of words like "because" and concluded that a child's "judgments, being ***juxtaposed***, are lacking in logical necessity." *Judgment and Learning*, at 56 (emphasis added).

The key to Piaget's notion of egocentric thought and juxtaposition concept formation is that the child has not yet developed the mental skills that are used to organize concepts. Chief among these is the skill to make moves in thought without muscular action, to "re-trace" mental moves in reverse order and/or in different orders, and, generally, to engage in what Piaget calls ***operations***. "A system of operations such as the elementary operations of arithmetic or geometry and logical seriations and nestings, can equally well be considered as a set of objective transformations successively reproduced through mental experience... the characteristic feature of operations is their ***reversibility***... Rational operations are...characterized by a definite, mobile and ***reversible*** structure..." (*Play, Dreams and Imitation* at 289 and 291, emphasis added.)

There is, in the alternative view, a clear and most important connection between psychological reversibility and reversible activity of engines. In this section, however, I am not concerned with operations, reversibility etc. for their own value, but only to stand in contrast to "juxtaposition" concept formation. Suffice to say that fully developed "operations," including reversibility, are what adults use to organize structures of ordinary life.

As I read Piaget, intelligence begins with the construction of a ***schema***. That is: "In the presence of certain objects of thought or of certain affirmations the child in virtue of previous experiences, adopts a certain way of reacting and thinking, which is always ***the same***, and which might be called a schema of reasoning." Schema are "unconscious tendencies," but not up to the status of "general propositions," even if having similar functions. "To put it another way, they form a logic of action but not yet a logic of thought." *Judgment and Reasoning* at 56-57 (emphasis added).

Examination of Piaget's observations shows that "the same" are the central words in his statement of schema. I suggest that "the same" is a foundation of all reasoning and all knowledge and I suggest that here's where "the same" comes from: ***from action***.

The suggestion that "the same" is based in action has support in reason. No one object is really "the same" as any other object (even if they start out "the same," differences quickly appear) and a single object changes so that it is not "the same" one day as it was another. But bodily muscular acts can be quite close to "the same." The purpose behind some bodily muscular acts, like hitting an "a" key on a keyboard, is identical time after time. Musicians and athletes "practice" to reproduce complex sequences of bodily acts "the same."

There is, in addition, a ***single unified experience*** involved in a sequence of bodily muscular acts that have been smoothly integrated; and we have no difficulty is saying that a performance, i.e., of an integrated sequence of acts, is "the same" as a prior occurrence or "not the same." E.g., "without my Steinway, playing Rachmaninov is just not the same." As seen from an active perspective, I construct a single unified performance from individual acts. Regardless of whether ***objects***, such as those constituted by physical matter, are "reducible" to some set of constituents, there are ***structured acts*** where such "reduction" ***cannot be made***. The integration of acts into a unified performance is to be discussed in § 10 ("shaping experience with heating and cooling brain waves").

In other words, some acts have an irreducible overall nature that means that each such act has an individual character. Acts with "individual character" are often performed by a ***person*** with an individual character and constitute such a person's exercise of freedom. See § 11 as to the individual character of a person.

An infant's first schema are motor schema; that is, muscular action is the focus of activity and sensory activity is initially meaningful as a signal. See *Judgment and Reasoning* at 57. Only one motor schema can be active at a time and there is no possibility of concept formation. Sensory activities, on the other hand, persist and co-exist; and thereon develops a capacity to construct and sustain images, developing into a capacity to sustain images in the absence of the object that was the source of the image, e.g., to maintain an image of Mama when Mama is absent.

"Development of the Object Concept" is the heart of Piaget's pivotal work, *The Construction of Reality in the Child* (1937) and the original for my imitation in the Objective Person Psychological Model. In his *Beyond Piaget: A Philosophical Psychology* (1983), J.-C. Brief developed the concept of ***action*** as a primal organizing concept for developmental psychology, e.g., at xv, "Sensations occur at the onset of actions... Sensations conclude the outcome of the motor part of actions ... [and] Sensations are events that are fed back and influence the future of the corresponding type of action ... it is not the sensations which are structurally significant but the ***mobile linkages of sequences*** leading to those sensations." (Emphasis added.) In the Ideal Brain proposed below, exercises of freedom are expressed through sequencing and phasing of acts. For example, a pianist performs first by placing fingers in readiness for action and then by releasing the fingers in a particular sequence with particular muscular shaping to achieve a desired phrasing. The releases involve activity in the nature of the "Clutches" incorporated in the Structural Engine Example: Waiting at the Traffic Light.

In the Objective Person Psychological Model, an "atomic element" is "repetitive act" and objects start off as products, signals, etc. that appear in connection with acts. Then a person uses those objects to hook up acts into a ***connected sequence of acts***. Stepping through a geographical terrain is a primal example – the objects are the places – "footholds" – where I put my feet or, using terminology from Model, where I ***produce attachments to Reality***. Each of the objects (footholds) is momentarily stabilized and set off from the environment and the objects can be "strung together" to make up a direction of travel, e.g., toward the pass to which a person is traveling.

An attachment may be permanent or transient and attachments can sometimes be systematically varied. If the subject matter that is being engaged allows, as with a technological subject matter, we use acts to hook up and vary objects and then use various objects to construct new acts and to vary acts. If objects and acts can be liberally assembled into structures and varied usefully in a coordinated fashion, we're off to the races.

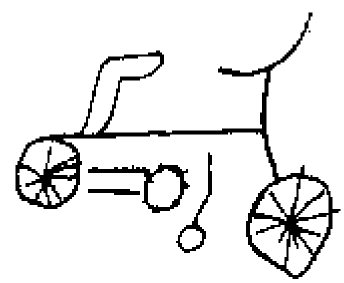
To return to Piaget's analysis, juxtaposition is a ***factual*** activity in an infant's intelligence. "For any two phenomena perceived at the same moment become caught up in a schema which the mind will not allow to become disassociated, and which will be appealed to whenever a problem arises in connexion with either of these two phenomena." *Judgment and Reasoning* at 229.

"Juxtaposition" is one side of this style of concept formation coin; another is "syncretism." "[S]yncretism and juxtaposition constitute two phases alternating over indefinite periods in the mind of the child." (*Id*., at 59)

"[S]yncretism is a vision of the whole which creates a vague but all-inclusive schema, supplanting the details." (*Id*.) Syncretism, "which makes the child connect everything with everything else, and prevents him from making the excisions and distinctions necessary to analytic thought, ***will have the natural consequence of making him concentrate heterogeneous elements within a single word.*** We have here a second cause of ***irreversibility***." *Id*., at 240 (emphasis added). For example, a "child, unable to choose between two contradictory explanations of one and the same phenomenon, agrees to both simultaneously and even fuses them into each other." *Id*. at 242.

A particular example brings the juxtaposition style of concept formation into sharp view:

"The drawing of a bicycle by a child of 6, for example, will show, in addition to the frame and the two wheels, the pedals, a chain, a cog-wheel, a gear. But these details are juxtaposed without any order; the chain is drawn alongside of the cog-wheel instead of being correctly inserted, and the pedals are suspended in mid-air instead of being fixed. Thus everything happens as though the child really felt the relations in question, knew that the chain, the pedals and the cogwheel were necessary to set the machine in motion and that these different pieces 'went together.' But this is as far as his consciousness of the relations goes; it does not extend to a precise knowledge of the details of the insertion and contact. The drawing is therefore comparable to the thought, and the thought to the drawing. Both juxtapose instead of synthesizing." *Judgment and Reasoning* at 58. (The adjacent image is a ***different but similar*** bicycle drawing reproduced in Piaget, *The Child's Conception of Physical Reality* (1927) and Gruber & Vonèche at 125.)



I suggest that, when investigating an exercise of freedom involved in a ping-pong stroke, I am in a position similar to that occupied by a child of 6 or 8 years. Each of us can form a concept through juxtaposing disparate elements; but relationships between the elements are "lacking in logical necessity." It is with me thinking about ping-pong strokes as with the child drawing the bicycle who "really felt the relations in question ... that these different pieces 'went together,'" but who could not obtain "a precise knowledge of the details of the insertion and contact." In ping-pong, the different pieces are objects, acts and intentions and there is something organized going on that I "really feel" but about which I cannot obtain "precise knowledge." I do not understand how object, act and intention make "insertion and contact" with one another. Lacking understanding, I am forced to "concentrate heterogeneous elements within a single word."

The psychological analysis helps clarify the nature of the block on the way to a conception of freedom hiding at the center of a ping-pong stroke. Unlike the children I have fully-developed capacities for synthesis and operational thought. They just don't work on the exercise of freedom that produces a ping-pong stroke. Juxtaposition works well enough to form a syncretic concept and that is what I have.

In the next section, I propose to account for this state of affairs and for the Question of Freedom.

§ 4 A Place for Freedom: in the Blind Spot of the Mind

To sum up the present position: "personal freedom" has been developed in the form of an example, namely, ping-pong strokes. The facts about a ping-pong stroke are that there are three structures involved, identified as structures of objects, acts and intentions. "Somehow," the three structures are combined, with remarkable speed, to produce a particular stroke. It is possible to consider a representative stroke that involves particular perceptions, a particular pattern of muscular acts and a particular intention. An investigation into "how" a representative stroke is produced leads to defeat. I can't see "how" the combination occurs even though I see "that" it occurs.

It is noteworthy that a normal 7-year-old child is in a position as to bicycles as I am to ping-pong strokes. A child knows "that" a bicycle works but does not know "how." A drawing of a bicycle by a 7-year-old does not show the mechanisms that pass force from one part of the system to another.

As discussed in the previous section, the child is using ***juxtaposition*** concept formation but has not developed ***synthesis*** concept formation. Juxtaposition tells the child "that." A person needs synthesis to say "how" and, indeed, the child needs synthesis even to conceive of "how." As the child grows and develops, he or she develops skills in synthesis.

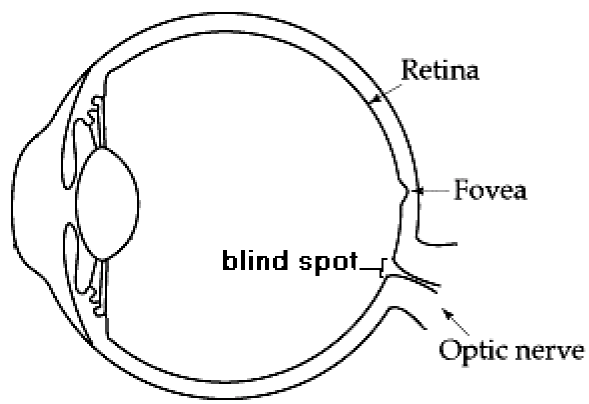
It is also noteworthy that children of age 7, although unable to form concepts through synthesis, are quite active mentally and typically have as much enjoyment in their lives as shall be achieved at any time thereafter. There are many matters where children perform successfully without synthesis concept formation, e.g., riding bicycles without understanding how they work.

I suggest that synthesis concept formation ***cannot*** produce satisfactory concepts suitable to understand some matters, including exercises of freedom. It is certain that synthesis concept formation is better than juxtaposition for most matters. Especially through science and in civilization, we have built complicated systems where synthesis concept formation works well, or some approximation thereof. Some of these systems interface Reality with rich and powerful techniques. Despite these accomplishments, I suggest that synthesis concept formation is not sufficient to comprehend "everything that happens in our universe." I conclude that, as a matter of fact, there are systemic ***limitations of intelligence*** in human beings that result in ***defects*** in the products of intelligence, including all of our ideas and theories. As to some matters in Reality, seriously consequential defects are generated by our intelligence and, as a consequence, useful concepts cannot be formed by synthesis. I conclude that freedom is such a matter.

Limitations of intelligence and defects in the products of intelligence are ***self-concealing***. I presume that there could be a superior intelligence that is not troubled by such limitations and defects and from the perspective of which I appear rather like a 7-year-old appears to me. The 7-year-old does not understand the problem because his or her mental equipment does not have the requisite capacity. Likewise, in these Researches, I presume that I do not have the capacity to grasp directly the limitations of my intelligence and the defects of its products but must conceptualize about them and construct accounts about them from evidence.

Some persons believe that a superior intelligence has provided guidance, e.g., through revelations to humans that have been recorded in scriptures. I have no dispute with a person holding such a belief (possibly reserving dispute about the scriptures), but I do not rely on any such guidance in the presentation of these Researches. Reliance on such guidance is not appropriate to a presentation based on objectivity. [There is a discussion in § 11 about one particular guidance – the teaching of medieval theologian/philosopher Duns Scotus on a ***principle of individuation*** that declares a central position for personal character and responsibility – as an example of matters that could be stated consistently along with the Model but that are beyond the scope of formal statement within the Models. See also discussion of "abstention" and "licentious abstention" in § 5 that is used to justify such speculations.]

A useful metaphor is ***the blind spot of the eye***. Likewise, I suggest, synthesized images of freedom, could they be constructed, would fall on ***the blind spot of the mind***. Freedom is not the only concept where synthesized images would fall on the blind spot of the mind but such images of freedom would fall squarely on the blind spot and illustrate the ways the blind spot works.



Eyes provide the basis for the blind-spot metaphor and every eye has the same functioning parts. The ***retina*** is a distinct layer of nerve cells in the back of an eyeball and the nerve cells in the retina respond to light and generate the primal material of visual experience. "Signal wires" from groups of nerve cells in the retina are gathered together inside the eyeball and make up the ***optic nerve*** that connects the retina to a person's brains. The retina is ***inside*** the eyeball and the optic nerve passes ***through*** the eyeball, in the depths of the eye socket. Where the optic nerve passes through the eyeball there can be no and, indeed, there are no light-detecting nerve cells. This is the basis of the "blind spot." ***It is like a <u>hole</u> near the center of every photograph***.

Even worse, the blind spot is located close to the ***fovea***, the area in the retina where light-detecting nerve cells are most closely packed and where visual perception is most fine-grained. When I want to examine an object visually, I adjust the object and my eye so that the image of the object is projected onto the fovea. Because the fovea is near the blind spot (about 16 degrees around the circle), as a practical matter, important material is often not seen. It is as if, despite the hole near the center of every photograph, the photographer typically puts all the interesting stuff in the central area. ***The blind spot affects every visual image and we don't even notice!***

Where we don't notice what's going on, we make up stories. We "fill in" the visual image by extending what ***is*** seen so as to "cover up" the deficit. Often, "filling in" works successfully; and, because we look at things from a multitude of angles and places, we catch up on what we've missed. Clever psychologists have devised experiments that block corrective measures and demonstrate the operation of the blind spot. The person who is the subject of the experiment is induced to "fill in" falsely and to make statements that are contrary to Reality. Everyone but the subject sees *x*, but the subject sees something different, *y*, say.

Metaphorically, images of freedom fall on the blind spot of the mind. There's freedom in many places where we look only we don't see it. The way intelligence operates, freedom cannot be imaged. More precisely, as in the Models presented here, intelligence constructs experience and the kinds of experience that intelligence can construct do not include freedom. I hold that freedom is real regardless of whether or not intelligence can construct images of freedom. I suggest further that Reality is different from what we get by just "filling in" according to what we do see. In particular, freedom is in Reality even if we don't see it because we are blind in that direction.

In sum, I hold that ***there are matters that both real and unknowable and that personal freedom is such a matter***. I approach such matters in multiple ways and try to connect the ways however I can.

Here is one fast overall description of an approach, necessarily somewhat vague. When a person experiences Reality, the person constructs an ***image***. What is experienced is the ***content of the image.*** The content of images is constituted, in the most general way, by ***activities***. That is, "activities" is the biggest container for stuff going on in images, and the "activities" container includes, e.g., perceptions, muscular acts, purposes and intentions. I also use the word "activities" to mean images where "nothing is happening" and this includes an image with a static object. It also includes an image with no object at all, i.e., a "void." In the Model, a "void" and "static objects" are like a "0" in a system of numbers or a null set in set theory, important subordinate constructs.

In other words, the alternative view starts off with a ***plenum of activity*** – where there's something going on everywhere you look – the "buzzing, blooming confusion" psychologist William James said was the first impression infants had of the world. There is, at moment one, nothing known. Intelligence must proceed to engage Reality, e.g., by objectifying a particular something in activity or by dividing activity into bodies of activity.

In contrast, the conventional view starts off with a ***void*** that is ***then*** populated with entities. Activity comes from the entities, e.g., action of a body stated in terms of values of specific properties of the body. The most popular entities nowadays are ***atoms***.

One important difference is that the alternative view allows for matters that are no more than ***implicit*** in the plenum of activity; while, in the conventional view, all matters are ***explicit*** and based on the properties of the entities that populate the void.

In the alternative view, when the plenum of activity divides, it divides into ***subject matters***. ***Matter*** is a concept and word I use "the same" with respect to all subject matters, namely, as a ***pointer*** to identify something particular within something larger. In other words, the word "matter" denotes a relationship with something else rather than a concept of itself. (Computer programmers, e.g. while programming in the language C, use the word "pointer" in a similar way.) I generally prefer to identify a matter narrowly and/or exactly but this not always possible and I use ambiguous terms to discuss vague matters when ambiguity is appropriate or necessary under the circumstances. Used as a pointer and not to describe objects, "matter" states an element of structure. If classes are pointed to, they can be ambiguous or narrowly identified depending on the circumstances. (In the Objective Person Psychological Model, a constituent element is a ***structural event*** that relates objects; and the relationship is specific even when the objects are ambiguous. The specificity of the relationship between the objects licenses ambiguity in definition of the objects.)

I am concerned chiefly with matters where agreement among persons is compulsory, e.g., distances and times and other matters studied in the physical sciences, but extending also to other matters, e.g., matters involving commercial transactions, the existence of geopolitical states, juridical laws and meanings of some words. One important kind of activity is ***persons acting in ways*** (my technical language), e.g., a person walking on a pathway in a forest or baking a cake according to a recipe. Persons use ways to engage Reality. A person can ***know ways*** to engage a particular subject matter in Reality and the ways a person knows constitute that person's ***repertoire of ways*** for engaging that subject matter.

Among the matters in Reality are those where intelligence is highly successful. There are matters where a person can learn ***ways of knowing*** that are so thorough ("dense") that the person can meaningfully say that he or she "knows the matter." There are, in addition, ways of knowing that must be in a person's repertoire for that person to qualify as intelligent and competent, such as knowledge that enables a person to find an address in a city. But such knowledge, I suggest, is available only as to certain subject matters and not generally or comprehensively.

I suggest that, factually, there are subject matters in Reality about which agreement is compulsory but with respect to which ***ways of knowing cannot be found***. I suggest that the Question of Freedom is such a matter.

In the alternative approach, I propose to focus on the Question of Freedom by a means other than conventional synthesis concept formation. I do not propose to "fill in" from some supposed system of comprehensive knowledge; rather, I presume that no such system can be constructed.

My approach presumes that there exist matters in Reality that human intelligence engages successfully to the highest degree (paradigmatically, while identifying and applying the laws of physics) and that there also exist matters where attempts at engagement by human intelligence necessarily fail because of the limitations of intelligence and because of defects in the products of intelligence.

My approach is opportunistic. Having studied electrical engineering, physics and metallurgy, I construct my approach so as to take the most advantage of the ***technological ways*** of thinking that were developed to discover and apply physical law. I suggest new uses for those ways. I am not suggesting that technological ways were developed to address freedom, but they have generated a massive body of tested methodology and I have been able to adapt some useful materials for my purposes. Of paramount importance is the union of technology and objectivity. To the extent freedom can be made objective, to that extent can technological ways be usefully employed.

I also use ***juridical ways*** of thinking that have been developed by lawyers, judges and others involved in legal proceedings. (I have been practicing law for 30 years.) Juridical ways of thinking overlap with technological ways, e.g., through disciplines of formalism and objectivity; but juridical ways often incorporate concepts and conceptual structures that are foreign to science. E.g., science and technology abhor ambiguity but juridical ways of thinking employ ambiguities as standard structural elements. In § 5 below, I introduce "virtual concepts" borrowing from a juridical original.

My approach to matters is practical, an approach that might be called "instrumentalism" because I view concepts and constructions as "instruments" to achieve purposes. I do not say instrumentalism is "true" in some metaphysical sense. Instrumentalism is what I do and it fits in very nicely, thank you.

In the rest of this section I set forth a Statement of General Principles that also previews the Construction of Part II.

1. I hold that human intelligence has important ***limitations*** and that our experiences, generally constructed in systemic ways, have ***systemic*** features of form that often incorporate ***defects***. In particular, I model human intelligence by processes that ***stabilize, explicate*** and ***identify*** matters; and, according to the Model, the products of the processes (objects that are stabilized, explicated and with features identifiable with features of other objects) are sometimes ill-suited to a particular task that requires engagement with Reality.

In support of this proposition, I suppose that intelligence works in a certain fashion, or in certain fashions, and that such fashion or fashions generate concepts suitable for some purposes and not for others. That is, factually, there are situations presented to intelligence where the products of intelligence are not fully satisfactory. E.g., your lawyer won't give you any better prediction about the outcome of your case than some sort of "odds" and he says even those aren't reliable.

There are also situations presented to intelligence where intelligence is not able to produce successful products with any assurance whatsoever. E.g., predicting the daily behavior of a stock market. The situation with stocks is even worse than with the lawyers. A lawyer may persuade you that his or her past performance is a reliable measure of future performance but no one will persuade you that past performance of stocks provides a reliable measure of the future.

I suggest that the shortfalls in knowledge are based on limitations of intelligence. The problems with lawyers illustrate universal problems of humankind. A predictable stock market is impossible to conceive, presuming that every person would make the same prediction. (Differences of opinion are essential for horse races and stock trades.)

I sum up this situation by saying that ***the capacities of intelligence are limited***. I hold that limited capacities of human intelligence are factual and irremediable. Limits to and failures in products of intelligence are ***built into*** those products through the very operations that construct them.

Products of intelligence is a broad class that includes: manufactured items such as consumer electronics; laws formulated by scientists; laws enforced by judges; decisions of social, political and business organizations. These are grand products and there are many more humble products, including the draft of an email I recently discarded. Generally a product is an ***object*** (used broadly) made by one person that can be used by another person. From such a perspective, a product is a vehicle for the maker's intention.

Classes of ***defects*** are: artifacts – stuff inserted into products of intelligence by activity of intelligence (e.g., "stereotypes" of race, gender, etc. projected onto the image of another person); omissions – stuff that intelligence cannot and does not handle; and distortions – stuff where relationships are altered in a systemic, aggregate way. Psychological experiments show that intelligence does, indeed, generate defects (e.g., "illusions") of such kinds.

Often, defects are discovered when products of intelligence fail during use. Failures of laws and theories of physics are well documented. I suppose (even "hypothesize") that important systemic defects and/or defects of form would be discovered as to each and every product of intelligence supposed to describe Reality – e.g., each law of physics – if that law could be measured directly against Reality by a superior intelligence that is unhampered by limitations. As to some products the defects would be seen to be vanishingly small or completely inconsequential, but all products would clearly incorporate some defects and, as to some, crippling consequences would be seen. Consequences of defects in some products would appear to vary according to the particular product and its attempted applications.

I use the word "Reality" to denote what I cannot describe. (It is probably better to think of my use of capital letters, e.g., those identifying particular ideals such as the Ideal Gas Law, as indicating expressly ***defective*** concepts rather than concepts that are entitled to special respect.) The word points toward that which is beyond even an attempt at meaningful overall description but which, in its apparent "Unity" and "Existence," has awesome power. The Existence even includes the person trying to form the concepts about It – hey, that's me! My limited intelligence, operating with its defective products, is unable to navigate this confusion – and my mind boggles. I henceforth abstain from such general speculations. I have learned that scientists have better methods for investigating the details of Reality. My approach is through construction.

I presume you acknowledge a Reality that is similar to the Reality I acknowledge. Notwithstanding abstinence from general speculations, we have common knowledge from ordinary experience and from science that ***particular*** aspects of Reality can be partially described and that some particular aspects of Reality can be described exactly, or nearly so. To the extent possible, we will be focusing on those matters in Reality, called ***objective matters***, where our agreement is most complete and certain and where, therefore, thorough and exact descriptions of Reality seem most likely to have been accomplished. Scientific knowledge itself can be examined as such an objective matter.

As I use the word, a matter is ***objective*** if agreement about that matter is ***compulsory*** among intelligent persons. Otherwise you don't qualify as intelligent, at least as to that matter. This does not mean that all intelligent persons have the same capacities to construct concepts about the matter or that all concepts will coincide. It does mean that a ***conflict or dispute*** about the matter can be decided by reference to the matter that will compel at that least one person to change his, her or its concept so as to resolve or remove the conflict or dispute. For purposes here, such compulsion is the biting edge of Reality. For example, a lawsuit may construct an object, called a ***judgment***, that compels a person to change his or her concepts about a matter that had been hotly disputed. A person who loses a lawsuit is faced with the fact that persons in general and financial institutions in particular recognize the judgment and its conclusions as part of Reality; and that fact is an objective fact. A person who refuses to recognize that objective fact is not acting intelligently.

I suggest that limiting the examination to objective matters helps to minimize the adverse consequences of defects in products of intelligence. Even taking advantage of objectivity does not control or eliminate all adverse consequences of the limitations of intelligence. Even though all persons agree on a description of Reality on the basis of facts known, facts later discovered may show the description to have been in error. This is a chief lesson taught by the history of science. Objectivity may not be a sure test of reliability but it's perhaps the best we have.

In the Objective Person Psychological Model, I construct ***the objective person***, an invented concept, and suggest that such construction imitates important activity of the intelligence of all intelligent, adult persons. Surveying use of the Tool, a goal of these Researches is construction of an ***artificial objective person*** who exercises freedom and who is constrained to engage Reality only as to and through objective matters. As an artificial person, the objective person would join a class of artificial persons that includes corporations, computers, governments and courts. Artificial persons are distinguished from ***natural persons***, who are men and women of "ordinary intelligence," without further definition. Every person, natural or artificial, engages in communications with other persons (the identifying feature) and has certain capacities and limitations in such engagements.

The chief feature of the objective person construction is that, presumptively, every natural person's parallel construction will construct "the same" objective person concept that I construct (or any differences can be incorporated into equivalency relationships); and this presumptively identical construction supports the single-voicing implicit in the phrase "***the*** objective person." The presumptions and the construction are based on the ***fact*** that there are matters in Reality about which all persons are compelled to agree. E.g., at a certain time, everyone agreed that a certain piece of metal in Paris, France was the "standard meter" (now the standard meter is based on measurements of radiation from krypton gas). Given an opportunity to measure for one's self, every person would agree, e.g., that the length of a specific object is more than 2.5 of those standard meters and less than 2.6. In juridical law, there are "facts and propositions that are of such common knowledge within the territorial jurisdiction of the court that they cannot be the subject of dispute" and that are allowed into evidence by the judge without any "authoritative" testimony, e.g., the layout of roads and intersections where an accident occurred. (California Evidence Code § 452(g).) As another example, lawyers divide particular facts about a case into "undisputed facts" and "disputed facts." See California Code of Civil Procedure § 437c(b).

The construction of "the objective person" mimics the courtroom concept of "a reasonable person" or (in olden times), "a reasonable man." A juror is instructed to evaluate a party's conduct based on the standard of what "a reasonable person" would have done in the circumstances, in contrast, e.g., to evaluation on the basis of what the juror himself or herself would have done in the circumstances. In jurisprudence the reasonable person test is an ***objective standard*** and everyone in the community is supposed to apply "the same" standard.

The artificial "objective person" is designed to mimic the activity of a natural person engaging Reality as to objective matters only. Such activity includes activity requiring exercises of freedom. An example is ping-pong. Consider also the other "Phenomena of Freedom" identified on the opening page of *Researches in Personal Freedom*.

Hence, I suggest that focusing on the activity of an objective person minimizes the adverse consequences of the defects of intelligence. When focusing on freedom, such restrictions are helpful. Some defects, however, cannot be removed because they are bound up in the intelligence that produces experiences. There are, I suggest, defects in products of intelligence generated by operations of intelligence and these defects are systemic and incorrigible.

Details about defects generated by processes of intelligence are set forth in the Objective Person Psychological Model. In brief, the foundational concept is that of ***process***. "Process" is a concept that presumptively applies "the same" to different subject matters, e.g., thermodynamics, brain science, psychology. A process ***does*** certain things in a way that, in an Ideal form, can be ***continuously*** described.

I construct idealized psychological processes (1) ***stabilization*** (much as in mechanics), (2) ***explication*** (also known as boundary-drawing, setting-off or particularization) and (3)

identification (saying of features "they're the same.") Each process ***selects*** material in Reality that is suitable for engagement and, when able to operate in combination, the processes generate and assemble structures in an ***image space*** that imitates a mind. ***This is how I model synthesis concept formation***. I start with images of matters in Reality that include juxtaposed objects and I construct structures involving features of those objects. Because there are always at least two juxtaposed objects, such a structure always involves multiple attachments that must be coordinated through some common element or through some intermediary. This description applies not only to constructions involving permanent material objects but also to constructions involving acts and intentions treated as objects. Relations can involve all such matters. To the extent, I successfully use the relations to engage Reality, I ***understand*** the matters so imaged. This gives a practical meaning to the word "understand."

Let us suppose that the model stated above sufficiently describes some activity of human intelligence and suppose also that such activity of human intelligence is seen by a superior intelligence. The superior intelligence observers that there are places where the relations I have synthesized don't fit Reality and it's in those places where defects are generated. I can't see the defects because all I can see are images that are limited to (1) juxtapositions (and their syncretic products) and (2) relations and structured concepts. What happens, as a practical matter, is that the structures don't work as desired. Unfortunately, this happens all too often and reasons for failure are never really understood. I attribute such failures in general to systemic defects generated by limitations of intelligence.

I maintain a ***foundational premise*** of discrepancies between the products of intelligence and Reality. The premise is expressed in the presumption that defects in the nature of artifacts, omissions and distortions ***pervade all our experiences***, including experiences of objects and acts, etc., but also including appropriate exceptions. As a consequence of the defects, and despite our best efforts, our concepts do not fit Reality exactly . There are, generally, a lot of ***misfits***.

"Misfits" is a general statement and misfits can often be reduced, sometimes to insignificance, through hard work that involves exercising freedom – hopefully, the more work, the better the fit. Knowledge, especially scientific knowledge, is often extremely helpful when you want – and can get – a tight fit. Because of limitations of intelligence, however, knowledge is often unable to achieve success in engagements with Reality. Often, we must act without sufficient reason to make an informed decision. As a further consequence of the limitations of intelligence, our attempts to act are always subject to error and are sometimes poorly suited to achieve our purposes. We grope and cope to overcome the adverse consequences of the limitations and the defects. Where misfits lock together, there are matters in Reality that our intelligence cannot grasp. I suggest that freedom is such a matter.

Undeterred by but bearing the consequences of shortcomings in our intelligence, we must and we do exercise freedom to perform a day's work, to get chores done and to accomplish other purposes. We have awareness of the freedom in our lives but our limited intelligence is unable to conceptualize freedom and, when we try to focus, we see only a confusing haze.

2. One consequence of limitations of intelligence is that we do not have actual experience of some limitations. In other words, some limitations are concealed by the defects the limitations collectively generate. Or, from another perspective, we have adapted to the limitations and have no awareness of them.

There is a general human tendency, when encountering a disturbance or troublesome matter, to adapt thereto and then to cease having awareness of the disturbance that required the adaptation. For example, a subject in a psychological test wears special glasses that grossly alter the visual scene. Adapting to the alterations, the subject changes his ways of experiencing until the new visual capacity has become his norm. Then, he must re-acquire the former capacity when the glasses come off and everything looks so strange. Such experiments raise the question: how can we know whether or not we are all wearing "the same" distorting glasses all the time?

As to systemic, lifelong limitations common to all humankind, we have no standard against which to compare our experience and thus have no idea how "strange" or "wrong" our experience might be. We do know, for example, that there is a complicated and oddly clumsy relationship between the human sense of color and what we believe is the underlying reality. (C. L. Hardin, *Color for Philosophers: Unweaving the Rainbow* (1988).) We also know that we are prey to illusions we have ourselves created, such as the cinema illusion where a succession of still images is experienced as motion. Anyone who uses experience to engage Reality must always be aware and beware because Reality is often surprising.

3. To extend the foregoing and state foundational premises: As a consequence of limitations of intelligence, defects (artifacts, omissions, distortions) are incorporated into our experiences, e.g., experiences of objects, acts and intentions. Such defects could conceivably be identified by a superior intelligence. We have no direct experience of some limitations of experience and are often ignorant of the defects.

I suggest that we can learn about the limitations of intelligence and about the defects ***indirectly*** by observing differences between (1) matters in Reality involved in successful activity of intelligence and (2) matters in Reality involved in activity where intelligence more often fails. "Here's where intelligence works successfully and here's where intelligence fails" and differences are attributed to defects and limitations. I construct a ***spectrum*** and place activities of intelligence along the spectrum according to the success of intelligence in achieving the goals of the activity, such goals being defined within the activity. The spectrum incorporates analysis and supports interpretation and insight.

I observe variable success of intelligence when engaging diverse subject matters. Physics has been ***extremely successful*** in its goals of ascertaining the properties of physical matter under circumstances achievable in the laboratory. The technology of consumer electronics has been ***highly successful*** in goals of producing and delivering complex products efficiently and cheaply. Some technologies, including steam power generation and metallurgy (both discussed below), achieve ***practical success*** that is based on extensions of prior art as much as on knowledge. Civil law is ***partially successful*** in its goal of regulating society as to certain matters and is ***more***

successful in regulating banking transactions and ***less successful*** in regulating residential remodeling transactions. Because all human beings die eventually, medicine can only achieve ***transient success troubled by side-effects***, but its successes are of foremost importance in extending our lives. Family law (e.g., divorce and child custody) has ***some successes*** but also ***many failures*** and often barely limps along. Approaching the pole opposite to that occupied by physics, no known systematic use of intelligence has been successful in predicting "behavior of markets" (where people trade things for money, e.g., the stock market) to any extent more detailed than a single overall trend and, despite enormous investments, there has been ***general failure of intelligence*** to predict market behavior. The history of war is a showcase for ***glaring, catastrophic failures of intelligence***, both getting into wars and during combat.

4. Observations of daily life and studies of diverse areas of specialized knowledge show that human intelligence is most successful in achieving goals when the subject matter that is being engaged by that intelligence is structured into elements that are (1) isolated, (2) repetitive, (3) simplified and (4) constrained by known influences. I suggest that these conclusions are objective (i.e., that they are a basis for universal agreement) and that they apply to activity of human intelligence in general.

Accordingly, I presume that isolation of subject matter, its repetitiveness and simplicity and knowledge about its constraints are ***factors*** or parameters that measure how well human intelligence works with a particular subject matter. At one end of the spectrum are matters where intelligence works best. At the other end of the spectrum, activity of human intelligence is risky and prone to error. At the error-prone end, observation shows that the subject matter is, respectively: ***embedded*** in other subject matters as opposed to "isolated;" ***unique***, as opposed to "repetitive," ***complex*** as opposed to "simplified;" and subject to ***unknown or open influences*** rather than to "known constraints."

Note that these factors are a ***provisional tool*** and that the Tool of the Objective Person Psychological Model accounts for the factors as resulting from activity of a constructed set of psychological ***processes***, namely, "stabilization, explication and identification."

For example, apply the factors to physical phenomena that have been successfully studied by physics. (1) Such phenomena are ***isolated*** from all but a few influences in a laboratory setting or in "space" (e.g., interplanetary space). Thermodynamics, for example, begins with a ***closed surface*** that divides the ***system*** from the ***surroundings***. (2) To be valid, an experiment must be reproducible or capable of being ***repeated***. (3) A physics experiment is ***simplified*** to identify and highlight certain relations – often the means of simplification is what the experiment is all about. (4) A physics experiment is always ***constrained by known influences*** and all other influences are rigorously excluded, e.g., by a vacuum chamber, purity of materials, electromagnetic insulation (Faraday cage), general cleanliness. It is behavior of physical materials under known constraints that physics seeks to identify and explain.

"The same" factors apply to intelligence resolving a dispute in a courtroom. A trial of one case is isolated from all others and, within a case, legal proceedings isolate individual issues. Legal proceedings also seek to frame each issue in a way subject to repetitive treatment – "like cases, like judgments" or "precedent determines the result." Likewise, legal proceedings seek to simplify and to constrain actions and decisions according to established forms. These factors guide an attorney in daily tasks.

I suggest that both physics experiments and legal proceedings are ways to organize activity so as ***to minimize the adverse consequences*** of limitations of intelligence. The effort is more often successful in physics because physicists can select and shape their experiments to achieve minimal distortion. Courts must deal with every case filed.

At the polar extreme from physics, the oppositional factors apply. Pick a war you know about and ask yourself whether the involvement of a particular country in that war was the result of matters that were "isolated" or, instead, "embedded" in many matters; of a "repetitive" or, instead, "unique" nature; and "simplified" or "complex;" and ask also whether there might have been influences that are now known only as possibilities. Your answers will, if the factors apply, likely point toward "causes embedded in circumstances of a unique and complex nature likely influenced by matters that can only be guessed about." That seems to describe wars I have read about.

[This construction of a spectrum with placement in the spectrum measured by factors is imitative of a legal construction. See, e.g., 17 U.S.C. § 107 (four factors used to evaluate whether an unauthorized use of copyrighted material is or is not a "fair use" – e.g., whether one can publish a full-length quotation for purposes of criticism).]

5. These observations about successes and failures of intelligence apply to a wide variety of human activities and I suggest that the factors are based, not on the nature of Reality, but on the way intelligence operates. ***I suggest that the factors measure the consequences of limitations of intelligence engaging Reality and that the factors measure ways intelligence incorporates defects into experience***.

To illustrate: if an isolated animal is well-suited for scientific study, that suitability is based, in part, on the greater ease of studying an isolated animal. ***The isolation of the animal minimizes the adverse consequences of the limitations*** and makes scientific study possible. The difficulty is that knowledge about the animal's activity obtained when the animal is isolated may not be applicable to the life of the animal acting in a social setting.

In a similar way, I am suggesting, studies of physical matter under the constraints required for physics may "leave something important out." And what is being "left out" is stuff that our minds can't handle.

6. To re-organize the observations for a different handling, I identify some particular ***arenas*** of human activity where the factors are useful guides. The arenas are arrayed in a spectrum.

(a) At one end of the spectrum, where intelligence is most successful, stands "the laboratory." Next door is the "high-technology manufacturing plant," successfully and repetitively producing and shipping identical units of commerce, each in its single package and each according to specification, at least when things go smoothly. "Outer space" is the natural environment that is most suited for activity of intelligence, e.g., predicting planetary orbits.

At the commencement of the era of modern science, Galileo (1564-1642) identified some classes of phenomena that were suited to the mathematics of his day. E.g., in *Two New Sciences,* Galileo constructed mathematical formulations that relate strength to size in weight-bearing bodies such as building beams and that trace the trajectories of heavy bodies such as cannonballs that are propelled into the air . The factors showing "success of intelligence" are clearly evident in Galileo's subject matters.

Successful legal institutions show the same factors, e.g., the complex and efficient system of international commercial law that smoothly facilitates massive world-wide trading involving multi-party exchanges of goods and moneysworth. E.g., large quantities of electronics goods manufactured in China selling nationally in the United States. Trades are isolated, e.g., by reference to a specific "purchase order" or "shipment." A few simple forms of procedure are repeatedly employed, with a possible multitude of variations subject to specific constraints.

(b) At the other end of the spectrum, where activity of human intelligence is risky and prone to error, are found "the wilderness," "mean streets" or "the battlefield" depending on circumstances. Under some circumstances and in such environments, isolated, repetitive, simplified and/or constrained events simply do not occur and, correspondingly, attempts to use intelligence often fail. After-the-fact attempts to reconstruct a course of events, e.g., by historians and trial lawyers, is fraught with risk and the whole notion of such reconstruction appears seriously suspect. Supporting materials: Rosenbaum, *Explaining Hitler* (1998); Frank, *Law and the Modern Mind* (1930).

(c) Many arenas provide opportunities for action such that conditions are between extremes of easy, exact success and high-risk groping. In the middle ground, persons have opportunities for ***constrained exercises of freedom***. I suggest that, as a practical matter, exercises of freedom are efficacious where there is ***insufficient knowledge for certainty***, but ***sufficient knowledge to act***. In other words, as a matter of fact, there is a middle ground where exercises of freedom increase opportunities for success.

In the middle ground, I particularly focus on disputes over money and property that are resolved in a courtroom according to rules of ***juridical law***. These matters are important here because, in juridical law, ***partial (incomplete, ambiguous and/or indeterminate) formulations of law are sufficient for many practical purposes*** and ***partial formulations allow for and even require exercises of freedom*** by judges and juries. [The first proposition is also true of physical law in the "alternative branch of physics" of ***thermodynamics*** that I explore in these Researches.] The existing structures of juridical law provide detailed support for analysis of exercises of freedom; and my participation in litigation as a lawyer has provided opportunities to observe judges, lawyers and parties exercising freedom under constrained circumstances.

7. As discussed in § 3, psychologist Jean Piaget studied the origins and development of intelligence in children and propounded a “constructivist” psychological system. Piaget taught that intelligence is an ***activity*** and that activity of intelligence can be analyzed into a number of distinguishable ***processes*** that develop incrementally and continuously from inborn action-patterns that start as reflexes. ***The processes construct experience.*** External activity of the child reflects psychological activity of the processes; and the character of the developing processes can be inferred from evidence of external activity. I construct a crudely parallel set of “processes” to produce an artificial objective person’s experience. “Production” is constrained “construction.” That is, I imitate Piaget’s constructive approach, but I modify it, constrain it, e.g., to objective matters, and call it “production.”

8. I set forth my system of processes in the Objective Person Psychological Model, where I apply the foregoing principles and where features of the processes can be identified with supposed thermodynamic processes that are involved in operations of proposed Ideal brains. The theme of the Model is that the processes ***mimic*** or ***imitate*** certain activities of intelligence and that the processes show, in a crude, primal way, how intelligence constructs experience and exercises freedom both physically and psychologically. The developmental approach, borrowed from Piaget, suggests that crude, primal mimicry can be progressively refined.

In the mimicry, it is as if there is an objective person with intelligence, called ***Homunculus***. Homunculus is formally introduced in § 11, “Howdy Doody vs. Mickey Mouse; or, there’s a Real person pulling ***my*** strings.”

In the Model: it is as if Homunculus sustains a purpose; and it is as if, on the basis of the sustained purpose, a repertoire of available acts and an object structure, Homunculus selects material from Reality that Homunculus uses to assemble structures of perceptions, muscular motions and transient intentions; and it is as if Homunculus acts on Reality through the structures, by moving and modifying structural parts; and it is as if Homunculus experiences the consequences of the acts by reason of changes in the structures. It is as if Homunculus uses the processes to generate ***structural elements*** that constitute the experience of Homunculus; as if Homunculus uses the processes to build structures out of the structural elements and as if Homunculus “puts things together” provisionally or conjectures. It is as if Homunculus uses the processes to search the structures for particular structural elements; as if Homunculus recalls previous experience on the basis of particular information; as if Homunculus uses the processes to modify the structures, e.g., by replacing one assembly with another, and as if Homunculus learns or cogitates. It is as if the structures constituted forms of experience for Homunculus and as if the structures are the means for Homunculus to engage Reality. In these activities, I suggest, Homunculus mimics the activity of a person.

9. The intelligence of Homunculus mimics the intelligence of a person and, Homunculus serves as a mirror, however prone to distortion, for insight into activity of intelligence of a person that cannot be directly seen. Accordingly, on the basis of the activity of Homunculus, I draw certain conclusions about activity of human intelligence. These conclusions have been

folded back into the design of Homunculus so I propose that ***Homunculus is a marionette of human intelligence*** engaging Reality as to objective matters.

10. The marionette produces ***structures***. The structures are not inherent in Reality but are produced by the marionette through engagements with Reality. ***Structure is an artifact***. This is a central tenet. I hold that "structure is not inherent in Reality" and that there are no "structures of reality," notwithstanding and contrary to the conventional scientific view about some "mathematical scheme that governs the universe." (Prof. Penrose, § 1, above.)

I hold that "structure" is generated by activity of intelligence and I hold that structure is introduced into images of Reality by our intelligence that constructs those images. The nature and form of structure is artifactual. When we structure matters that are, in Reality not inherently structured, we sometimes make errors. And often, the structures incorporate distortions. Structures incorporate defects into experiences.

Even when it suffers from defects, an artifact, such as structure, is often useful and makes things better than what would be available without the artifact. I enthusiastically affirm that, under many circumstances, structure is a "good" artifact and that we have made some wonderful uses of structures. Invented structures, both conceptually and in Reality, are essential to civilization. Science and technology are ***some of the best artifacts*** we have. Artistic artifacts are often equally excellent. Whatever their problems, structures are what we have and we are properly grateful to those who have developed them, however artifactual and even defective they may be.

In this Introduction, I chiefly concentrate on one concept that I hold is an ***artifact*** notwithstanding that, in the conventional view, that concept is Real. "***Energy*** is inherent in all matter." (Emphasis added, from Faires, *Thermodynamics* (6th ed. 1978), discussed below.) I hold to the contrary and contend that Energy is an artificial concept that fails to engage Reality as to just that subject matter that is most important here: nonequilibrium (=irreversible) phase transitions in brains. Where Energy fails to engage Reality, mechanics loses capacity for productive use. Thermodynamics can be useful here. An eminent spokesman for the conventional view said: "When knowledge is weak and the situation is complicated, thermodynamic relations are really the most powerful. When the situation is very simple and a theoretical [mechanical] analysis can be made, then it is better to try to get more information from theoretical analysis." R. P. Feynman, R. B. Leighton, M. Sands, *The Feynman Lectures on Physics, Vol. I* (1963) at p. 45-7.

"Structure is an artifact" is also a central tenet because it provides the basis for my ***action plan***. If structure is "inherent in Reality," then I have to understand Reality to mimic structural processes and understanding Reality is beyond my capacities. If structure is something we human beings construct as part of our common concepts, then maybe I can mimic that activity using Homunculus.

11. I hold that we ***project*** our structures onto Reality both conceptually, seeing structures as existing in Reality, and also through action, building structures into and out of Reality. Often

such projections are successful: we get a good practical grasp of Reality through use of the structures and we can use the structures for practical purposes such as shelter, transportation, communication and trade.

12. We experience Reality only indirectly, through the structures we generate, assemble and project. As a consequence of the projections, we tend to confuse our structures with Reality. Concepts of "absolute" space and time are examples thoroughly explored both psychology, e.g., Piaget & Inhelder, *The Child's Conception of Space* (1948) and in the literature of Einstein's Relativity Theories (which show that absolute concepts are erroneous).

We project feelings into artificial personalities created by actors. We respond "as if" the situations imaged in television dramas and on movie screens involved real personalities.

I suggest that confusions between structures devised by intelligence and Reality are going on everywhere all the time and that such confusions are one way we stitch our lives into Reality, including the Reality of other persons. The confusions are tools we use. Artificial conceptual constructions like computers and the Internet that are used "the same" by everyone, at least as far as anyone can discern, are ideally objective and identify something reliably in Reality. They even become stronger points of attachment to Reality than those naturally existing prior to conscious construction. Other examples of artificial conceptual constructions that are ideally objective, or nearly so, are clocks, television receivers, license plates and dollars. An important addition here is engines, especially Heat Engines and, perhaps, Structural Engines.

13. As a metaphor, compare the activity of intelligence engaging Reality and generating experiences to the activity of a photographer capturing an image on film. Because of limitations in cameras, a photographic image is subject to distortions – e.g., spherical aberration – and some distortions are given picturesque names like "barrel" or "pincushion." Under some circumstances, e.g., the sun shining from a particular angle, artifacts may appear in the image, like a spot of bright yellow that obscures a face. A photographer deals in various ways with the distortions, artifacts, errors and limitations, e.g., by sharing practical knowledge with other professionals and by using cameras with cleverly designed lenses.

It is possible for a photographer to state some "rules of thumb," such as, to take an ***ideal photograph***: (1) choose a subject that is perfectly stationary, that is compact, that contrasts with the background and that occupies about 60% of the area of the image; (2) center the subject in the image space; (3) photograph the subject from a distance (and with sufficient depth of field) so that the entire subject is sharply focused in the image; and (4) use a lens aperture as small as possible consistent with the lighting and a suitable shutter speed. It is also possible to state a coarse, general principle: to the extent these rules are violated, the quality of the photograph will suffer.

In photography, the "rules of thumb" for an ideal photograph serve to minimize the adverse consequences of limitations of cameras and to reduce defects in photographs. I suggest that similar principles apply to the activities of brain generating experiences. Limitations of intelligence generate defects in experience but there are circumstances and subject matters where the defects are minimal. Conversely, identification of such circumstances and subject matters can minimize adverse consequences of the limitations. Such facts and circumstances, if identified, define matters where an ***Ideal*** can be employed.

14. In science, intelligence selects and deals with matters that are most suited to successful activity of intelligence and where adverse consequences of the limitations are reduced to a minimum over entire domains. In mathematics, I suggest, intelligence constructs an ***ideal world*** where activity of intelligence, although subject to the limitations, would have ***no adverse consequences*** from the limitations whatsoever, or, at least, where adverse consequences would be attenuated almost to a nullity. By comparing the ideal objects of mathematics with objects in Reality it is possible to further illustrate and elucidate the limitations of intelligence. E.g., mathematical objects are eternal but real objects have a transient existence; and the difference is attributed to the ideal success of the process of stabilization in engaging matters in the imagined world constructed of and for mathematical objects. It is also noteworthy that the world constructed of and for mathematical objects is entirely objective. If intelligence for this purpose is defined as the capacity to follow mathematical argument, there is a presumption among mathematicians that all intelligent persons must agree about the existence or non-existence of mathematical objects and this presumption holds good in the discipline of mathematics. Even when there is an open question about the existence or non-existence of some mathematical object, e.g., an object supposed by "Somebody's Conjecture," the existence or non-existence is supposed to be definite even if not presently known.

15. It is factual that there exist aspects of Reality that can be identified with mathematical structures, e.g., Einstein's General Theory of space-time-mass-gravity. Such aspects are marked by the factors that measure successful application of intelligence. E.g., Einstein's Theory in its essentials applies to a space void of activity of matter other than particulate motion. Later formulations may "add" influences but the "void" context is always in the background. Successful identification of aspects of Reality with particular mathematical formulations does not prove that a comprehensive identification has been constructed, or that widely general identifications are somehow to be presumed.

16. Examination of subject matters studied by physics shows that there are subject matters where attempts at mathematical formulation have failed completely, or nearly so. Focusing in, there are classes of physical phenomena where attempts at such formulation have consistently failed and where there appears to be ***something in the nature of activity of physical matter itself*** that is responsible for the failure. One example is turbulence, where models are qualitatively erroneous and where complexity of the calculations increases so rapidly that meaningful application of formulations is all but impossible. A subject matter more important here is the physics of the ***thermodynamic critical state***. I suggest that there is activity of physical matter that our limited intelligence cannot organize into a structure no matter how we might try. I suggest that such activity is going on in our brains.

We are, however, able to grab onto the edges of some of that activity, perhaps even able to set some hooks. Physicists have obtained knowledge about the thermodynamic critical state even while sharpening our appreciation of the unique nature of this form of activity of physical matter and of its mathematically intractable nature. In these Researches, I seek to grab onto the edge of freedom.

17. ***The thermodynamic critical state*** is a well-defined state of physical matter reproducibly studied in the laboratory. Physical matter in the thermodynamic critical state is ***unstructurable***; that is, inside the material, there is nothing stable and no identifiable features appear ***or can appear***. The critical state is found in so many different kinds of physical matter that physicists use the word ***universal*** to describe it, meaning that many different and diverse systems all display "the same" behavior.

Notwithstanding many difficulties, during the 1960's and 1970's, physicists achieved substantial if limited success in describing some of the underlying physical governance of the thermodynamic critical state and in formulating descriptive mathematics. The universality is shown to result from activity of matter that is stated in general terms common to broad classes. The mathematics also shows why the problem was so long completely intractable (insoluble), why any generalization of the limited success is fraught with error and why any application to another situation will require clever ingenuity directed at the particular problem.

I previously examined the thermodynamic critical state in "A Patchwork Of Limits: physics viewed from an indirect approach" (2000), available on the website. Below, I reproduce a statement at pages 26-27 of that paper that sets forth essential facts of physics about the thermodynamic critical state with minor editing but without the citations to authority.

The first definite study of "the critical state," published by Andrews in 1869, showed that several fluid substances exhibited similar phenomena when subjected to a temperature and a pressure sharply defined for each substance (the "critical point"): the separation of the substance into liquid and gas phases abruptly disappears and light passing through a substance normally transparent is strongly scattered, a dramatic phenomenon called ***critical opalescence***. For example, carbon dioxide, the substance most easily studied, becomes critical at 304.13 °K (near room temperature) and 7.375 atmospheres pressures. Corresponding behaviors were later observed among broad classes of systems including apparently all liquid-gas systems, magnets, alloys, polymers, liquid crystals, gels and foams, giving rise to the term "universality."

It is possible to account for critical state behavior by general notions that are independent of the details of the system under consideration. Each particle in a system interacts directly with its nearest neighbors and indirectly with other particles more distant. Thus, the motions of any two particles are correlated through multiple pathways. The correlation between two particles along each of the interaction paths that connect them ***decreases*** exponentially with the length of the path. On the other hand, the number of such interaction paths ***increases*** exponentially with distance between the two particles. At the critical point, the two effects exactly balance, and the influence of each particle extends throughout the system strongly affecting every other particle. A slight disturbance at each point will affect each other point and reciprocally. Thus, a system at the critical point is characterized by ***correlations of infinite range***. Away from the critical point there is no balance. With less energy, correlations exist but the range is finite and structures can be sustained. With more energy, no structures can be sustained and correlations become increasingly inconsequential. (For purposes here, consider substituting "neuron" for "particle" in the preceding paragraph.)

A number of unique conditions occur at the critical point. At the critical point, the substance cannot be in thermodynamic equilibrium because certain thermodynamic quantities are exactly zero and for stable states, these quantities must be less than zero. Because of correlations that extend indefinitely without diminution, fluctuations grow anomalously and both the amplitude of deviations and the size of the density-correlated domains in space increases without limit. The asymptotic behavior of some physical quantities is nonanalytic. Basic response functions such as compressibility and specific heat capacity become indefinitely large, i.e. approach infinity. Thermal perturbations do not relax for many hours or even days. Hence, it is impossible to apply principles of "atomic thermal physics" (kinetic theory) which require that the time needed to measure a thermodynamical observable must be large compared with relaxation times for macroscopic variables of the system.

18. I suggest that there are two related ***spans***: (1) a ***span*** of activity of physical matter that stretches between fully simplified activity of matter studied in elementary physics (e.g., an ideal gas) at one end and activity of matter in the critical state at the other end; and (2) a ***span*** of activity of intelligence that stretches between activity of intelligence acting mechanically at one end and activity of intelligence exercising freedom at the other end. I use the word ***antipodal*** to describe the relationship between the two ends of any such span. In such a span, factors describe variations; the factors are graded between extremes; and the extremes of the factors are collected at ends. In its span, the critical state is antipodal to an ideal gas. Similarly, freedom is antipodal to mechanism.

19. I am suggesting that the two spans are coterminous at one end and that ***psychological activity of intelligence exercising freedom is "the same" as activity of physical matter in brains involved in Neuronal Critical State activity***.

I propose a definition of an Ideal Neuronal Critical State that is based on the properties of the thermodynamic critical state but extended into the more complex activity of brains. I suggest that the Ideal Neuronal Critical State is what unites psychological activity and activity of physical matter. Unfortunately, I can approach this unity only in a contraptional way; and here the means of exploration is a Structural Engine. Notwithstanding my ineptitude, I suggest that ***there actually exists a coterminous antipodes in Reality*** and that activity of intelligence exercising freedom and physical activity of brains – the activity of neurons participating in a Neuronal Critical State activity – is actually happening at the antipodes and is "the same" activity. (Might be called an "identity theory" if contraptions are allowed.)

20. That phenomena are antipodal does not foreclose all investigation, but investigations

must be carried out indirectly – the limited successes in physics were achieved by clever, indirect techniques – and the difficulties are multiplied. Faced with such difficulties, I use multiple approaches (Structural Engine, Structons, Objective Person Psychology), I am interested in development more than truth and I shamelessly use suppositions about Reality, constructions imputed to intelligence, speculative constraints and anything else that will ***advance the plan***.

Part II: Construction

§ 5 Ideals and virtual concepts: novel methods of conceptual construction

Part I considered the Question of Freedom: each of us exercises freedom when making choices and when acting on the choices during daily activity; but the conventional scientific view that claims comprehensive power does not allow for freedom. Examination of ping-pong shows that a ping-pong stroke requires quick coordination of complex structures involving objects, acts and intentions and that we are unable to see "how" such coordination takes place. I suggest that the failure can be traced, at least in part, to limitations in human intelligence and to defects in all our concepts. We use a childish form of concept formation, "juxtaposition," to see "that" freedom is taking place but our fully developed and mature "synthesis" concept formation cannot see "how" freedom is taking place.

Defeated in my attempts to use synthesis concept formation to understand the exercise of freedom at the center of a ping-pong stroke, I devise novel methods of concept formation. I then suggest using the new concepts to construct a Consciousness Contraption based on the alternative scientific view that imitates activity of intelligence engaging Reality.

My novel constructions are adapted from existing models and I use names previously invented: the "Ideal" and "virtual" concepts.

(a)

"Ideals" have a long philosophical history that is of secondary interest here (but see § 11 where there is a discussion of philosophical "Universals"). My use of the word "Ideal" is based on physics, as is my use of the word "virtual." One philosophical passage expresses how my use of the word "Ideal" connects with the nature of physics. Even though the author was directing his argument in a different direction, his penetrating vision and statement provide illumination here:

> "When Galileo caused balls, the weights of which he had himself previously determined, to roll down an inclined plane, when Torricelli made the air carry a weight of which he had calculated beforehand to be equal to that of a definite volume of water; or, in more recent times, when Stahl changed metals into oxides, and oxides back into metal, by withdrawing something and then restoring it,[a] a light broke upon all students of nature. They learned that reason has insight only into that which it produces after a plan of its own, and that it must not allow itself to be kept, as it were, in nature's leading-strings, but must itself show the way with principles of judgment based upon fixed laws, constraining nature to give answer to questions of reason's own determining. Accidental observations, made in obedience to no previously thought-out plan, can never be made to yield a necessary law, which alone reason is concerned to discover. Reason, holding in one hand its principles, according to which alone concordant appearances can be admitted as equivalent to laws, and in the other hand the experiment which it has devised in conformity with these principles, must approach nature in order to be taught by it. It must not, however, do so in the character of a pupil who listens to everything that the teacher chooses to say, but of an appointed judge who compels the witness to answer questions which he has himself formulated. Even physics, therefore, owes the beneficent revolution in its point of view entirely to the happy thought, that while reason must seek in nature, not fictitiously ascribe to it, whatever as not being knowable through reason's own resources has to be learnt, if learnt at all, only from nature, it must adopt as its guide, in so seeking, that which it has itself put into nature. It is thus that the study of nature has entered on the secure path of a science, after having for so many centuries been nothing but a process of merely random groping.
>
> [a] I am not, in my choice of examples, tracing the exact course of the history of the experimental method; we have indeed no very precise knowledge of its first beginnings." I. Kant, *Critique of Pure Reason* (Kemp Smith) at B xiii - xiv. ("B" (1787) was Kant's revision of "A." (1781))

This passage has several points of interest. Kant considers matters that are "not ... knowable through reason's own resources." Some such matters can be "learnt," but the phrase "if learnt at all," suggests that some such matters cannot be learnt. Kant is suggesting the existence of matters that are "real and unknowable" (see discussion above, § 4, involving "the blind spot of the mind") and leaving space for such matters in his construction. The suggestion is followed up, as discussed later in this section.

The main thrust of the passage emphasizes the ***intentional and focused activity*** of the scientist who is carrying out the investigation and the ***means used in that activity***. Intentional and focused activity is described in language such as "he had himself previously determined," "it [reason] produces after a plan of its own" and the "judge who compels the witness to answer questions which he himself has formulated."

As to the "means used in the activity," these are "principles based on fixed laws." The "fixed laws," are also the basis for "questions of reason's own determining." Of course, reason must not "fictitiously ascribe" to nature whatever is to be learnt. Rather, knowledge is obtained "only from nature." The knowledge is shaped by what reason "has itself put into nature."

As I read the passage, Kant is saying that although "fixed laws" must be grounded in Reality, the "fixed laws" are constructions of intelligence in both concept formation and application. When engaging in physical science, active intelligence devises such constructions based on experiment but refined for productive purposes. I focus on "fixed laws" that are constructions of intelligence and that take the form of an Ideal.

An Ideal is a ***concept*** to which something real approximates. Factually, it is possible to construct and constrain real somethings so that the approximation is excellent. In practical terms, this is engineering, guided by physics.

Note the reversal from conventional thinking. In conventional thinking, our concepts approximate Reality. From the standpoint of the Ideal, Reality into which we have projected our structures approximates the Ideal concept. That is, we select matters in Reality that approximate the Ideal concept and that's one way we get the Ideal concept to work. Another way is to construct an experiment that targets the Ideal concept. Typically, methods of science isolate phenomena and sharpen investigation into one phenomenon by suppressing others. Such methods of selection and targeting are often quite effective as to particular matters; but claims that the results have comprehensive reach require additional support.

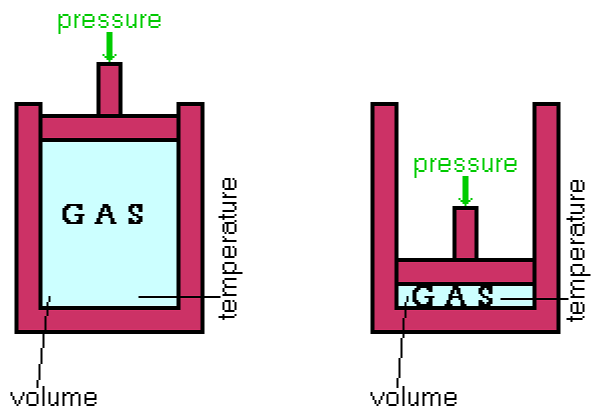
We will see in these Researches how ideals are used. I suggest that we use them all the time, in one form or another, indeed that we use them most productively, only without understanding their nature. The defects incorporated in them do not render them useless, even if they are not as comprehensively useful as we might like. The quality of our lives depends on their utility and their real scope of application. In these Researches, the most important ideal is Energy.

(b)

As an example consider a simple and important ideal: the Ideal Gas, sometimes called the Perfect Gas. I capitalize the names of ideals, such as Reality, the Carnot Heat Engine, Virtual Energy and the Structural Engine. This use of capitals is meant to set ideals apart from concepts that are not ideals. It is not meant to suggest that ideals have some inherent metaphysical status superior to that of other matters. There are ideals that work well and there are ideals that are complete failures. Even ideals that work well may only work well under particular circumstances.

The Perfect Gas is stated by (1) a mathematical formulation and (2) rules for applying that formulation to real phenomena. The formulation is easy to state: $pV = nRT$, where p stands for "pressure," V stands for "volume," T stands for "the temperature," R is number with dimensions and n is a number without dimensions. (The numbers are inconsequential to the discussion and are sometimes omitted or expressed in different forms.)

The rules for application are based on the adjacent image of an Ideal Thermodynamic System. A quantity of a specific gas or gases (e.g., air, steam, oxygen) is confined in a chamber formed by a moveable piston in a cylinder. The fit between the piston and the cylinder is "perfect." There is nothing but the specific gas in the chamber and no chemical reaction or other change in the gas occurs. No gas leaves the chamber and no matter enters the chamber. Any flow of heat through the material that makes up the cylinder and piston is to be stated and is initially presumed to be 0. There are devices to measure the volume, temperature and pressure of the gas.



A "state" of the system is specified in terms of the ***thermodynamic coordinates***: volume, temperature and pressure. The chief constraint on the system is an ***equation of state***, e.g., pV=nRT, or equivalent knowledge that specifies the relationships between the thermodynamic coordinates for a specific material substance, e.g., a Perfect Gas or steam. With an equation of state or equivalent knowledge, knowledge of the volume and temperature suffices to derive (determine or calculate) the pressure ***and, for a successful body of knowledge, the pressure derived from the equation of state is "the same" as the measured pressure***. For example, there are universal Steam Tables that specify the properties of steam, e.g., the energy available for conversion into electricity, at any particular temperature and pressure. There are also formulations that provide approximate values for steam in particular ranges of temperature and pressure.

With an Ideal Thermodynamic System, success in getting "the same" results from the derivation, calculation and/or measurement all being performed at a ***single, particular moment*** (or a short interval of time around a moment) and the result does not depend in any way on the ***history*** of states. Another important constraint is that, if the volume, temperature and/or pressure are changed, it is presumed that measurements are made after the activity in the gas has entered into a "state of equilibrium" in which no further changes take place. More on the "state of equilibrium" in § 6, below. Recall, that in the activity of brains as seen from the alternative scientific view, most important activity is "nonequilibrium" activity, especially "nonequilibrium phase changes." There are never any phase changes with in a Perfect Gas and a Perfect Gas always reaches a state of equilibrium instantaneously after any change of state.

Here's how a standard engineering text describes the Perfect Gas.

"The ideal gas is ideal in that its equation of state pv = RT is so simple that the resultant mathematics is simple, which makes it a fitting substance to learn about... Not only is idealization a practical thing to do in engineering and science, but it also happens that many actual gases behave very nearly as an ideal gas. *All gases approach the ideal gas behavior as pressure decreases*... Hence, we think of a gas at 'low' pressure as acting as an ideal gas, but 'low' must be interpreted in terms of the substance... Since there is no distinct line of demarcation for an actual gas between states where it acts 'ideally' and where it does not, the engineer must often make a decision based on his experience and know-how. *If the ideal-gas laws yield sufficiently accurate results for the purpose, the substance is considered as an ideal or perfect gas; otherwise it is a nonideal or imperfect gas.* At this state the reader accepts the judgment of his test; in practice, an enormous number of engineering problems can be satisfactorily solved with the ideal-gas constraint if realistic values of specific heats are used." (V. Faires, *Thermodynamics* (6th ed. rev. by C. Simmang 1978) at 143, emphasis in original.)

A standard physics text states: "The *ideal gas* is an important idealized thermodynamic system. Experimentally all gases behave in a universal way when they are sufficiently dilute. The ideal gas is an idealization of this limiting behavior." K. Huang, *Statistical Mechanics* (1963) at 5.

Although ideals are constructs of intelligence, they attach to Reality and may even attach to Reality in structured ways. The Ideal or Perfect Gas was historically one of the first planks in the structure of modern science and remains near the top of important concepts today. In physics, the Ideal Heat Engine (Carnot Heat Engine) uses an Ideal Gas to construct Energy. I hold that Energy is an Ideal. In addition to these Ideals, there is the Ideal Thermodynamic Critical State that has been more recently explored in mathematics and that is of central importance in these Researches. I further hold that the conventional construction of Energy is problematic when matter is involved in nonequilibrium phase changes, e.g., because conventional Energy strictly requires a continuous succession of states in equilibrium and during nonequilibrium phase changes, the matter is never in equilibrium and there is fast, large-scale activity.

Next, I construct a span and spectrum for substances where a substance can be put into an Ideal "Perfect Gas" condition in one experiment and then the same substance can be put into a Ideal "Critical State" condition in another experiment. Recall notions of span and spectrum from § 4, articles 3 and 4. There are an enormous number of substances that can be put into both ideal conditions (at different times in different experiments), including water and all (or nearly all) substances that we know as gases. It is possible to conceive of an experiment where a single quantity of substance in a chamber is continuously varied from Perfect Gas behavior to Critical State behavior. Call such a substance a "full range substance" and call the collection of all states of the substance the "range of the substance." That is, the substance can be put into any state in its range and the range includes both Perfect Gas behavior and Critical State behavior. The Ideals define the antipodal states.

Physicists use an atomic model to construct a quantity called the "correlation length" (introduced above in § 4, ¶ 17). Supposing a correlation length can be assigned to each state in a succession of states (making up a "path") that starts with the material acting like a Perfect Gas and ends up at the Critical State, the result is a function that assigns to each such state of the substance a number between 0 and ∞. The number is 0 when the substance is in a Perfect Gas condition and the number is ∞ when the substance is in the Critical State. Presumably the number is greater than 0 and less than ∞ when the substance is in some state other than the Perfect Gas condition or the Critical State. My initial examination of the formulation for correlation length suggests that it is reasonable to think of correlation length as subject to ***continuous*** variation through appropriate thermodynamic processes. That is, I suppose (for convenience in thinking) that, for any number between 0 and ∞, it is possible to find a path made up of a succession of states and a state in that path such that, if the system is put into that state, the correlation length will be specified by desired number; moreove, there is a path connecting that state to both the Perfect Gas state and the Critical Gas state.

Continuing with the same line of suggestion, it would appear that, for each correlation length, there is a corresponding ***relaxation time***. That is, there is another function that assigns to each state in the path another number, called the relaxation time, that varies between 0 and ∞. Roughly, relaxation time measures how long it will take a system, once disturbed, to enter into the "state of equilibrium" introduced above. When a substance is in the Perfect Gas state, the relaxation time is 0 and the substance relaxes instantly from any disturbance. When a substance is in the Critical State, the relaxation time is ∞: the substance ***never*** enters into an "state of equilibrium."

The structure based on the Perfect Gas Law attaches to Reality in multiple ways. Likewise, the structure based on the Critical State attaches to Reality in multiple ways. Such attachments establish the validity of each of the Ideal States. Unfortunately, as set forth in *A Patchwork of Limits* (available in the online Archive), there appears to be "no way" to bring both Ideal States within a single theory. In that paper, I attribute this shortcoming to limitations of intelligence.

(c)

In addition to Ideals, I use a novel method I call ***virtual concept formation***. Concepts formed by virtual concept formation are ***virtual concepts***. Concepts that are formed by juxtaposition or synthesis are called ***real concepts*** because they are concepts that people really form and use.

A virtual concept is artificial and can include matters that have no attachment to Reality other than to serve some contraptional purpose. Some virtual concepts ***mimic*** or ***imitate*** real concepts and some virtual concepts ***extend*** real concepts. Imitation is "the same" in some respects but not in others. Virtual concepts are made for variation and modification.

Ping-pong illustrates construction of a virtual concept. Construction commences with an ***empty conceptual container*** to be named "virtual ping-pong stroke" and to receive contents placed therein.

The notion of "an empty conceptual container" has numerous originators, but I take the statement from a legal treatise, Gilmore & Black, *The Law of Admiralty* (2d ed. 1975), § 10-20.

The background of law is simple. Over many decades, the United States Congress enacted and the President signed bills that, in the aggregate, are called the Limitation Act. Included in the Act are two key phrases, "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 ("take the wreck, I'm through") – ***unless*** his involvement in the catastrophe was characterized by "privity or knowledge" or "design or neglect" and, if so, then there is ***no*** limitation and ***no*** exoneration. The first such rules were established when seafaring was routinely hazardous and meant that a shipowner was secure from claims if he attended to matters involving the ship in the ordinary course of business. The ***empty containers form*** of the enacted laws ("statutes") is clearly identified by the authors of the Admiralty treatise, 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 seem 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 toward what constitutes "privity or knowledge," "design or neglect." ***The Act, like an accordion, can be stretched or narrowed at will***.

Without minimizing their point (I seize upon their point), Gilmore and Black are a bit overenthusiastic. There are external or political limits to judicial activism and there is a limit also to the extent to which concepts can be stretched. A ***real*** core of meaning exists as to each concept used in the Limitation Act and the real core of meaning must not be disregarded. "Privity" is an established concept in juridical law indicating a "close relationship" and subject to further definition in particular circumstances, such as privity between contracting parties or privity of estate characterizing right-to-land relationships, e.g., landlord-tenant. All of the other terms in the Act – "knowledge," "design," "neglect" – have ordinary-life foundations. A real core of meaning in each term attaches to something in Reality and, in my view, should always remain centrally attached to Reality. There is some acknowledgement of this by the authors, but indirectly, in their reference to "successive generations."

In my use of the device, an empty container construction is not detached from Reality but is constructed to hold real contents. In my empty container constructions, I put ***all*** known real contents involving a concept into the container. That is, any concepts formed by juxtaposition ***or*** by synthesis are included. Complex structures formed by synthesis are highly prized but I also include images crudely constructed through juxtaposition and without assuming that relations will be filled in.

In ping-pong, I construct a virtual concept called "the virtual ping-pong stroke." I start off with an empty container and then I put into the container, that holds the virtual stroke concept, all the previous facts stated about a representative ping-pong stroke.

So far the contents of the virtual ping-pong stroke are not substantially different from those of the representative ping-pong stroke – it's just that the containers are different. Next, I construct differences in content.

In talking about the representative ping-pong stroke, I am talking about a concept grounded in the facts of actual ping-pong strokes and I cannot detach the concept from those facts. No such constraint limits what I can do with virtual ping-pong strokes. I can and do ***reconstruct*** virtual ping-pong strokes and define ***new*** rules for use of the concept of virtual ping-pong strokes that are different from the rules for use of the corresponding real concept. Of course, I expressly state and justify or, at least, constrain each part of any such reconstruction.

Virtual concepts have uses different from real concepts. When using a real concept to engage a matter in Reality, I presume that objects are specified by their attachments to the Reality of the matter and I presume that relations involving the objects can be ascertained through synthesis concept formation. Using real concepts, I maintain these presumptions even when I don't know the structure of relations – or, I may see my task as figuring out such a structure like a scientist or as seeing that Reality should be made to incorporate some desired structure like a lawyer asking the judge to incorporate a proposed rule of law in a decision. When using a virtual concept, I do not make such presumptions. As to stuff that consists of only juxtapositions, I don't presume that some sort of relationships are going to supersede juxtapositions. Maybe I can't do better than a concept formed by juxtaposition. Alternatively, I consider myself free to imagine that there is some other way for stuff to be organized, like a Structural Engine. In furtherance of my plan, I apply the notion of Structural Engine to the virtual ping-pong stroke just by reason of such construction directed toward that end. Whether such construction successfully models anything substantial in Reality is a different question and a most important question for the reader to answer when rendering judgment on the *Researches*. Virtual concept formation enables that judgment to be rendered in a useful way, e.g., as part of a class of such judgments that can be reconstructed into a spectrum.

As a final, important feature of virtual concepts, some virtual concepts have ***secret compartments***. A secret compartment in a virtual concept is a space set aside in the once-empty container for matters that are both ***real*** and ***unknowable*** as discussed in § 4. I suppose that such real and unknowable matters are involved in many activities. In the secret compartment of the virtual ping-pong stroke, I suppose, could be found the knowledge of "how" a person produces ping-pong strokes were such knowledge obtainable. Likewise, I suppose that the secret compartment contains knowledge about the exercise of freedom involved in a ping-pong stroke. One important virtual concept in these Researches is Virtual Energy, an Ideal that is based on quantities defined in physics but with an additional secret compartment that I suppose could be used to explain activity of brains if only we had access to it. Another important virtual concept is the Neuronal Critical State, an ideal where the secret compartment contains a description of the activity of Consciousness that is known to a person through personal, incommunicable experience. In the Structural Engine, the secret compartment is the Domain of Consciousness. In § 11, speculating licentiously (see below), I suggest that all the secret compartments are interconnected and that, in the aggregate, there might be a dwelling suitable for the person whom I call Homunculus, the Ideal Objective Person.

A secret compartment does not mean "anything can go in." *Au contraire*, selecting what goes into a secret compartment is of pivotal importance. I am quite selective about what goes into secret compartments I construct and I have a decided preference for ***constraints***. In this Model, the more constraints, the more freedom. The development of "classical music" in Western Europe since the year 1600 (c. Monteverdi) illustrates the value of constraints and what happens when the constraints wear out. In constructing secret compartments, I am also selective about what is left out. I leave ***out of*** the secret compartment matters that I hope to understand ***by means of*** the secret compartment.

The existence of a secret compartment in a concept presents questions about proper handling. Strictly, the unknowability of matters in the secret compartment precludes any attempt to discuss or describe them. The use of a secret compartment thereby seems to impose some rule of silence about matters supposedly within the secret compartment, a kind of rule I call ***abstinence***. The rule of ***strict abstinence*** completely precludes discussion about the contents of a secret compartment in a virtual concept.

Once the rule of abstinence is recognized, however, the way is open to relaxing it. "Discussion" is ok as long as there is no claim of a "valid basis." I hereby affirm that there is not and cannot be a valid basis for discussion about matters presumptively unknowable. Hence, any discussion about matters in a secret compartment is without a valid basis. But a discussion may have purposes other than to prove that certain statements have a valid basis. See, e.g., § 11 ("There's a real person pulling ***my*** strings"). Hence, with notice thereof, I indulge in ***licentious abstinence***. I carefully note that there is no valid basis for my speculations and I then set forth my speculations.

It may seem strange to include a secret compartment in a concept. This was, however, the invention of Kant, who called his by the name "noumenon" and discussed it in detail in his *Critique of Pure Reason*, quoted above in subsection (a). See esp. B306-B311 concluding with: "The concept of a noumenon is thus merely a *limiting concept*, the function of which is to curb the pretensions of sensibility; and it is therefore only of negative employment. At the same time it is no arbitrary invention; it is bound up with the limitation of sensibility, though it cannot affirm anything positive beyond the field of sensibility." "Sensibility" is the name Kant gave to the faculty that enables us to perceive appearances of objects. See B29-30 and B61-62.

My use of secret compartments in virtual concepts is different from Kant's noumenon in significant ways. Kant apparently saw his noumenon as a repository for grandly comprehensive truths like those included in his *synthetic a priori*, which are mathematical truths and, as the chief matter, Newton's Mechanics, which Kant believed to be "real, certain, indubitable, and demonstrable knowledge–divine *scientia* or *epistēmē*, and not merely *doxa*, human opinion." Karl R. Popper, "The Nature of Philosophical Problems and Their Roots in Science," in *Conjectures and Refutations* (1962). Disbelieving as I do that I can obtain "real, certain, indubitable and demonstrable knowledge" while still believing in a Reality about which a superior intelligence could obtain such knowledge, I must follow a different path. What's going on in the secret compartments of these Researches are ***personal activities***, e.g., producing ping-pong strokes.

My secret compartments are more modest than Kant's noumenon in some ways but my aims are more ambitious in a practical way. Something is going on in that secret compartment that produces ping-pong strokes; and I aim, if not to find out exactly what is going on, then at least to imitate some of the action.

My secret compartments are designed for uses that Kant would not countenance for his noumenon. Mine are avowed "inventions" although constrained and therefore far from "arbitrary." I ***activate*** the secret compartment and turn the virtual concept into a Structural Engine.

§ 6 An alternative view of physics: Energy is <u>not</u> real, but only Ideal

Energy is a most important concept in physics and the challenge I state in the title of this section may at first appear bizarre if not outrageous or ridiculous. But my challenge is nothing more than a reconstruction of facts universally recognized by physicists. The differences between the conventional view and the alternative view are, above all, a matter of stance and interpretation. The revised interpretation of energy is combined with facts about nonequilibrium phase changes discussed in § 7 to show defects in the conventional view as applied to activity of physical matter in brains and to suggest an alternative.

In this section I propose to show the following:

1. Energy is a ***constructed*** concept.

2. The principles of construction require that, for the concept of energy to apply exactly to a body of physical matter, the body must be in a particular condition, namely a condition of ***equilibrium***.

3. Although the concept of energy can be used when conditions diverge from

equilibrium conditions, the application is no longer exact. The errors grow larger as conditions diverge further from equilibrium.

4. Analysis beyond the scope of this report suggests that conditions under which the concept of energy is supported with exactitude can be described as ***equilibrating***. In simple terms, when conditions are equilibrating, the system maintains activity that is stable in a general sense, e.g., including steady-state flows and repetitive motion. (The word "equilibrating" is borrowed from Piaget who used it as a large-scale concept in psychological analysis in, e.g., *Biology and Knowledge: An Essay on the Relations between Organic Regulations and Cognitive Processes* (1967, English transl. 1971).)

5. The concept of energy cannot be meaningfully applied to a body in a critical state because, in the critical state, equilibrating conditions are not present. It is important to note that equilibrating conditions are ***just barely*** not present. A tiny bit "less energy" means that the body is not in the critical state and the energy concept would then apply. Hence, for many purposes the concept of energy "might as well" apply to a body in the critical state. I am only suggesting that for ***some*** important phenomena, the energy concept does not apply as constructed. I am suggesting that among such important phenomena are Neuronal Critical State activity and nonequilibrium phase changes in brains. Using a mathematics terminology, critical state activity is singular and processes that approach such activity by different paths may not be convergent.

I am fortunate in having a superb presentation of the conventional scientific view provided by Richard P. Feynman in *The Feynman Lectures on Physics, Volume I* (1963). Feynman's high eminence in theoretical physics turned into popular fame and even celebrity because of his stellar skills in public presentation. *The Feynman Lectures, Vol. I* were based on an introductory physics course given to first year students at the California Institute of Technology but their elegance, depth and clarity qualify them as classics for many kinds of readers.

Feynman's status as a spokesman for the conventional view is established by the following statements in §§ 1-2 and 2-1 of the *Lectures* (emphases in the original texts) where Feynman asserts "the *atomic hypothesis* (or the atomic *fact*, or whatever you wish to call it) that *all things are made of atoms–little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another*." "[T]he real particles in nature are continually jiggling and bouncing, turning and twisting around one another." "Now the jiggling motion is what we represent as *heat*: when we increase the temperature, we increase the motion." Mechanics describes the motions of particles so that: "When atoms are in motion, the more motion, the more heat the system contains, and so *heat and all temperature effects can be represented by the laws of mechanics*."

As we shall see, "represent" and "represented" are lawyer-like words, artfully selected; and correctly selected because "representation" in terms of "energy" has problems needing such arts.

In Chapter 4 of *The Lectures*, "Conservation of Energy," Feynman starts the construction of the energy concept, which proceeds afterwards piece by piece. First, there is mechanical energy carried by a moving particle, or ***kinetic energy***. The kinetic energy of a particle is calculated by multiplying the mass of the particle by the square of the speed and dividing by 2, or K.E. = $\frac{1}{2}mv^2$. As long as the velocity of the particle is constant, the kinetic energy is constant or "conserved." According to Newton, this will occur if there is no external force acting on the particle.

There are systems where it is possible to define a "potential energy" such that, at any moment, the potential energy and the kinetic energy add up to fixed number. Then energy supposedly "trades off" or "converts" between kinetic energy and potential energy. "Conversion" between forms of energy is what energy is all about. The system of "kinetic energy plus potential energy is constant" works great for gravity. If you throw a ball up in the air, the kinetic energy "turns into" potential energy on the way up and then the potential energy "turns back" into kinetic energy on the way down. For a system governed solely by gravity, energy is an exact measure.

Kinetic energy and potential energy are the stuff of "classical mechanics." but the word "energy" was not used until 1807. The concept of energy in mechanics began with G. Leibniz (1646-1716), who identified what later became kinetic energy as "the *vis viva* or 'living force' to distinguish it from the *vis mortua*, the 'dead' or static force of equilibrium ... Leibniz maintained that moving bodies had *vis viva*, whereas bodies at rest that were raised or stretched had *potentia* or 'potential force' in that they could bring about further action or change." E. Hecht, "An Historico-Critical Account of Potential Energy: Is *PE* Really Real?" **41** The Physics Teacher 486 (2003) available at http://link.aip.org/link/?PHTEAH/41/486/1

In mechanics, nearly all systems are ***constructed as inherently conservative systems*** where conservation of energy is part of the statement of system. An investigation into what happens in other systems, e.g., where there are "electromagnetic forces between moving particles," can lead into a thicket of "nonholonomic" constraints where "[t]he potential of the forces of constraint will thus vary in time and it is then important whether or not the 'total energy' in question includes the contribution of the forces of constraint." Goldstein, *Classical Mechanics* (1950) at 4, 10-14 and 54-55. In other words, under the "wrong conditions," mathematical methods supposedly clear and definite disappear into a cloud of qualifications, limitations and unstatable specifications. Such disappearance often happens in physics and especially in studies of the critical state.

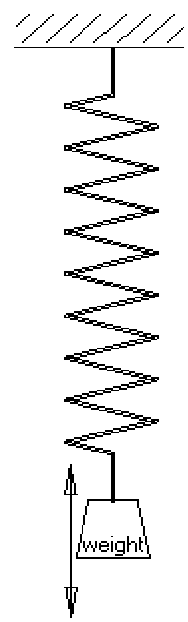
Feynman himself, characteristically exact and expressive, states facts about energy that show some of the problems. In the following passage from *The Feynman Lectures*, notice that Feynman has a "dream." This "dream," which I call ***Feynman's dream***, is the dream that a system of physics founded on "the atomic *fact*" will comprehend all activity of physical matter. This is a physicist's dream, like that set forth in S. Weinberg, *Dreams of a Final Theory*: *The Scientist's Search for the Ultimate Laws of Nature* (1992).

Feynman relies on some unspecified or vaguely indicated knowledge to satisfy himself that his "dream" is a true dream. We will be investigating this knowledge as explained by Feynman and

I suggest that there are reasons for dissatisfaction with this knowledge. There are some reasons stated by Feynman and there are some reasons that Feynman does not state. The reasons for dissatisfaction Feynman states in the parentheses at the end of the following passage are especially important. Notice that "we cannot really demonstrate conservation of energy" and how "reversible machines" sneak in. "Reversible machines" operate under equilibrium (or, more exactly, equilibrated) conditions. I suggest that the "because" in "because every time" points to the shortfall in the Ideal of Energy that prevents application of simple energy concepts when dealing with activity of brains. Hence, I construct an alternative energy concept.

In the passage, Feynman talks about motion of a weight on a spring. If the weight is pulled down and released, it will first move up, pulled by the spring, and, while moving, possesses kinetic energy. There then develops an up and down motion presumably with trading off between kinetic energy and potential energy. After a time, however, the motion fades away until the weight is apparently still. Feynman asks rhetorically, how could this situation be consistent with conservation of energy? Feynman then answers the question he has posed.

"Inside a spring ... there are crystals which are made up of lots of atoms, and ... there is bumping and jiggling because of irregularities of the material, and the atoms start to wiggle inside. So we lose track of that energy; we find the atoms are wiggling inside in a random and confused manner after the motion slows down. There is still kinetic energy, all right, but it is not associated with visible motion. What a dream! How do we *know* there is still kinetic energy? It turns out that with thermometers you can find, in fact, the spring ... is *warmer*, and that there is really an increase of kinetic energy by a definite amount. We call this form of energy *heat energy*, but we know that it is not really a new form, it is just kinetic energy–internal motion. (One of the difficulties with all these experiments with matter that we do on a large scale is that we cannot really demonstrate the conservation of energy and we cannot really make our reversible machines, because every time we move a large clump of stuff, the atoms do not remain absolutely undisturbed, and so a certain amount of random motion goes into the atomic system. We cannot see it, but we can measure it with thermometers, etc.)" Page 4-6 (emphasis in original).



On the next page, Feynman says further: "In the last analysis, we do not understand the conservation laws deeply. We do not understand the conservation of energy. ... So we do not understand this energy as counting something at the moment, but just as a mathematical quantity, which is an abstract and rather peculiar circumstance."

In the principal passage, Feynman first says that "we lose track of that energy" but later that we can "count" energy "as a mathematical quantity." What is happening during the time "we lose track of that energy"? What does it mean to get back on track of that energy and what has happened to the energy in the meantime?

For example, there is a concept called ***waste heat*** that is used to make the energy "count" come out exact. Energy is never obtained without a source but, according to the energy concept, some energy will "disappear" if perfect constraints are not in place. "Waste heat" is where energy disappears to. R. L. Hills, *Power from Steam, A history of the stationary steam engine* (1989) states at 7: "It is a fundamental principle in nature that energy, though it may be made to assume different forms, cannot be destroyed but the sum total remains the same. Hence the heat which is carried into the engine in the steam is either transformed into useful work, such as turning the spindles, or it passes to waste in various forms, such as heating the enginehouse. The sum of the heat usefully employed by being converted into work such as spinning plus the heat which is wasted always equals exactly the heat which was applied."

From the perspective of the alternative view, waste heat is an "empty container" concept that has been defined so as to make the concept of energy appear exactly applicable even when application cannot be made at all. That is what Feynman is doing in the passage quoted above when he says "it turns out." Feynman is satisfied with this conceptual construction because, as a practical matter, it advances the realization of Feynman's dream.

In the conventional view, constraints are imposed on activity of matter but all that these constraints do is to make it possible to ***measure*** energy that is supposedly inherent in matter. In the alternative view, "energy" is **<u>not</u>** inherent in matter but is only an ideal, constructed concept that I call Energy. The constraints define ***foundational conditions*** that must be satisfied before the concept of Energy can be applied. The concept of Energy can attach to the Reality of a matter that is being investigated only when sufficient constraints are in place. That is, when sufficient constraints are in place, energy provides a reliable "representation" (quoting Feynman's word) of activity of matter and there is an "energy" formulation that can be attached to matter in physical Reality and provide useful results.

This is not a bad situation, rather it is very good even if limited. Because a Carnot Heat Engine is "perfectly constrained for purposes of energy," energy can be based thereon. To the extent a real engine approximates a Carnot Heat Engine, the energy concept can be applied with assurance. However, under other circumstances, such as those that occur in steelmaking (§ 7, "we ***cook up*** our experiences") the validity of simple energy concepts is highly doubtful and is, in any event, not useful for investigating important phenomena. Rather, a constructed energy concept (called "Gibbs energy") is usefully employed. Virtual Energy uses an imitative construction.

In the alternative view, the constraints that support an Energy concept are ***isolation*** and ***stabilization***. By imposing these constraints on a matter in Reality, we make that matter suitable for engagement by intelligence. Such constraints are imposed in a practical way when something is measured in the laboratory or put into a piece of technology.

In a thermodynamic system, discussed below, constraints of isolation and stabilization are part of the requisite definition of a ***system*** (1) that is isolated from its ***surroundings*** by a ***control surface*** – a control surface is the boundary between a system and its surroundings; and system, surroundings and control surface are defined as a single structural unit; and (2) that is restored to ***equilibrium or equilibration*** at the conclusion of each process or action. On the other hand, when such constraints are not in place, e.g., when a system with inputs and outputs is undergoing a nonequilibrium (=irreversible) phase transition, concepts of Energy or Virtual Energy may lose capacity to represent such activity and there is no justified attachment of such concepts to the matter in Reality.

The conventional view, e.g., that of Feynman, is based on the ***atomic or particle concept*** where constraints of isolation and stabilization are ***inherent*** in matter. By its nature, an atom or particle is set off or isolated from surrounding matter, interacting only through external relations.

General concepts of stabilization in mechanics are constructed in several ways. Physicists have developed systems of ***invariances*** based, to the extent possible, on ***constants of nature***. Some properties of a particle, such as ***charge*** and ***mass***, are inherent in the particle and permanently fixed while the particle is in existence. Other properties, such as ***momentum*** and ***spin***, are subject to conservation laws. In the conventional view, explicit, distinct, stable relations are built into nature. Indeed, in the conventional view, all of nature can be stated in terms of such distinct, stable relations.

In the Objective Person Psychological Model, I construct an alternative model for cognition of structure where isolation (explication) and stabilization are psychological processes used by intelligence to engage Reality. Matters in Reality that have been isolated and stabilized are good candidates for "objects," which intelligence can attach to Reality. In this way, matters in Reality can be made into a source of knowledge.

"Psychology" is anathema to many conventional physical scientists and the alternative scientific view depends on psychology. In the alternative view, physicists select and study matters on the basis of human psychology and, most important, on the basis of limitations of intelligence that all persons share. E.g., because of its limitations, intelligence works best when matters can be isolated and stabilized. Matters successfully studied on this basis mark places in Reality where defects in the products of intelligence are likely to have minimal adverse consequences. This is the converse of the proposition that isolated and stabilized matters are good potential sources of knowledge.

Such musings are not novel. Nobelist P. W. Bridgman (1882-1961) searched for "understanding of the attitude of physicists toward thermodynamics ... in the realms of psychology. Ever since the days of the Greek philosophers or of Lucretius human speculation has run straight to the atomic. At first there was absolutely no experimental justification for this, or logical justification either, for that matter. From our present point of vantage, we must not draw the conclusion that because atoms have now been found in the laboratory our primitive urge to analyze into atoms was therefore justified. It just seems to be a fact about our thinking machinery that we must have our atoms." *The Nature of Thermodynamics* (1941, 1961 reprint) at 9-10 quoted in Truesdell's *Tragicomedy*, discussed below.

I similarly suggest that there are "facts about our thinking machinery" that mean that "we must have energy" as a concept. And just as the atomic concept has proved useful, so has energy. It's only that ***sometimes*** these concepts don't provide useful images of Reality. The "sometimes" when energy is not a useful concept can be identified by investigation of the history and bases of the concept of energy carried out later in this section. I further suggest that the concept of energy misfits the Reality of nonequilibrium phase changes in brains. Such Reality is antipodal to the kind of Reality that is well described by conventional concepts.

We are following the "ideal" path where the concept of energy fits well. Here's how Feynman describes the imposition of constraints on operations of heat engines in § 44-3 of the *Feynman Lectures, Vol. I* so that definition of energy is possible. Notice the word "ideal" and its variants and the word "reversible."

Feynman had previously introduced an "idealization that we did when we studied the conservation of energy; that is, a perfectly frictionless engine [described in Chapter 4]. ¶ We must also consider the analog of frictionless motion, 'frictionless' heat transfer. ... when we have a practically frictionless machine, if we push it with a little force one way, it goes that way, and if we push it with a little force the other way, it goes the other way. We need to find the analog of frictionless motion: heat transfer whose direction we can reverse with only a tiny change. ... So we find that the ideal engine is a so-called *reversible* engine, in which every process is reversible in the sense that, by minor changes, infinitesimal changes, we can make the engine go in the opposite direction. ... Let us now consider an idealized engine in which all processes are reversible." (Emphasis in original.)

My reconstruction of conventional energy into Ideal Energy is set forth in contexts (1) the problem of how steam engines work and (2) a historical review of the development of the energy concept. I especially rely on the view of thermodynamics and history provided by Clifford A. Truesdell III (1919-2000), an eminent physicist who devoted himself to establishing thermodynamics on a rigorous basis. Chief sources are C. Truesdell, *The Tragicomical History of Thermodynamics 1822-1854* (1980) ("*Tragicomedy*") and C. Truesdell & S. Bharatha, *The Concepts and Logic of Classical Thermodynamics as a Theory of Heat Engines Rigorously Constructed upon the Foundation Laid by S. Carnot and F. Reech* (1977) ("*Concepts and Logic"*). The two books were written contemporaneously and interdepend. *Concepts and Logic* has a "Pro-Historical" as well as "Conceptual" and "Pedagogical" scope. (*Concepts and Logic* at ix.) Analysis presented in *Tragicomedy* is sufficient for a serious student to learn the science of thermodynamics. (*Tragicomedy* at 5.)

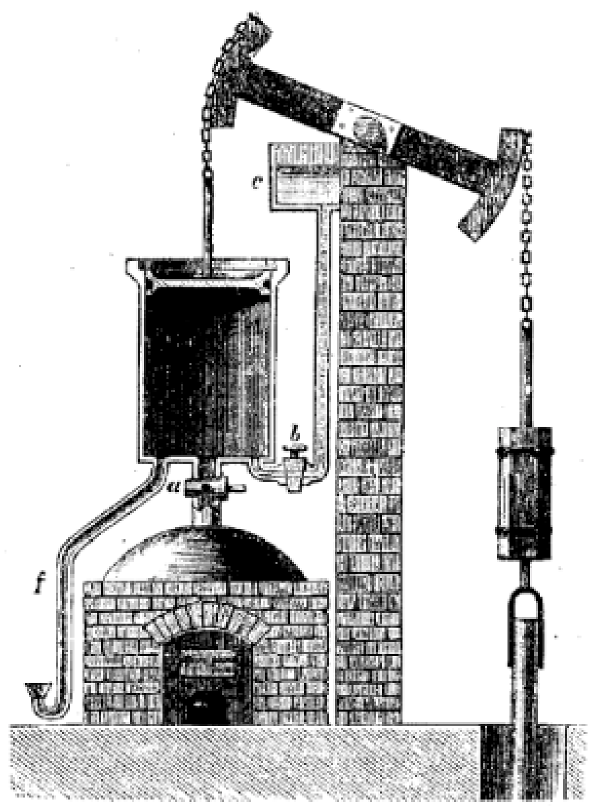
The theme of the *Tragicomedy* is summarized at p. 135: "The curse of thermodynamics has been, not that, as happened in every other branch of physics, the great creators occasionally erred or failed, but that their successors have treasured the errors and the deficiencies while neglecting to seize, purify, and exploit the successes." Truesdell's mission was to expose the errors and set thermodynamics on a simpler, stronger and, above all, a mathematically rigorous foundation. Topics he avoided (chiefly steam and phase changes) are as significant as the matters where he succeeded in his mission. In § 12, I adapt Truesdell's method to suggest how some matters in

Reality are susceptible to structuration by activity of intelligence and how others are not.

The development of steam engines was, of course, the opening event of the Industrial Revolution. One of first practical devices was the "Newcomen Steam Engine," c. 1720, similar to the ideal form shown below.

We will be considering the problem of ***how*** steam engines work. Prior to 1824, people knew ***that*** steam engines worked but there were no good concepts of "how." I discuss the problem of how steam engines work, and the supposed answer – "energy" – that was constructed to solve that problem. I suggest that, although the concept of energy is very useful in steam engines, it is not and cannot be made to describe ***exactly*** "how" real steam engines work. Engineers work around the shortfalls and the work-arounds, such as Steam Tables, can be excellent as a practical matter. I am suggesting that a similar line of reasoning applies to brains and that energy can be a useful concept in thinking about brains if some work-arounds are added.

In 1824. Sadi Carnot, an engineer, published *Reflections on the Motive Power of Fire and on Machines Fitted to Develop That Power* (*Réflexions sur la Puissance Motrice du Feu et sur les Machines Propres à développer cette Puissance*). "[T]his constitutes one of the few famous cases in which engineering has contributed fundamentally to physical theory." *Feynman Lectures, Vol. I*, at 44-2. "Carnot's approach is entirely new." *Tragicomedy* at 79. A leading physicist had recently published a comprehensive text that showed an almost complete absence of any substantial understanding of how steam engines work. *Id*.



Let's imagine a Newcomen steam engine in operation. The image is an idealized Steam Engine. That is, friction and steam losses are disregarded and the image and description are simplified. E.g., an operating Newcomen engine had levers and rods to open and close valves automatically (more "energy sinks"). The "useful work" of the Engine is to exert a downward pull on the working arm (located above the Engine in the image). (The first work of steam engines was to draw water out of mines). In the idealized Steam Engine, the Fire is in the brickwork furnace under the Boiler.

To enter the cycle of operation, imagine that the piston is all the way down in the cylinder and that the ***working arm*** attached to the piston is at the opposite end of its range of motion from that shown (referring to the position of the teeter-totter at the top of the image). In this state, valve "a" to the boiler and valve "b" to a cold water cistern "c" are both closed and there is nothing but air in the squashed-down chamber. The eduction tube f is open and the cap at its end is removed (or an equivalent valve is open).

Then, valve "a" opens and hot steam is fed into the chamber from the boiler below. The steam fills the cylinder, the steam forces air through the eduction tube, which is then capped, and the steam raises the piston and working arm into "ready" position. This requires little if any work. In "ready" position, the working arm is attached to the underground pump (heading into the ground) and valve "a" is closed. The configuration is now as pictured and the chamber is full of steam. The Fire has supplied the Power and can be forgotten – you can imagine the furnace and boiler removed below valve "a." Ideally, the chamber is perfectly insulated and the engine can stand in a "readiness" state indefinitely.

In the crucial step, valve "b" opens and cold water enters the chamber. Upon coming into contact with the cold water, the steam ***condenses***, changing phase from steam to liquid water. The space, previously occupied by the steam is now only slightly occupied by water, plus some residual vapor and air, and the pressure is greatly reduced. Outside air pressure forces the piston down with a force of up to 14 pounds per square inch, doing work. Valve b is then closed. The chamber is drained through tube f with cap removed. We are now where we started ("To enter the cycle," above) and the scenario can be repeated.

The Steam Engine tames the Power of Fire and produces Useful Power, the life blood of modern civilization. Despite modern advances, our electricity still comes overwhelmingly through Steam Engines (using turbines rather than reciprocating engines) and the work of nearly all nuclear reactors is to boil Steam or, occasionally, some similar substance.

In the eighteenth century while Steam Engines were being developed, people knew ***that*** they worked but had no clear idea ***how*** they worked. Recalling § 3 above with the contrast between juxtaposition vs. synthesis concept formation, the foregoing description is a juxtaposition description saying "that" the Steam Engine operates. The juxtaposition is summed up in the phrase "The Motive Power of Fire" used by Carnot. The phrase in and of itself states the problem but provides no insight into principles that, e.g., would help make a better engine. Such principles, the kind that physicists seek and obtain, are what say "how" a Steam Engine operates.

Without such principles, I feel like the children from § 3 trying to explain how a bicycle works.

One conceivable principle is that, when the steam condenses to water, a "partial vacuum appears" and "the partial vacuum does the work." This supposed principle even appears in some published explanations. However, the principle that "a partial vacuum does the work" does not stand up to scrutiny. It takes work to make a vacuum or a partial vacuum, as anyone knows who has used a hand pump. The underground pump driven by the steam engine that lifts water from the mine also involves a "partial vacuum." So, supposedly, vacuum turns into work turns into vacuum turns into work that lifts the water. That's a lot of work for a vacuum. I can't see any way for a vacuum to do that work. I suggest that "vacuum" will not serve as a vehicle to carry the Motive Power of Fire. It's got to be in the steam.

Abandoning vacuum as an explanation, we are back at square one with juxtaposition of Fire and Power and with the kind of concepts that are produced through juxtaposition. First there is the fire, then there is work done, the "Motive Power of Fire." Now, I say that the Power gets into the steam, and then, when the cold water comes in, the Power leaves the steam and does the work.

Now I have something approaching a principle – called "Power" – that has the kind of continuity that "force" has for bicycles. To make that principle applicable, I have to extend the Power to the coal, from which I must suppose it originated.

But this extension is, at least at first, unsatisfactory. With this kind of explanation, I might as well say that there was a ***ghost*** imprisoned in the coal. Then the ***ghost*** came out of the coal, the ***ghost*** got into the fire, the ***ghost*** came out of the fire, the ***ghost*** got into the water, the ***ghost*** made the steam and then the ghost ***hid*** in the steam. While in "readiness" state, I might as well say that ***a ghost is hiding in the steam in the steam engine***. I might as well as say that when the cold water came in, the ***ghost*** came out from hiding in the steam and pulled down the weight. I might as well say that a ***ghost in the steam engine*** did the work.

The "ghost in the steam engine" is chosen to echo the "Ghost in the Machine" declared to be absurd in G. Ryle's *Concept of Mind* (1949) and further derided by his student, D. Dennett in *Conscious Explained*, discussed in § 1 of this Introduction. I suggest that "ghosts" identify regions of ignorance. And there are "ghosts," I suggest, that identify matters that are real but unknowable to our limited intelligence that constructs defective products.

Physics seeks to exorcise the ghosts or, at least, to exclude ghostly apparitions from aspects of Reality. The exclusion of ghosts from an aspect of Reality is accomplished by obtaining sufficient knowledge about that aspect so as to describe activity of that aspect by means of structured relations. Physicists seek to generalize from successful exclusion of ghosts from particular aspects of Reality and seek comprehensively to exclude ghosts and to achieve complete exorcism. These are purposes that are, as a matter of fact, beneficial to humanity and highly laudable. Exclusion of ghosts leads to useful inventions. However, the alternative approach challenges the belief that complete exorcism is possible. The technical presentation in this section shows that there are ways and places to exclude ghosts but no support for a claim of complete exorcism. On the contrary, there seem to be places left for ghosts to do whatever ghosts do.

As noted above, the first statement of "how" a steam engine works was provided by Carnot in 1824. His statement, although a big step forward, was based on a concept of *calorique* (part of "the Caloric Theory") that misfits modern concepts and is now seen to be erroneous. See *Tragicomedy* at 81, n.5. Fortunately for Carnot's approach, and as shown in the *Tragicomedy, calorique* is "inessential" to Carnot's chief conclusions. Carnot's theory and ideas survived the demise of *calorique* with scarcely a dent.

It is useful to look at *calorique* because energy is "not much different" and the difference marks the narrow conditions – equilibrium – where the energy concept applies exactly. *Calorique* was the basis of a paper, *Account of Carnot's Theory*, published in 1849 by William Thomson, later Lord Kelvin (1824-1907). *Tragicomedy* at 168 *et. seq.* Only two years later, in 1851, after papers by Rudolf Clausius (1822-1888) (the titular founder of thermodynamics) and William J. M. Rankine (1820-1872) and incorporating some of their ideas, Kelvin published a new paper based on energy. *Tragicomedy* at 224 *et. seq.*

Clausius based an "awkward" mathematical approach on "his kinetic theory of gases, to which with [little] basis in actual experiment, he adhered as an article of faith. Unlike RANKINE, CLAUSIUS kept his faith private." *Tragicomedy* at 205 (typography as in the original). Rankine had publicly based his energy concept on a "hypothesis of molecular vortices" and Kelvin avoided this hypothesis; but Kelvin felt obliged to introduce a new concept, "inanimate material agency." *Tragicomedy* at 226. This history shows physicists attempting to address the difficulties and fumbling at first. "Molecular vortices" looks silly to a modern eye; but hydrodynamics was being vigorously pursued by Rankine, Kelvin and many others and is a rich source of mathematical formulations, e.g., formulations called "spherical harmonics" that originally described wave phenomena and now describe electron states of an Ideal Hydrogen Atom.

The transition from *calorique* to energy is significant because, notwithstanding its defects, *calorique* serves many purposes well. Under the Caloric Theory, there is "heat," something like a substance, that is never created or destroyed, that is resident in matter and that is measured by a thermometer. *Tragicomedy* at 34 and, generally, chapter 3. Throughout the *Tragicomedy*, Truesdell specifies matters where the Caloric Theory gives the same results as an energy theory. A branch of thermodynamics, calorimetry, started off with *calorique* but smoothly made the transition to energy because during calorimetry, no mechanical is peformed. See *Tragicomedy* at 195.

Where *calorique* went wrong was that the theory did not allow for any conversion between heat and mechanical work. Factually, there are two at least two kinds of conversions. First, mechanical work heats things up, as demonstrated by Benjamin Thompson, later Count Rumford (1753-1814), who showed that he could boil large quantities of water at a cannon manufacturing plant he superintended with heat produced when horses walked around a circular track and supplied mechanical work for a boring tool. Second, heat can generate mechanical work as shown by the steam engine. Between 1840 and 1850, James Joule (1818-1889) performed and published reports of experiments that supported a theory based, according to the title of the 1850 paper, "On the mechanical equivalent of heat." See *Tragicomedy* at 348-350.

In a broad-brush way, I reconstruct the change from *calorique* into energy.

Calorique depended on a concept of "heat" where "heat," as described above, had the nature of a substance. Under *calorique*, a body held a certain quantity of "heat" or "caloric" like an ordinary person holds dollars. There is always a fixed amount in the person's account. If there is a group of persons, one person can transfer dollars to another person and then each person's account changes by the same amount but in opposite directions. If no dollars enter or leave a group, the total amount of dollars in the group is constant. Likewise for *calorique*.

Calorique does not work; *calorique* is wrong. Thermodynamics changes the way the problem is approached. According to Truesdell, the change actually came with Carnot but Carnot did not realize it. The entire system of thermodynamics, including a correct statement of an "energy principle," could have been constructed by Carnot, but Carnot missed the point. Instead, Clausius introduced the concept of "internal energy" that behaves in many ways like *calorique* in the sense of a "store" in matter. But the concept of "internal energy," the pivot on which Clausius' energy construction depends, is established only for equilibrium conditions.

As a matter of fact, concepts of "heat" and "work" misfit the facts of physical matter. Such concepts suggest substances that can be held and measured and there are no such substances. There are factually, rather, ***heating*** and ***working***. "Heating" can be turned into "heat" but only under certain conditions; likewise for "working" being turned into "work." Equilibrium conditions are suitable for such conversions; but, as a matter of fact, a broader range of conditions is suitable that I call "equilibrating."

In *Rational Thermodynamics* (1969), Lecture 1, C. Truesdell sets forth a system of thermodynamics based on Axioms where primal quantities include "Heating" and "Net Working" that are ***rates*** out of which "heat" and "work" can be constructed under appropriate conditions. An Internal Energy is also included, but it figures in only by way of a ***rate***. In the Thermal Model of Brains I propose, all thermodynamic quantities are rates. Rates work fine for brains where the basis in Reality is the flow of blood sugar through the carotid arteries, i.e., a flow measured by a rate.

These rigorous constructions do not incorporate phase changes and avoid matters that depend on the constitution of a particular body. E.g., Truesdell abhors Steam. I suggest, however, that phases changes need to be figured in. And not just any phase change, but the ***mother of phase changes*** in brains, the Neuronal Critical State.

Here's how energy "explains" the Steam Engine. Let's see if the explanation is entirely satisfactory. According to the energy concept, there is energy stored in "chemical bonds" in coal. When the coal is burned, the energy is released from chemical bondage and becomes "heat energy" in the fire. Then the heat energy gets into the water in the boiler and makes the water hot. Heat energy not only gets into the water, heat energy changes the water into steam. This is a tricky but important step. It takes a surprisingly large amount of energy to turn an ounce of water at 100 °C into an ounce of steam at 100 °C. If it takes 1 unit of energy to heat a quantity of water from just above freezing to just below boiling, it takes over 6 units of energy to turn that water into steam. (This is at atmospheric pressure.) The energy needed for this phase change is called ***the latent heat of vaporization***. It was discovered, investigated, described and named by Joseph Black (1728-1799), a scientist at Glasgow University who appears to have been talking to James Watt (1736-1819) while Watt engineered world-changing advances in steam engine technology.

According to the energy concept, the energy that used to be stored in the chemical bonds and that passed through the fire into the water ***is now stored in the steam*** in the form of this "latent heat." In the final step, when the cold water comes in, the steam turns back into water or condenses, the steam "***gives up***" the latent heat of vaporization which becomes ***Gibbs energy*** and it is Gibbs energy that does the work of pulling the weight. [Josiah Willard Gibbs (1839-1903) made many advances in thermal physics.]

Please note that "the same" energy explanation applies to bursting of pipes by freezing water. According to the energy concept, when water freezes, it "gives up" energy called ***the latent heat of fusion***, which becomes Gibbs energy, and it is this Gibbs energy that tears open the metal pipes.

In attempting to understand these phenomena and in stating these "explanations," I can acknowledge progress from "ghosts" but I can also identify sources of dissatisfaction. Dissatisfaction comes from the fact that we are talking about a number of different kinds of activities, e.g., "bound" activity in coal, activity of fire, activity of water, activity of steam and activity of a moving weight. Although the word "energy" (and an apparent synonym, "heat") is used as if there is something "the same" in each activity, so far that is only a verbal assertion and no support has been shown. "Energy stored in steam" certainly sounds more grownup than "a ghost hiding in the steam" but so far "energy" is just a word which is being used indiscriminately as if "the same" but under different circumstances and such usage is like the prior usage of "ghost" even if more apparently sophisticated.

Of course, physicists seek to justify each and every use of the word. The question is whether the justifications amount to a comprehensive justification or whether the justification is limited to particular circumstances or governed by constraints that define not only regions of application but also regions where application is possibly erroneous. "Justification" means that there is strong support for a ***single*** concept of "energy" that is so wide and deep ("dense") that energy can be said to attach comprehensively to Reality.

An alternative view is that support for an energy concept is only partial and there might be parts of Reality, e.g., brains, where there is no solid attachment and, indeed where the conventional physics of energy might be seriously misleading. In support of the alternative view, I suggest that energy is no more than an Ideal Energy with respect to which some important parts of Reality are good approximations but that cannot be applied with assurance to other parts of Reality.

To introduce the concept of thermodynamic energy, "the tragicomic muse of thermodynamics chose the muzziest of her muzzy retinue: ROBERT MAYER, a gifted and thoughtful physician who knew no mathematics and whose mode of reasoning was emasculated by the school of *Naturphilosophie*, from which he was just beginning to free himself." *Tragicomedy* at 154. *Naturphilosophie* was the work of F. von Schelling (1775-1854) and was the kind of philosophy where, in a fashion reminiscent of the childish “syncretic concept” described by Piaget in § 3, everything connects indiscriminately to everything else.

To start out with energy is like the “Forces” of Socrates, as lampooned by Aristophanes: “Forces are therefore indestructible, convertible, imponderable objects.” Quoted in *Tragicomedy* at 155.

At 150-153 of *Tragicomedy*, Truesdell considers “some particular beliefs about heat” that were held in or about 1842, including “Claim B” that he then rejects.

“*B. Heat is only a kind of ‘force’ or ‘energy’; hence heat and work are universally and uniformly interconvertible in all circumstances*. This idea, one of many sometimes called the “First Law of Thermodynamics”, would seem to include as a special case the universal and uniform Interconvertibility of Heat and Work in cyclic reversible processes. ... Like the *vis viva* theories it refers to the ‘total heat’ resident in a body. ... *Claim B is unsound*.” (Emphasis in original.)

Truesdell rejects the notion that “heat and work are universally and uniformly interconvertible ***in all circumstances***” Instead, he concludes that there is ***universal and uniform Interconvertibility of Heat and Work in cyclic reversible processes***.” This is “the same” difference I construct between the conventional view and the alternative view.

“Universal” would appear to extend the notion to all bodies but there are constraints and conditions. Processes involving phase changes are not included in Truesdell’s mathematically rigorously theory. The theory does not exclude the possibility of patching phase changes (“patching” discussed below) but neither does the theory suggests ways to patch. The only bodies considered are those with a mathematically definable equation of state (e.g., pV=nRT) and such an equation of state has no place for memory or lack of precision.

“Uniform” means that there is a formulation by means of which: “Conversion of units of heat into units of work in cyclic processes is *independent of the temperature* at which the conversion is effected.” *Tragicomedy* at 150 (emphasis in original). The temperature-independent formulation can then be used as a basis for the energy state function. However, the statement limits circumstances under which temperature-independence can be established.

In *The Feynman Lectures, Vol. I*, Feynman shows the difference between interconvertibility “in all circumstances” and inconvertibility “during cyclical reversible processes.” The chief vehicle is ***kinetic theory*** applied to ***evaporation*** of water. Kinetic theory is a branch of thermal physics based on mechanics where a gas is treated as a number of identical particles and each particle has a specific momentum (mass times velocity). Under some circumstances, and using atomic concepts, it is possible for a scientist using kinetic theory to derive rules for “counting” energy and to use the rules to specify interconversions between heat and mechanical work. Kinetic theory provides an Ideal Count and, for appropriate systems, e.g., those described by a Perfect Gas, there is a solid basis in Reality for the energy concept. Recall that the question is not whether energy attaches to Reality but whether energy attaches to Reality ***comprehensively*** and, if not, where the failures are. Kinetic theory shows where the attachments are most solid and, by negative implication, suggests places to look for failures.

Although perhaps not immediately clear, Feynman's discussion of "evaporation" is well suited to the study of steam engines. When conditions are Ideal, "evaporation" is ***reversible*** and the reverse of evaporation is "condensation," involved in the operation of steam engines. (When the cold water comes in, steam condenses into liquid water, the ghost or energy comes out of the steam and pulls the weight.) So the exact description of evaporation that Feynman provides can be "run backwards" and then it provides an exact description of condensation. Running backwards is what "reversibility" means. If a process is reversible, you can run it backwards and/or forwards indefinitely and without cost. See above where Feynman talks about a "frictionless heat transfer." We are dealing with Ideal conditions here and we take advantage of the opportunities and enjoy the benefits.

At the center of thermal physics – including some formulations of thermodynamics, all of kinetic theory and all of statistical mechanics – is the concept of ***equilibrium***. In kinetic theory, deviations from equilibrium are permissible but then conditions ***relax*** toward equilibrium conditions.

In *The Feynman Lectures*, Feynman develops the concept of equilibrium in the context of evaporation of water in considerable detail, but spread through several chapters. Indeed, showing how equilibrium and the atomic model work together in evaporation is one of the "paradigms" that is developed in several ways throughout the course.

Recall the statement from § 1-2 where Feynman states "*the atomic hypothesis (*or the atomic *fact*, or whatever you wish to call it) that *all things are made of atoms–little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another*."

This statement incorporates a prototype of equilibrium by implication. Attraction is the opposite of repulsion and equilibrium is where attraction and repulsion just balance. If we think of two particles at rest, there is a specific distance – call it d_0 – between those two particles such that if the distance between the particles is greater than d_0, the particles will attract each other but that if the distance is less than d_0, e.g., if the particles are "squeezed," the particles will repel. If the two particles are exactly the specific distance d_0 apart, they will neither attract nor repel but remain at rest. This is the prototype of "equilibrium." Any conceivable real situation is much more complicated because there are many particles so each particle is subject to multiple attractions and repulsions and because no particle is ever at rest with respect to any other particle; however, mathematicians prove that a more refined concept of equilibrium comes to much "the same" result as the prototype. ***Equilibrium is built into mechanics as the center point and without the center point there is no mechanics***.

According to Feynman, water consists of "real particles in nature [that] are continually jiggling and bouncing, turning and twisting around one another. ... Now the jiggling motion is what we represent as heat: when we increase the temperature, we increase the motion. If we heat the water, the jiggling increases and the volume between the atoms increases, and if the heating continues there comes a time when the pull between the molecules is not enough to hold them together and they *do* fly apart and become separated from one another. Of course, this is how we manufacture steam out of water–by increasing the temperature; the particles fly apart because of the increased motion." (Page 1-3, emphasis in original.)

> "Thus, molecule by molecule, the water disappears–it evaporates. But if we close the vessel above, after a while we shall find a large number of molecules amongst the air molecules. From time to time, one of these vapor molecules comes flying down to the water and gets stuck again. So we see that what looks like a dead, uninteresting thing–a glass of water with a cover, that has been sitting there for perhaps twenty years–really contains a dynamic and interesting phenomenon which is going on all the time. To our eyes, our crude eyes, nothing is changing, but if we could see it a billion times magnified, we would see that from its own point of view it is always changing: molecules are leaving the surface, molecules are coming back. ¶ Why do we see *no change*? Because just as many molecules are leaving as are coming back! In the long run 'nothing happens.'" Page 1-5 (emphasis in original).

"***By equilibrium we mean that situation in which the rate at which atoms are leaving just matches the rate at which they are coming back***." Page 1-6 (emphasis added).

Equilibrium is an important concept, just as important as "atoms and the void." Matters in equilibrium are ***in balance*** as to something specific. There is something that is stationary or static. Identifying matters that are stationary or static is important in acquiring knowledge.

Consider ways "how" something in Reality might seem stationary or static. Ultimately we want to suggest that there ***actually exists*** something in Reality that is stationary or static and on which the something observed is based. One way to support that suggestion is to suggest that there are stationary or static units in Reality, such as atoms. As a matter of fact, this suggestion, even if fully embraced, is insufficient. Additional ways must be suggested.

Another good way is through ***equilibrating processes***. In brief, the image is that there is a system in a state that persists, more or less, through time and where a small deviation of the system from the equilibrated state initiates a process that returns the system to the equilibrated state.

For an example of equilibration, consider activity of water in a stream bed after a rainstorm. The flow surges and ebbs but the flow is always centered and the flow always returns to much the same place. This is "ordinary activity" in an "ordinary" stream bed after an "ordinary" rainstorm. If there is an "extraordinary" rainstorm and an "unusual" stream bed that is prone to flooding adjacent lands, then the concept of equilibration cannot be so easily applied.

Physicists use equilibrating processes as one of the standard tools. Joseph-Louis Lagrange

(1736–1813) analyzed planetary orbits using Newton's Mechanics and considered what would happen if there were "perturbations" in a 3-body gravitational problem where a small body of mass *m* interacted with two larger bodies. Gravitational and centrifugal forces are in balance and the forces also tilt toward correction when a deviation occurs. J. B. Marion, *Classical Dynamics of Particles and Systems* (1965) at 304. In the analysis of the Critical State set forth in § 8, perturbations turn into ***fluctuations***. The Critical State is the point where equilibrium first fails and where fluctuations extend indefinitely.

Equilibrating processes can define a ***steady state***. A steady state is characterized by constant ***flows*** and by processes that are sustained continuously. A classic statement of steady state behavior and its breakdown was made in connection with the onset of turbulence in water flow.

> "The case of flow through a pipe of circular section was made the subject of a careful experimental study by Reynolds, by means of filaments of coloured fluid introduced into the stream. So long as the mean velocity (w_0) over the cross-section falls below a certain limit depending on the radius of the pipe and the nature of the fluid, the flow is smooth and in accordance with Poisseuille's laws; 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 but if care be taken to avoid these the smooth rectilinear flow may for a while be preserved, until at length a stage is reached beyond which this is no longer possible. When the rectilinear *régime* 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." Lamb, *Hydrodynamics* (6^{th} ed. 1932, Dover 1945) at 663-664.

An Ideal Steady State turns the "molecule by molecule" approach (Feynman, above) into a "steady stream" of molecules. In an Ideal Steady State, there is a continual flow of molecules through the system. Equilibrium is never reached (see definition above) but the molecules substitute for one another perfectly and the streaming is so smooth that it can be reversed without any difficulty or cost. This is equilibration.

Equilibrating processes can provide simple models. For example, a reciprocating steam engine is an equilibrium state system but a continuously-operating steam turbine, e.g., producing electrical power, is an equilibrating system.

Reversibility is the focus here and an Ideal Steady State can claim that property. That is, until as suggested in the hydrodynamic case, "the rectilinear *régime* breaks down [and] the motion becomes wildly irregular."

Accordingly, a concept centered on equilibrium or equilibrating conditions incorporates an automatic correction of deviations. ***Conversely, I suggest, automatic correction of deviations from equilibrium is a condition or constraint for a concept centered on equilibrium or equilibrating conditions***. When such constraints are no longer effective, the concept loses applicability.

Automatic correction of deviations is the problem of "stability" in mechanics but it has a different appearance in thermodynamics. In mechanics, everything is presumptively knowable and the knowledge is used to ascertain which states are stable and which are unstable. In thermodynamics, stability is a condition of the system that is required before the system can be studied. I suggest, one tool in the toolbox of mechanics, energy, is suitable only for systems that meet that requirement. As deviations from stability become so extensive that "equilibration" loses any meaning (as, I suggest, it does during important activity in brains), the concept of energy becomes of increasingly doubtful validity. A mechanics approach without energy is severely handicapped and no strong or comprehensive claims can be based thereon.

Feynman explores kinetic theory and thermal physics in chapters 39 and following of *The Feynman Lectures, Vol. I*. He assumes throughout that "equilibrium has set in," "the collisions are effectively perfectly elastic" and that "the gas is in a steady condition." Page 39-3. When dealing with temperature, reference is made to "*constant temperature*" involving "a condition that they would get to if we left them alone long enough!" These are "the conditions for equilibrium." *Id*., at 39-7 (emphasis in original). Again, at page 41-1: "we have been perpetually making a certain important assumption, which is that if a given system is in thermal equilibrium at some temperature, it will also be in thermal equilibrium with *anything else* at the same temperature. ... we assume that if a thing is once in equilibrium–parts of it do not get hotter and other parts colder, spontaneously." (Emphasis in original.)

The concept of temperature requires that a body be in a condition of equilibrium. Strictly, if a body is not in equilibrium, temperature cannot be defined. For example, one statement of classical thermodynamics expressly states: "The temperature of a closed system is the property that determines whether or not the system is in thermal equilibrium with its surroundings." M. Sprackling, *Thermal Physics* (1991) at 18. Of course, everybody assigns temperature to bodies not in equilibrium. That's fine; you just can't do it exactly. And the greater the deviation from equilibrium, the greater the inexactitude.

Feynman returns to evaporation in § 42-1 and uses a result obtained along the way (the "general principle" in the last paragraph):

> Suppose we have a box with a large volume, partially filled with liquid in equilibrium and with vapor at a certain temperature. We shall suppose that the molecules of the vapor are relatively far apart, and that inside the liquid, the molecules are packed close together. The problem is to find out how many molecules there are in the vapor phase, compared with the number there are in the liquid. How dense is the vapor at a given temperature, and how does it depend on the temperature?
>
> Let us say that *n* equals the number of molecules per unit volume in the vapor. The number, of course, varies with the temperature. If we add heat, we get more evaporation. Now let another quantity $1/V_a$ equal the number of atoms per unit volume in the liquid: We suppose that each molecule in the liquid occupies a certain volume, so that if there are more molecules of liquid, then all together they occupy a bigger volume.

Thus if V_a is the volume occupied by one molecule, the number of molecules in a unit volume is unit volume divided by the volume of each molecule. Furthermore, we suppose that there is a force of attraction between the molecules to hold them together in the liquid. Otherwise we cannot understand why it condenses. Thus suppose that there is such a force and there is an energy of binding of the molecules in the liquid that is lost when they go into the vapor. That is, we are going to suppose that, in order to take a single molecule out of the liquid into the vapor, a certain amount of work W has to be done. There is a certain difference, W, in the energy of a molecule in the liquid from what it would have if it were in the vapor, because we have pulled it away from the other molecules which attract it.

Now we use the general principle that the number of atoms per unit volume in two different regions is $n_2/n_1 = e^{-(E2 - E1)/kT}$. So the number n per unit volume in the vapor divided by $1/V_a$ per unit volume in the liquid, is equal to $nV_a = e^{-W/kT}$.

The situation that Feynman has set up is an Ideal situation and. along with him, we enjoy the advantages. Energy works "perfectly" here as an accounting principle. There are, however, some problems with the imagery. What does it mean "to take a single molecule out of the liquid into the vapor"? That apparently means that a certain quantity of energy is transferred into that "single molecule." Apparently, the excess energy came when "we add heat." How did the "heat" added to the entire body come to be concentrated in the single molecule? Supposedly this process can seen "molecule by molecule." So, over and over again, there is this mysterious concentration. Dividing a ghost up into a billion ghosts that can be counted is an improvement but it is not a wholly satisfactory explanation. Something ghostly is still going on with an energy explanation even under the best of circumstances.

But there is an even bigger problem for the imagery and the formulation and that problem is that the formulation cannot be exactly applied except under the best of circumstances. For convenience, I rewrite the formulation as follows: nV(a)=exp(-W/kT). "k" is a number with dimensions; it's called Boltzmann's constant. The temperature T can be stated in many ways and the dimensions of k are adjusted to fit. So people use, e.g., Farenheit, Celsius and Kelvin scales for temperature. Physicists use the Kelvin scale, but neither k nor the Kelvin scale is important here.

Note first that the quantity nV(a) is ***sensitive*** to the temperature T. Temperature is a ***collective*** or ***aggregated*** quantity based on an equilibrium (or equilibrated) system. No single particle has a "temperature." You need at least thousands of particles before you can define a temperature. ***Every other quantity in the formulation is specific to a particle***.

The formulation breaks down when there are ***huge quantities of molecules*** involved in a phase transition. In steam engines, this occurs when the cold water comes in. ***Suddenly***, all the steam condenses to water and the piston comes down with a bang! This was discovered by Newcomen by accident during an experimental test when "cold water, which was allowed to flow into a lead-case embracing the cylinder, pierced through an imperfection which been mended with tin-solder. The heat of the steam cause the tin-solder to melt and thus opened the way for the cold water, which rushed into cylinder and immediately condensed the steam, creating such a vacuum that the weight attached to the little beam, which was supposed to represent the weight of water in the pumps, proved to be so insufficient that that the air, which pressed with a tremendous power on the piston, caused its chain to break and the piston crushed the bottom of the cylinder as well as the lid of the small boiler." Hills, supra, at 25, quoting a book published in 1734 about Newcomen's epochal discovery. Hence, in a Newcomen engine, "the cold water tank had to be placed high enough to obtain a good head and so give a good initial jet of water into the cylinder as soon as the valve opened." *Id*., at 26. Likewise, Truesdell's thermodynamics is crafted "for engineers who wish to see engines run, not creep." *Concepts & Logic* at xii.

In the next section, I suggest that large-scale phase changes in steelmaking during a "quench" can be instructive in investigating activity of brains during such as the speedy activity as ping-pong. There are huge numbers of neurons involved that undergo a massive change of activity and the behavior has characteristics that, like the cold water in Newcomen's engine, show a "good (forceful) head," a "good (forceful) initial jet" and "tremendous power." This is the "readiness, release/trigger and discharge through a transmission channel" I try to imitate with a Structural Engine.

Way back near the beginning of this section, there is an image of a weight on a spring and Feynman is quoted as saying about the spring: "So we lose track of that energy; we find the atoms are wiggling inside in a random and confused manner after the motion slows down." Here's where and how "we lose track of that energy" in a steam engine.

Examining the formulation nV(a)=exp(-W/kT) shows how tracking is lost. If the formula is applied to one particle, T is fixed or it varies by an inconsequential amount. This is no longer the case if so many particles are affected in a single step so large that the temperature no longer can be considered constant. The indeterminacy in the temperature prevents exact application of the formulation and prevents exact tracking of energy. Such indeterminacy becomes of major importance near a critical state.

§ 7 An alternative view of brains: we ***cook up*** our experiences

According to the conventional scientific view, we ***calculate*** our experiences. Some scientists say the calculations are "the same" as a computer. Others scientists say the calculations are "the same" as a mathematician solving differential equations. The calculations are supposedly carried out by collective action on the parts of neurons using signals.

In the alternative scientific view, we ***cook up*** our experiences. The obvious image is heating foods in a pot or oven. A better image for scientific purposes, explored in this section, is a metallurgical furnace producing alloys in ways that can be systematically varied and investigated by exact means. A third image is a potter's kiln. All involve "secret compartments" where ingredients combine and become something new and different but where the workings cannot be fully understood.

As noted above, *The Feynman Lectures on Physics, Volume I* (1963) states in §§ 1-2 and 2-1: "[A]ll things are made of atoms–little particles that move around in perpetual motions." "When atoms are in motion, the more motion, the more heat the system contains, and so ***heat and all temperature effects can be represented by the laws of mechanics***."

I suggest that claims about such "representation" can be erroneous during ***phase transitions*** or ***phase changes***, of central importance here. A phase transition, is an ***overall and sometimes sudden change*** in condition of a distinct body of matter, e.g., melting, freezing, boiling, condensing (vapor to liquid). As stated by physicist David Ruelle in *Chance and Chaos* (1991) at 123-124: "In fact, there is not a single type of atom or molecule for which we can mathematically prove that it should crystallize at low temperature. These problems are just too hard for us."

Facts about sudden phase changes involve the physics of ***thermodynamics***. Although not generally known, thermodynamics exists ***independently*** of mechanics and provides the basis for the alternative view of science.

The independence of thermodynamics has a venerable tradition. In a study of the rise of atomism in thermal physics, *The Kind of Motion We Call Heat* (1976) at 279, S. G. Brush wrote about "The tradition of *Pure Thermodynamics*, uncontaminated by atomism. Many scientists thought it worthwhile to preserve Thermodynamics as a set of laws based directly on experiment, whose validity would not depend on the acceptance of any theory about the internal structure of matter. Note that these scientists–Clausius, Kelvin, Rankine, Helmholtz, Gibbs, and Max Born– were not anti-atomists. They all contributed to atomic theory in separate publications." (Emphasis in original.)

When people think of "atoms," they generally imagine a nucleus surrounded by "hard-ball electrons" tracking circular orbits. Such an image is not suitable for bulk matter like that found in brains.

Solid-state physics studies the bulk properties of metals, including the behavior of negative electronic charge in metals in bulk form. In bulk form, a metal is formed by arrays of atomic nuclei in the nature of a three-dimensional "lattice" or repetitive pattern. The image of negative electronic charge ("electrons") in bulk metals is based on the "Fermi sea," named after physicist Enrico Fermi (1901-1954), who first suggested the notion. Individual "electrons" are absorbed into a "probability density" that pervades the whole body of the physical matter. The important "electronic" properties, including electrical response, are based on ***cloudy probability densities***. These principles apply to all forms of bulk matter, although usually not so neatly as in metals, and it would appear that, from an atomic view, "seas of electronic charge probability density" are sloshing around in my brains.

(A "probability density" is a function involving a particle that assigns to each possible state of the particle a probability that the Reality of a particle or a property of a particle will realize that possibility. The chief facts about probabilities are that they can be added together and that, if you consider all the possibilities allowable as states, the corresponding probabilities sum to 1. Because possibilities in brains are supposedly defined in terms of space and time, the possibilities are continuous and require a "smooth" concept of probability, which turns into probability density.)

An accurate "atomic image" of brains would have atomic nuclei constrained to local motion (e.g., within the confines of a neuron) or moving slowly, e.g., in molecules drifting in a synapse; but all surrounded by and actively governed by a ***shimmering nimbus*** of negative electronic charge probability density that has ***incomprehensibly complex, transient and indefinable activity*** but wherein supposedly lie the secrets of everything important that's going on.

I suggest that atomic imagery is not conducive to practical application and I suggest another way.

The following table states contrasting features of the two views. The purpose of either view is to state correspondences between a proposed model of neuronal activity in a person's brains and experiences of the person supposedly based on that neuronal activity.

	Conventional Scientific View e.g., Kelso, *Dynamic Patterns*	**Alternative Scientific View**
1. Supposed brain activity that forms experience:	Continuous co-evolution of state functions	Episodic phase transitions in the style of a Structural Engine
2. How neuronal activity connects to experience:	Dynamical variables become theoretical objects	Repetitive activity identified to acts/percepts/intents etc.
3. Constitutive notion:	Neuronal signals	Neuronal Virtual Energy
4. Governance by:	General comprehensive physical laws	Particular imposed constraints
5. Organizational motif:	Self-organization	Organization through engagements with Reality
6. Proposed scope of view:	Comprehensive	Zones of application and abstinence

On the largest scale, the conventional view and the alternative view begin at opposite ends of the problem and work in different directions. The conventional view begins with microscopic entities ("neurons") that contain features that are presumed to incorporate the "whole story" or, at least, everything that matters. Then, the "rules" for interactions of the features of are stated;

supposedly, these rules are based on comprehensive physical laws (at least the proponents so declare). Again, the presumption is that all essential interactions are included. Finally, there is an attempt to "sum up" the interactions of the features and to show that highly focused and directed biological activity "emerges"

The alternative view begins with a ***global view***. I first make statements about the system in its largest aspect, along with such global hypotheses and constraints as are required. For example, the first act of definition of an Ideal Brain under the alternative view is a statement of a ***constraint on global energy flow*** that I suppose models the flow of sugar in the blood and that I suppose is the sole source of energy for brains. The simplest constraint, which I initially adopt, is that global energy flow is constant. Such statements are limited in reach and any global hypotheses and constraints are far from defining. Then I turn to another aspect of brains and the Model and make additional statements, along with additional hypotheses and constraints. I intend to build up the alternative view from such statements, hypotheses and constraints and present it in as coherent a fashion as possible. Others could use similar methods but construct different views.

In the alternative view, thermal concepts support imagery where initial neuronal activity is subjected to the equivalent of a ***heat treatment*** and the resulting final neuronal activity depends both on the initial neuronal activity and also on constraints imposed during the heat treatment by other neuronal activity that is stable throughout. At a particular moment, there is a stable "crucible" or "mold" in which "ingredients" are being "cooked" or "formed." Both the crucible/mold and the ingredients are constituted of neurons involved in neuronal activity and a particular neuron may be in the crucible/mold at one time and part of the ingredients at another time. "Cold" stable neuronal activity makes up the crucible/mold; "hot" neuronal activity is simmering in the soup.

In the Thermal Model, neurons exchange, not signals as in the conventional view, but ***energy*** or, as reconstructed, Virtual Energy. "Heating" means that particular neuronal activity, e.g., that inside the crucible, is infused with Virtual Energy, typically until stable activity patterns have been destabilized. "Cooling" means that Virtual Energy is dissipated until fresh patterns emerge and stabilize. Stable patterns are called ***phases***. Kelso (see table above) also uses the term and his use often converges or even coincides with my own, but there is a different conceptual background.

"Virtual Energy" as I use the term is reconstructed in an "empty container" and I allow for ***virtual*** activities in "secret compartments." "Virtual Energy" is constructed on the basis of "real energy" (blood sugar) and constraints on Virtual Energy are important parts of the Model. "Hot" means "containing high Virtual Energy." The relationship between real (blood sugar) energy and Virtual Energy has a general form that is subject to variations (needed to satisfy other constraints). The general form incorporates a simple "monotonic" constraint where more real energy flowing into a neuronal group means that the group has more Virtual Energy to contribute to the generation and maintenance of phases that exist in assemblies of neuronal groups.

There is no ***conflict*** between a Thermal Model based on Virtual Energy and a mechanical model proposed in the conventional view. Under the mechanics' view, any result correctly suggested by a Thermal Model will be confirmed by mechanics. Conversely, thermodynamics incorporates Newton's Laws and all their implications, at least at the working end. I suppose that the Virtual Energy that the Thermal Model sees is "the same" as the signals that the conventional model sees but with a different instrument. The Thermal Model is an approach that is, in comparison with the conventional approach, coarse, primal and action-oriented but it has some advantages that may be useful here.

I suggest that a Thermal Model allows for conceptualization that is similar to juxtaposition concept formation in § 3. Juxtaposition may be available for concept formation under circumstances where Reality is not subject to synthesis concept formation. A successful mechanical model would be more satisfying than the clumsy Thermal Model but, lacking a successful mechanical model, a Thermal Model is worth considering.

In the Model, I also suggest that ***all concept formation is initially juxtaposition concept formation***. Synthesis concept formation is a ***particular kind*** of juxtaposition concept formation where ***additional conditions*** or constraints allow for greater insight and control over activity. When and to the extent these conditions or constraints are imposed, synthesis can be accomplished. (These are sufficient conditions but maybe not necessary conditions.) I sum up such additional conditions as ***covariant continuous differentiability.*** Section 12 explores the advantages of imposing these conditions on a subject matter. These conditions are most conveniently approached from the direction opposite to their listing,, i.e., first "differentiability," then "continuous," then "covariant."

"Differentiability" means that there is a general subject matter (which may be an activity, a property like temperature, a feeling like impatience or a large-scale context like time) where particular instances can be organized by means of a space, spectrum, grade or other concept of progression that I collect under the class ***dimension***. Thus, differentiability appears when intelligence is engaging a subject matter in Reality that supports attachment by a structure involving a general class of particular instances organized by a dimension.

"Continuous" means that the subject matter of the activity in Reality that intelligence is engaging supports attachment by the differential structure as previously described and that the particular activity in Reality that is being engaged supports attachment by an imaged (imaginary) smooth (continuous) course of attachment in terms of the dimension. I imagine the model train tracking unseen "in the tunnel" where I can no longer see it. Or, to show the versatility of imagination: "Now you tell me I have to wait another week for your business plan and I am becoming more doubtful about the success of this venture every time I talk to you."

"Covariant" means that, when activity in Reality supports, e.g., two different continuously differentiable subject matters, that activity also supports imagery where there is a relationship or a system of relationships that organizes one continuous course of attachment in terms of attachments of the other.

The simplest covariant continuous differentiable structure I know is {red-stop, green-go}. It is questionable whether {two states-two acts} is "large" enough to be "continuous," but I assign such status to this structure as a way of formulating a "complete set." A better representative but still simple example of a covariant continuous differentiable structure is the trajectory of a projectile thrown vertically in terms of height and time. A thermodynamic example is the "equilibrium liquid-gas line" that is prominent on pressure-volume graphs ("indicator diagrams"), e.g., showing the equilibrium co-existence states of liquid water and Steam.

Accordingly, I suggest that when Reality provides subject matter that supports covariant continuous differentiability, intelligence using juxtaposition concept formation can produce concepts that also qualify as syntheses. To the extent synthetic concepts describe the activity, we "understand" the activity.

A conceptual Structural Engine shows how concepts can be formed by juxtaposition in an episodic, periodic way. The Thermal Model of brains seeks to develop these notions by use of the science of physics. In physics, an Ideal Model is constructed so that important matters in the subject matter in Reality attach to features in the Ideal Model; the Ideal Model is subject to investigation and variation; and results obtained from the Ideal Model say something useful about the subject matter. Here, the goal is construction of an Ideal Brain and identification of the subject matters in Reality that support ideal activity by the Ideal Brain. The Ideal Brain is ideal because it can successfully engage such subject matters in ways that are illuminating and that help suggest further investigation.

In the Thermal Mode, different kinds of neuronal activity are called ***phases***. As the word was originally used, a phase identifies a pervasive condition of a body of matter and heat can change matter from one phase to another. In ordinary life, ice, liquid water and steam and their changes among themselves are familiar examples. The concept has proved to be very powerful and the word "phase" means, e.g., a particular form taken by a mixture or alloy of metals and a particular kind of muscular activity.

The Thermal Model uses conventional anatomy and basic neurology of brains where individual cells, neurons, are organized into groups and the groups interact. I suggest that specific classes of neuronal activity can be organized by a concept of phases where a phase is defined in terms of a specific assembly of neuronal groups that supports a circulating pulse of Virtual Energy. That is, a circulating pulse of Virtual Energy is the neuronal activity that identifies a phase; and such circulation is specific to the neuronal groups (and connections between neuronal groups) involved in the circuit of circulation. This concept of phase incorporates a dimension, namely the number of pulses sustained at a given time (alternatively, the frequency of pulsing). The particularity involved in the phase is based on the particular Neuronal Groups involved in the circuit and in the particularities of their Virtual Energy transfers. (Such particularities are subject to modification by "heating waves" and "cooling waves.")

As a principle of brain/mind correspondence, I suppose that such a concept of phase corresponds both to repetitively conscious perceptions, actions and/or intentions as well as to any parallel non-conscious activity. Repetitive activity is especially suitable for investigation and, to get the sharpest focus on problems, I often narrow my use of the word "phase" to refer to activity that is repetitive (or nearly so) in both brains and Reality, like a ping-pong player practicing services or a clerk visually reading paper information and entering the data with a keyboard.

In metallurgy, alloys go through large-scale phase changes that are especially illuminating. An alloy starts off as a mixture of metals and other elements in fixed proportions. For example, an ordinary steel is iron with 0.4% carbon. Aluminum with 4% copper is another popular alloy. The ingredients are cooked and a final phase is produced.

A phase of an alloy identifies a particular repeated arrangement of nuclei in a "unit cell" that is repeated like a wallpaper pattern in three dimension. The arrangement can be different at different temperatures and the arrangement can change abruptly. That is, a change in the temperature may cause an alloy to change phase. Tin is strong above a certain temperature and is called "white tin." If tin is exposed to cold for a long time, it will turn into a crumbly phase called "gray tin." Gray tin killed many soldiers during winter battles in World War II. (This phase change takes a long time to proceed toward completion.) There is one lattice arrangement at high temperatures where the bulk metal is strong; there is another lattice arrangement at the low temperature where the bulk metal is weak.

We will closely examine steel. Simplified for purposes of discussion, steels exist in one phase above 730 °C, ***austenite***, and in several possible phases below that temperature, e.g., ***pearlite***, ***bainite***, ***ferrite*** and ***martensite***.

Which phase is present at the lower temperature depends on (a) the ***composition*** of the alloy, i.e., the particular materials and their proportions; and (2) the ***heat treatment***, chiefly the way in which the material was brought from the higher temperature to the lower temperature, also known as ***the quench***. Alloys can be quenched, e.g., in air, in oil, in cold water or in very cold brine; and partial quenches can be targeted to different temperatures. Each quench or each sequence of partial quenches will lead to a different result.

Each kind of steel has particular properties. For example, bainite, developed by Edgar C. Bain, an employee of United States Steel during the 1930's and 1940's, is especially ***tough***, as well as ***hard***. Pure iron is ***soft***. Martensite is hard but ***brittle***.

"Toughness" is an empirically observed or "phenomenological" property of materials that varies on a scale with "tough" at one end and "brittle" at the other end. Tough material absorbs energy in action without breaking or fracturing; to measure toughness, you see how much impact the material will absorb and/or how long you can bend the material back and forth before it fails.

Contrast "toughness" with the "hardness" property that varies between "hard" at one end and "soft" at the other. Hard material resists pressure in a static way: to measure hardness, you support the material underneath, apply weight to the material from the top concentrated onto a small area, and measure the deformation.

Examples illustrate the differences. Well-cured leather is tough and soft. Glass is hard and brittle. In the "as-quenched" condition, martensite is very hard and also quite brittle; it can be toughened with a moderating heat treatment called ***tempering*** that also softens the steel. Bainite is both hard and tough without tempering and has uses for which it is particularly suitable, e.g., springs.

A single piece of steel can be soft or hard, tough or brittle, depending on the heat treatment. Because pearlite, bainite, ferrite and martensite all revert to austenite above 730 °C as "if new," a single piece of steel can be "cycled" between phases by heat treatments. Austenite to bainite to ausenite to pearlite to austenite, etc. Note that if: (1) martensite is first obtained; then (2) the temperature is raised to the austenitic range; and finally (3) there is a new martensitic quench – then: the ***details*** of the new structure will be different from that of the old martensite (there will be different arrangements of nuclei) even though the ***properties*** of the new phase may be "the same" as the old (and the two phases are thus "the same"). In parallel, in the Thermal Model, I suggest that such "phasic cycling" occurs in brains and that "cycling groups in and out of the Neuronal Critical State" by means of a Structural Engine is the driving force of such "phasic cycling."

It is easy to see, using atomic imagery, how the properties of steel depend on the heat treatment. Simple steel is an alloy of iron and a tiny amount of carbon, e.g., 0.4 % carbon by weight. There are two chief ways iron nuclei are arranged in bulk and which arrangement the iron takes is dependent on temperature. Above roughly 730 °C, iron takes the form of a "face-centered cubic" (fcc) arrangement – this is austenite; below 730 °C, the "body-centered cubic" (bcc) arrangement is obtained.

Things are complicated at the lower temperature because of the carbon. In the fcc arrangement of austenitic "hot" iron, carbon nuclei ***dissolve in*** or move around among fixed iron nuclei and the arrangement is relatively free of distortion. On the other hand, carbon nuclei do not fit easily into a "cold" bcc structure and, when the temperature is lowered and the iron nuclei go through a rearrangement from fcc toward bcc, there must be an adjustment in some fashion. Typically, iron nuclei reform, "excluding" carbon nuclei that "precipitate out" and form groupings scattered about the metal, while the new iron structures are distorted because of the precipitated particles. ***How*** the adjustment is made depends on the quench. A slow quench allows the carbon nuclei to get organized into large, orderly aggregates while a fast quench freezes things in transition and generates lots of misfits.

Misfits are described as fields of stress (force) and strain (distortion) and the misfits and precipitated carbon particles in the iron matrix prevent easy motion of blocs of iron atoms and thus are the basis for the hardness and other properties of steels. For example, bending a piece of metal may introduce additional defects and these tend to block further bending. When an arrangement of iron and particles is such that defects aggregate around a particle and produce more defects as bending continues, holes will develop and the metal will fracture. Another, different arrangement of iron and particles does not lead to aggregation and fracture. There is a ***phenomenological*** relationship between microstructure and aggregate properties. This is different from the ***mathematical*** relationship between microstructure and aggregate properties presumed by the conventional view.

Although overall properties of a final phase of steel can be specified and achieved on the basis of a known composition and heat treatment, no person could conceivably follow the motions of iron nuclei and carbon nuclei and ascertain bulk properties from the motions. Nor is it possible to predict the results of a new heat treatment. Bainite did not exist until E. C. Bain invented the new heat treatment. Of course he did so by application of metallurgical principles (see the classic Bain, *Alloying Elements in Steel* (1939) available online at http://www.msm.cam.ac.uk/phase-trans/2004/Bain.Alloying/ecbain.html), but the metallurgical principles were only guidances and actual knowledge had to be obtained in the laboratory. The only way to find out what a quench will do is to conduct the quench.

Two kinds of specific quenches are "as fast as possible" and "as slow as possible." "As slow as possible" takes place in a furnace where the temperature is gradually lowered. This means that results are rigorously reproducible and can be investigated in fine detail. Results are useful and available as "TTT diagrams" relating percentage_Transformed to Time and Temperature for many alloys. For a quench as slow as possible, a composition of 0.83 % carbon will result in a pearlite phase extending over the entire sample and this composition and quench constitute an "Ideal" for steelmakers. A quench "as slow as possible" results in reversible (equilibrium) phase transitions.

A quench "as fast as possible" results in martensite and martensite is the nonequilibrium phase transition. "[H]ardening of steel by quenching to obtain martensite is arguably one of the most important of all technological processes." D. A. Porter and K. E. Easterling, *Phase Transitions in Metals and Alloys* (2d ed. 1992) at 428.

Pearlite is formed by a slow quench and the slow lowering of the temperature allows the nuclei time to find overall rearrangement through migration or ***diffusion***. In contrast, ***nucleation events*** occur during a fast quench and the transformation to martensite is more dramatic. "A single plate of martensite in steel grows in 10^{-5} to 10^{-7} s to its full size, at velocities approaching the speed of sound ... speeds of 800-1100 m/s have been measured. The nucleation of martensite influences the strength and toughness of martensitic steels, since for a given austenite grain size, if the number of nuclei is large, then the final grain size of the martensite will be finer and hence the steel may be stronger." Porter & Easterling, supra, at 397-398. ("Nuclei" here refer to a "seed" of martensite that grows by invasion of surrounding austenite. Many seeds mean smaller final grain size.)

Rapid massive activity during phase changes in steel suggests possible imagery for the fast speed with which large-scale neuronal activity sometimes resolves into determined action, e.g., during ping-pong strokes. It is like a phase transformation in steel during a fast quench when change sweeps at high velocity over an entire system. There is a result because there has to be a result that is being driven by the quench. The result may not be the best-fitting result, as seen in retrospect, but it is one that can be and is achieved. Similarly, "nucleation" suggests occasions when, during fast decision-making, a person "seizes" upon a few details, momentarily considered most important, and bases the decision chiefly on those details. I think of "final grain size" as metaphorically describing texture of experience that varies in quantity and depth of detail according to the ways in which the experience is or can be generated. "Covariant continuous differentiability," if available in an ideal way, produces the smallest possible grain size.

An important conclusion of these Researches is something like "grain size of knowledge" measures the ***susceptibility*** of Reality to our structures. Mapping Reality with Structural Engines is the theme of § 12 and susceptibility is a measure of whether and to what extent such mapping is possible. In § 4, I suggest that there are parts of Reality that ***cannot*** be structured as thoroughly as we should like; these are ***insusceptible*** to our attempts. When we investigate susceptible aspects of Reality, e.g., laboratory study of specially prepared metal samples, we can obtain knowledge so "fine-grained" that further refinements would be inconsequential; and these are the aspects that afford us our most thorough knowledge. In contrast, I suggest that during the "rough judgments" of juridical law, grain size of knowledge is "blocky" and an exercise of freedom is involved. I distinguish between ***dense texture*** and ***open texture***; scientific knowledge is characterized by dense texture and juridical knowledge by open texture. ("Open texture" is a concept developed by H. L. A. Hart in *The Concept of Law* (1961).)

Under controlled conditions, a billet of iron loudly "clicks" as it undergoes a martensitic transformation. Sometimes, the outpouring of energy during a martensitic transformation is more dramatic. As stated in a Cornell University web page on "A Brief History of Martensites," (http://www.lassp.cornell.edu/sethna/Tweed/Martensite_History.html) (I have added the emphasis):

> The technique of quenching the iron into cold water is mentioned in this gruesome description in Homer's Odyssey, describing the blinding of the giant Cyclops (who had imprisoned Odysseus and his men in a cave). After getting Cyclops drunk, they heat an olive stake and plunge it into his one eye:
>
> "The blast and scorch of the burning ball singed all his eyebrows and eyelids, and the fire made the roots of his eye crackle. As when a man who works as ***a blacksmith plunges a screaming great axe blade or plane into cold water, treating it for temper***, ***since this is the way steel is made strong***, even so Cyclops' eye sizzles about the beam of the olive." (Translation after Richard Lattimore.)
>
> (Apparently the translation "treating it for temper" is a translator's anachronism representing our modern viewpoint.)

In the Thermal Model of Consciousness, the "quench," called ***the cooling wave***, is a most important matter conceptually. During the cooling wave, neurons begin in a state of undifferentiated, high-energy neuronal activity in a "secret compartment" and they end up in a state of lower-energy neuronal activity particularized in a phase, one among several possibilities. E.g., ends up with a particular ping-pong stroke. ***How*** a particular phase emerges from the secret compartment is not within the reach of the Model and there is often no predicting the final phase based on prior knowledge.

According to the Model, the emergence of a particular phase is achieved by imposing particular constraints during a cooling wave. I further suggest that under some conditions, coordinating the constraints and the processes can lead to reproducible results and even to compulsory agreement among persons. Each person's brains are subject to different particular arrangements and varying histories, but operating principles are similar so that when different persons engage certain subject matters but not others, the results converge as closely as desired.

§ 8 Designing an Ideal brain based on Virtual Energy

In the Thermal Model, heat treatments are incorporated into a Structural Engine, a ***cyclical conceptual device***. Features of design and operation of a Structural Engine resemble those of Heat Engines that have been extensively studied in thermodynamics and that provide useful models and ways of thinking. The cycling of the Structural Engine is the heating and cooling of neuronal activity in terms of Virtual Energy.

As I use the word, an Engine is a ***device that uses a working substance to engage Reality and produce a desired output***. Heat Engines produce physical work, e.g., lifting heavy objects. In steam engines, the original kind of Heat Engine, the working substance was steam. Steam engines illustrate the principles better than internal combustion engines used in automobiles. A Structural Engine produces structured combinations, e.g., the structure of particular sensory impressions, particular muscular acts and particular intentions combined into a ping-pong stroke. I suggest that, when engaged in some tasks, the activities of brains can be investigated in terms of a model where neuronal activity is treated as the working substance of a Structural Engine. A major task of the Thermal Model is to show how this could be so.

James Watt (1736 - 1819) made a world-changing improvement in steam engines: he separated the source of heat from the source of cold, greatly increasing efficiency. In a Watt engine, there is a particular ***cold spot*** where the steam condenses. The Newcomen engine required cooling of massive machinery. Just as important, what had been spurts of work in the Newcomen engine could, in the Watt engine, be smoothed into a continuous stream of power. Metaphorically, the Newcomen engine was like juxtaposition concept formation while the Watt engine was like synthesis concept formation.

In the Structural Engine, there are "cold spots" that are sources of "the cooling wave" and that have a functional importance comparable to that of the "cold spot" in steam engines. As I imagine the central activity of conscious brains, what starts as highly-energized and unstable neuronal activity is "cooled" (energy is dissipated) and new patterns develop that "fit in" with constraining neuronal patterns that remain stable throughout the process. ***The "stable patterns"***

are the "cold points." In both mechanics and thermodynamics, a stable pattern can absorb energy without losing stability, the amount that can be absorbed depending on the pattern and the conditions.

Carrying this image back to the ping-pong example, I suggest that particular "cold spot" stable patterns are a basis for object structures, repertoire of acts and sustained purpose. E.g., I suggest that a particular "cold spot" stable pattern is involved as part of a sustained purpose (to win!) with respect to which transient intentions are generated. In other words, according to the Model, a purpose is a stable activity pattern that constrains activity of a Structural Engine and the constraint takes the form of a "cold spot." Likewise, as the stroke develops, "cold spots" are "Ideal strokes" that shape the developing muscular act. There is an all-important "cold spot" called "the ball."

Adherents of the conventional view see brains as continuously operating, in the style of a computer where streams of bits are combined in a more-or-less steady fashion and under fixed operating conditions. The alternative view sees activity as ***episodic***. Episodes are distinct in time and subject matter. Each episode involves a sequence of activities closely-related by reason of involvement in a specific subject matter, but with separate episodes more distantly connected and perhaps not connected at all. In the alternative view, episodic structure pervades activity at all scales and includes activity, e.g., a neuron, a neuronal group, a person and a group of persons. I describe a repetitive nature of episodes as: readiness, trigger/release, relaxation and recharging.

One key feature of episodic activity is that two or more rhythms can be going on simultaneously. Activity that incorporates multiple rhythms can be organized in many ways and some subject matters can be accurately described by repetitive episodic activity on the basis of multiple rhythms. Ptolemy's astronomy, based conceptually on wheels within wheels, did very well for many practical purposes. In a simple-minded way, some instances of coordinating covariant continuous differentiation, as described is § 12, can be described in terms of a gear system subject to a multitude of different arrangements and where each gear has a variable number of teeth (if the Thermal Model is reduced to a gear system, each "tooth" is a circulating pulse of Virtual Energy).

In the Thermal Model, simultaneous activities operate at variable frequencies, all adjusting to engage Reality most efficaciously to achieve a purpose. Low frequency activity constrains higher frequency activity. I suppose that a Structural Engine goes through many cycles between re-adjustments to circumstances. E.g., the general approach is to: (1) structure some stuff using many cycles; (2) adjust to changed circumstances and/or move to a new engagement; (3) structure some more stuff using many cycles; (4) adjust and move; (5) structure etc. Each stage of structuring is different because of different constraints imposed according to circumstances. I suppose that constraints are grounded in perceptions, in memories retained in stable patterns and in operating conditions of the system.

In the Thermal Model, the "energy" is ***Virtual Energy***, a reconstructed concepts that starts with ***real energy*** (blood sugar flow). Virtual Energy moves when there is a relocation of real energy;

this is based mathematically on a differential relationship in the nature of a functional, but with fluctuations added. In imagery, the motion of Virtual Energy resembles the wavy motion of water in a bathtub when the person in the tub changes position. An incremental change in positioning of real energy results in flows of Virtual Energy to the newly higher real energy neurons (neurons getting more blood sugar) from the newly-lower real energy neurons (less blood sugar). This means that Virtual Energy flows from "cold" to "hot," but Virtual Energy involves a "sign flip" and this is where the sign flip comes in. (A neuroscientist's ***action potential*** in a neuron is a traveling "energy hole" in the electrical field of the neuron's axon.) The quantity of Virtual Energy is constrained but subject to variation. It is as if, at any moment, the amount of water in the bathtub is fixed but also as if both the size of the bathtub and the quantity of water in it may depend on how much the person is thrashing about. Virtual Energy can also support artifactual cyclical patterns that are independent of real energy (like eddies in bathwater) and that can provide new linkups between sustained cyclical patterns based on blood sugar, mimicking activity of imagination; the amount of Virtual Energy available for such artifactual patterns is similarly constrained.

The foregoing has focused attention on the "cold spots," or ***virtual energy sinks***. There are also, of course, ***sources*** of virtual energy, called ***twinklers*** herein. I emphasize cold spots initially because the concept is more difficult and because of their relationship to the other difficult concept, the quench.

The most obvious twinklers are those that generate pain. A source of pain, like a toothache, can be quiescent but suddenly flare up. At the other extreme, a twinkler can be based in a goal that motivates a person, such as an anticipated reward or an Ideal. In the middle ground, according to a folk practice, memory, modeled by a twinkler, can be aroused by a string around a finger.

A Structural Engine applies these principles. In a Structural Engine, important divisions are defined by ***thermodynamic surfaces*** or ***control surfaces***. A thermodynamic surface or control surface is a ***conceptual*** surface in ordinary (width-height-length or *x-y-z*) space. I conceive of them, e.g., in brains and in Structural Engines. For every thermodynamic surface, there are two sides and they are clearly separated by the surface. A thermodynamic surface typically has different stuff happening on the two sides, e.g, one phase on one side and a different phase on the other see. In general, a thermodynamic surface, a concept, can be moved or deformed if necessary or desired, like a stretchable beach ball.

In biology, cell membranes define thermodynamic surfaces. In both Heat Engines and Structural Engines, compartments holding working substances are defined by thermodynamic surfaces that are control surfaces. There is a moveable control surface in a Heat Engine, namely, the inner face of a moving piston is a movable control surface;. There are similar moveable control surfaces in a Structural Engine.

In Structural Engines, there are three thermodynamic or control surfaces.

(1) A ***system surface*** separates the entire system from its environment. The system surface is

closed and simply connected like a soap bubble or a beach ball. As applied to brains, the system surface is defined by the exterior membranes of nervous tissues. What is inside is chiefly constituted by the central and peripheral nervous systems. To define the system surface rigorously in imagery would separate nerve cells from muscles, nerve cells from glands and sensory nerve cells from sensory organs in which such sensory nerve cells are located. The system surface is the least important of the thermodynamic surfaces and fine points are inconsequential.

(2) The ***zone surface***, entirely inside the system surface, separates a region where neuronal activity is stable (outside the zone surface) from a region in which unstable activity may be occurring (inside the zone surface). In other words, inside the zone surface, ***plastic change in neuronal activity*** is possible but not outside. (I presume that plastic change is change in function and not change in anatomy or change in location.) The purpose of the zone surface is to ***confine*** plastic change but any ***definition*** would occur by other means. A zone surface need not be exactly defined but is presumptively definable if need be.

I presume that the zone surface (or something similar) in a person's brains changes from time to time, e.g., as the persons ceases doing one task and turns to another. A zone surface change corresponds to a re-apportionment of blood flow carrying blood sugar that fuels neuronal activity, i.e., after the change, some neurons get more blood sugar than before and some get less sugar. I presume such re-apportionments occur continually but that the tempo is slow with respect to other activity and that, e.g., many strokes of a Structural Engine can occur between re-apportionments. For example, the concept of Structural Engine might describe activity of a bird that twitches its head a number of times, moves to a different position, twitches its head a number of times, relocates, etc.

The ***system zone*** lies between the system surface and the zone surface. In the system zone, activity patterns are fixed in comparison to changes in other activity patterns. Fixed activity patterns in the system zone are Virtual Energy sinks in the Thermal Model.

(3) The ***Surface of Consciousness***, entirely inside the zone surface, is the "innermost surface" with a space inside the Surface that is all in one piece. Inside the Surface of Consciousness is the ***Domain of Consciousness***. Between the Surface of Consciousness and the zone surface is the ***plastic region***, noted above, where activity tends toward stabilization but where modifications are going on and change is implicitly possible in multiple ways.

Conceptually, the Surface of Consciousness in a Structural Engine is "sharp" or "narrow." At any given moment, the transition in space from the Domain of Consciousness to the plastic zone is abrupt. This requirement appears to be unnecessarily constraining and some relaxation may be appropriate for a more refined version, but it helps to maintain the "sharp" constraint at the outset. Note that a sharp boundary or surface is consistent with a boundary that is also complex or "finely-fingered." Something like fine fingers appear to be available in human brains in the form of the ***thalamocortical system*** discussed, e.g., in G. M. Edelman and G. Tononi, *A Universe of Consciousness* (2000). (The thalamocortical system is a dense network of connections involving the ***thalamus***, a brain organ at the anatomical center that "directs traffic," and the ***cortex,*** the upper external "cauliflowerets" of the exposed brain, where refined mental activity supposedly occurs.) Assuming such physical embodiment, I might suggest that Consciousness "dwells" in the thalamocortical system but such specificity is not essential to my view.

In the Thermal Model, the Domain of Consciousness is the region for neuronal activity presumed to be real and unknowable. The Surface of Consciousness is conceptually defined to include that activity within the surface but no other. In the Thermal Model, the activity inside the Surface of Consciousness is neuronal activity in the high-energy Neuronal Critical State . In other words, in the Model, the reach of the Neuronal Critical State is defined by the Surface of Consciousness and neuronal critical state activity "is" activity of consciousness. The Domain of Conscious is the "secret compartment" of the Structural Engine; and the Surface of Consciousness separates matters that are presumptively real and unknowable in the Domain of Consciousness from matters where investigation is appropriate in the plastic zone.

For purposes of the Thermal Model, ***the practical effect of "activity of consciousness" is motion of the Surface of Consciousness*** in a Structural Engine. Compare this to the motion of the piston in a steam engine.

In an ideal situation, the motion of the Surface of Consciousness is cyclical: it expands and contracts in a repetitive way. When the surface expands, neuronal activity taken inside is charged with energy and patterns previously established are destabilized or "erased." When the surface contracts, energy is dissipated and new patterns emerge in accord with constraints that are maintained throughout (the new patterns are influenced as well by activity happening during the emergence).

The Model does not directly describe motion of the Surface of Consciousness. Rather, the Model describes the Surface of Consciousness in different places at different times and motion is inferred. The Model is thus limited but in a way conformable to thermodynamics.

In other words, there are matters whereof the Model cannot speak and as to which the Model must remain silent. Such matters include what is going on inside the Surface of Consciousness and what is going on between steps and/or strokes of a Structural Engine. These matters are included in zones of ***abstinence***. As to matters in zones of abstinence, imagery may be helpful in suggesting possibilities but cannot serve as guidance. I offer some such imagery in the form of speculations according to a practice of licentious abstinence.

§ 9 Conscious Thoughts Streaming from Hot Sugar Twinklers

The presentation is now directed toward conceptual construction of an "Ideal Thermal Brain." The purpose of an Ideal thermal Brain is to use the Thermal Model to design a system that imitates activity of intelligence engaging Reality as to simple and objective matters in the clearest and most efficient ways possible.

One advantage of strictly constraining the model to simple, objective matters is that a mechanical analog can be used. In other words, both mechanical models and the Thermal Model can engage Reality as to simple, objective matters and the activity of the Thermal Model itself can be described in terms of a mechanical model. See § 12. This does not mean that the Thermal Model is a mechanical model, only that its operations can be mechanically described under some circumstances and those circumstances are Ideal for studying the Thermal Model. This advantage imitates that enjoyed by the Carnot Heat Engine that is used to study real engines.

As a preliminary matter, I disclaim any expertise in brains. I have read about brains from a perspective provided by the Thermal Model and my views are expressly limited and partial. Although the Model is based on methods of physics, there are no novel mathematical formulations. The presentation is chiefly imagery and intentionally vague in statements and specifications in important ways. Science often begins with imagery, e.g., Faraday's imagery of electric fields that preceded and led to their representation in mathematical formulations. The most difficult decisions in conceptual development involve narrowing in on specifications in sequenced ways that lead to a useful result. Narrowing in is a progressive task where every statement leaves some matters unspecified. Statements and specifications set forth herein are interim and provisional.

D. R. Chialvo, "Critical brain networks," Physica A 340 (2004) 756-765 provides a useful statement of issues and problems as seen from the conventional view. "One of the simplest things we do not know about the brain is how the cortex, being a mainly excitatory network, prevents the expected explosive propagation of activity and still transmits information across areas. If the average number of neurons activated by one neuron is too high (i.e., supercritical) this results in the massive activation of the entire network, while if it is too low (i.e., subcritical), propagation dies out. The critical regime is the one in which these opposing processes are balanced." Chialvo has no suggestion about "one of the simplest things" or about how "opposing process are balanced." [The nature of "explosive propagation of activity" in brains has been intensively studied in connection with epilepsy but such matters are beyond the reach of these *Researches*.]

The "simplest thing" is the basis of the Thermal Model of brains, namely ***energy***. Energy in brains is in the form of ***sugar*** (glucose) and sugar concentrations in brains can be viewed in images obtained through Positron Emission Tomography (PET) technology used in clinical medicine and research. These images show that, during any activity, some parts of brains are rich in energy and presumed to be highly active and other parts are relatively impoverished as to energy and presumed to be relatively inactive. A ***distribution*** of sugar flow states which parts of brains are getting more sugar and which less. There are strong correlations between different distributions of sugar and different tasks for any particular person, and there are correlations that relate distributions and tasks for a group of persons studied as a population (e.g., with averaged results). These show, e.g., that when a person is engaging in eye-hand coordination, much "the same" distribution of sugar is found in any person's brains regardless of the particular task of coordination or the particular person. Any conceivable model for brains must correlate blood sugar flow with neuronal activity with consciousness.

On the basis of energy, the reason more neurons don't get involved in the "expected explosive propagation of activity" is that activity takes energy and there's only so much energy available. To dramatize the situation, I say: ***neurons are in competition for energy***. This dramatization incorporates causal constructs that are troublesome because of chicken-egg problems. (More activity draws more energy that fuels more activity, "feeding back" "explosively" – oops, until constrained by system limits that are not known.)

I suggest that the "competition" has important consequences because there are advantages available to neurons "in competition." I suggest that the "reason" neurons combine their activity into aggregates is "because" they get an advantage in the competition for blood sugar when their activities are combined. There appear to be pinpoint biological "mechanism" involving blood circulation in brains that have such effects. (See, e.g., M. Zonta et. al., *Neuron-to astrocyte signaling is central to the dynamic control of brain microcirculation*, Nat. Neurosci, 6, 43-52 (2003).) But the advantage gained by neurons acting in combination has limits: there is a fixed amount of sugar flow available and high sugar for some neurons is achieved "at the expense" of the sugar consumed by other neurons.

In thermodynamics, energy flows from "hot" to "cold," i.e., from a region of high activity to a region of lower activity. In a Heat Engine, a productive (power) stroke involves a change in activity of the working substance from hot to cold and a corresponding loss of energy in the working substance that is channeled to produce useful work outside the Engine. Carnot, who first stated the physics of Heat Engines, said that there was a "falling" and that the "falling" produced work.

In a Structural Engine, the productive part of a stroke is during ***the cooling wave***. The thermodynamic Surface of Consciousness ***contracts*** and neurons previously in undifferentiated high-energy activity become ***detached from*** the Domain of Consciousness. ***Detachment from the Domain of Consciousness is what generates conscious experience.***

In the psychological aspect, the cooling wave produces experience. In the physical aspect, the energy flows away from high-energy undifferentiated activity in the Neuronal Critical State and, when the energy flows away, that activity "falls" into a particular neuronal pattern, a phase. ***It is the "falling" of activity from the Neuronal Critical State into particular neuronal patterns that generates consciousness; and the consciousness is consciousness of the particular neuronal activity patterns into which the activity is falling and of the "cold spot" sustained patterns that are absorbing Virtual Energy being dissipated***. In other words, according to the Model, there is experience that is based on high rates of change in Virtual Energy flows in Neuronal Groups during establishment of particular phasic dynamic patterns upon relaxation from the high-energy Neuronal Critical State.

For example, in a ping-pong stroke, the "readiness" energy is released and flows into particular neuronal patterns corresponding to particular perceptions, particular acts and particular intentions and based on sustained "cold spot" neuronal patterns. Sustained patterns are regions of low-energy activity and can absorb energy without destabilizing (at least to an extent).

In an active, episodic way, the Model suggests that experience is generated through activity of Structural Engines, both spatially and temporally and that experience arises as a result of Virtual Energy flows that generate stable phases, which identify individual experiences.

In this imagery, when Virtual Energy simultaneously falls into two or more particular neuronal patterns, generating consciousness of those neuronal patterns in combination, those neuronal patterns are united in a structure that is initially momentary but that can be sustained and combined with other structures into new and longer-lived patterns that may become permanent through additional structuring activity. This is how the Model imitates Piaget's ***schema***, discussed in § 3. One such schema is {red-stop, green-go}.

Imagining an Ideal Brain in animation, there is a repetitive cycle where a separation of high-energy activity from low-energy activity is followed by a flow of Virtual Energy away from the high-energy region but constrained by activity in low-energy regions which absorbs discharged energy; and new patterns emerge spatially intermediate between the high-energy activity and the low-energy activity; and this part of the cycle is followed by a new separation of energy levels that takes the cycle into a new turn. During the flow of Virtual Energy away from high-energy activity, consciousness is established when particular patterns of activity are established. Consciousness is consciousness ***of*** those patterns. It is happening during the "quench" or "the cooling wave."

In the Thermal Model, consciousness sometimes exercises ***selectional power*** – "freedom" according to the folk definition stated in § 1 – that is, the power to select ***which*** particular neuronal patterns are established during the cooling wave. In terms of energy, there is no basis for selecting one over another and I presume that, supposing favorable circumstances, any one of several patterns could be established consistent with energy constraints. The Model images this selectional power and shows ***that*** the selectional power is exercised. However, the Model abstains from statements about ***how*** that selectional power is exercised. The selectional power is exercised in a "secret compartment."

In §12, I suggest that, in an Ideal Brain engaging Reality as to objective matters, the "secret compartment" can be so tightly constrained as to represented by a mechanical model where there is a defined object called a ***twinker***. For purposes of discussion, I presume that such a object can be defined and generalized to describe activity of human intelligence. ***A twinkler is a source of Virtual Energy situated in a region of neuronal critical state activity and Virtual Energy, during outward flow, resolves into neuronal activity patterns and generates consciousness of those particular patterns.*** A twinkler is located inside the Domain of Consciousness but just at the Surface of Consciousness. In an Ideal Brain, the Domain of Consciousness can be ***reduced*** to twinklers under some circumstances and can thus perhaps become an object for technological investigation. The notion is that twinklers constitute a decomposition of one huge mysterious secret compartment into a set of small, specific secret compartments, some of which may even be opened for partial viewing.

Important features of the Model are imitative of the Gibbs Energy approach to phase transitions in metal alloys. Gibbs Energy is a function that assigns to each phase a number based on the temperature, pressure, etc. and such that, ***when a system is in a stable state where phases coexist, there is no difference in Gibbs Energy between the phases involved***. This is, when equilibrium phase transitions occur, "no Gibbs Energy" is required to change from one phase to another. In thermodynamic models, that's why both phases co-exist. As the temperature falls (and energy is dissipated), a difference between Gibbs Energies appears. At a temperature that just a tiny bit below the phase transition temperature, little Gibbs Energy is required to change material from one phase to another. Metallurgical models assume that small changes are being generated all the time by ***thermal fluctuations*** and these small changes can be seen as "attempts" to change phase. If conditions are favorable (Gibbs energy released by a change), the small change will grow large and occupy the entire material. If conditions are unfavorable (Gibbs energy would have to be consumed for further change), the small change will disappear. See, e.g., D. A. Porter and K. E. Easterling, *Phase Transitions in Metals and Alloys* (2d ed. 1992).

I suggest that, in the plastic region of a Structural Engine, there are neuronal groups that are, by reason of proximity to twinklers and higher levels of energy, involved in activity just below the Neuronal Critical State. Such activity may also involve temporary and/or transient activity patterns that may approach towards particular activity patterns of the stable sort where consciousness is generated when energy is dissipated. Perhaps initially the energy levels in the plastic region are too high for resolution into any particular activity pattern and the patterns in the plastic region are fragmentary and evanescent. As the energy level lowers, perhaps incrementally, patterns do resolve into particular patterns. If the energy level then rises incrementally back toward that of the Neuronal Critical State, patterns and fragments can interconvert, dissolve and re-form. Continuously varying patterns are conceivable under some circumstances, as formed under continuously varying constraints.

In this view, there are often coordinated resolutions into particular patterns. The activity of the Structural Engine involves more than a single particular pattern and the combination of particular patterns is produced by the activity. E.g., several patterns are produced simultaneously, like the perceptions, muscular acts and intentions of the ping-pong stroke; and/or patterns are sequenced, such as the notes played by a pianist. I suppose that selectional power of one twinkler can be coordinated with selectional powers of other twinklers and that relatively permanent patterns can coordinate phasic transitions with continuous variations and deformations so as to imitate covariant continuous differentiation.

§ 10 Shaping Thoughts with Warming and Cooling Brain Waves

No materials available for presentation.

§ 11 Howdy Doody vs. Mickey Mouse; or, There's a Real Person Pulling ***My*** Strings

In this section, I engage in speculation about matters real and unknowable under the auspices of "licentious abstention" described in § 5.

In the preceding sections, there are a number of different "secret compartments" that have been constructed in various domains of discourse. The chief instances are:

1. The secret compartment that produces a ping-pong stroke. (See § 2.)

2. The secret compartment that holds a "synthesis" (that is, a pervasive system of concepts constructed by synthesis concept formation) that would "explain juxtapositions" presently unexplained, presuming such a synthesis can be conceived. (See § 3.)

3. The secret compartment I suppose to exist in Reality that holds matters real and unknowable. (See § 4.)

4. The Domain of Consciousness in the Structural Engine about which statements are constrained by rules of abstention.

5. The secret compartment built into Virtual Energy that is based on real energy (blood sugar flow) but that supposedly involves "something more."

6. The secret compartment built into the Neuronal Critical State in which consciousness supposedly performs its unexplainable activity.

The secret compartments are interconnected by relations that have been constructed. Accordingly, the Thermal Model supposes that within the Domain of Consciousness there is occurring Neuronal Critical State activity that generates Virtual Energy. Activity of Consciousness (expressed through absorption and detachment of Neuronal Groups) is activity that is presumptively real and unknowable and that supposedly produces ping-pong strokes. Activity of Consciousness is supposedly imitated by a Structural Engine. A Structural Engine produces juxtapositions; but there are supposedly matters in Reality where the juxtapositions can be produced can be so as to support an image governed by covariant continuous differentiability and such an image, to the extent it can be constructed, supposedly constitutes a synthesis. These statements are statements of supposed relationships involving different secret compartments.

I suggest that such relations and connections add up to an Imitative Model of activity of intelligence and consciousness that has space for personal freedom.

The Models I propose are imitative only in that I suppose that there are human powers of selection guided by conscious thought that remain real but unknowable. In other words, any understanding of such selectional powers (presuming such understanding could be formed) falls on the blind spot of the mind. Such powers are exercised in secret compartments.

Such an analysis, however clumsy and contraptional, has, I suggest, a rough correspondence to activity of a marionette under the control of a person. The Structural Engine concept suggests that the Surface of Consciousness can be interpreted as a surface that separates the selectional control power of Consciousness (that I suppose to be real and unknowable) from activity in the plastic zone and in the non-plastic system zone. Hence, activity in the latter zones is subject to technological imitation. The marionette metaphor fits this division because the directing intelligence (the operator of a marionette) is in a "secret compartment," above the stage where the marionette performs, while activity of the marionette is open for investigation. Of course, the metaphor does not fit exactly; for example, taking the metaphor too far, the strings to the operator would enable the operator to see with the marionette's eyes, feel with marionette's fingers, etc.

A marionette metaphor is offensive to many philosophers. Under their views, the supposed "operator" of the marionette is given the derogatory name ***homunculus***. In § 1, above, Skinner denounced the notion of "the inner man, the homunculus, the possessing demon, the man defended by the literatures of freedom and dignity." "Who operates the homunculus?" it might be asked. My response is abstention based on limitations of intelligence and an inability to formulate an answer. I acknowledge that it would be better to construct Models that did not need to abstain from answering such an important question, but I am unable to construct such a better Model and I am taking an alternative approach.

C. Truesdell wrote in *Rational Thermodynamics* (1969) (p. 11) about the "laws of thermodynamics" as follows:

> I hesitate to use the terms "first law" and "second law" because there are almost as many "first and second 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 and give non-condemning names to the concrete mathematical axioms I wish to use in my outlaw studies of heat and temperature."

Although the suppositions of these Researches hardly rise to level of "concrete mathematical axioms" and suffer from many defects, I nonetheless presume to imitate my hero and to emulate Truesdell's exultant daring. With such an attitude, I even dare to suggest that ***a person*** dwells in the "secret compartments." So, I suggest, a ***person*** makes selections and exercises freedom. On what basis can such a person act? it is asked. On the basis of prior experience that includes attachments to a Reality supporting an integrated, even partially synthesized construction of that experience. Such overall construction, to the extent it is strong, corresponds to stable activity in the non-plastic system zone of a Structural Engine and makes up a person's nature.

The Objective Person Psychological Model develops the concept of an objective person as one with experience that is indisputably shared with all persons. I suggest that some activities of intelligence shared in common by all intelligent adults can be imitated by a Structural Engine producing experiences that are integrated through the Objective Person Psychological Model. It seems appropriate, therefore, to identify the person dwelling in the secret compartment as an ***objective person***. Based on the foregoing, I name that person "***Homunculus***." In brief, Homunculus dwells in the "secret compartment" of an objective person and runs Structural Engines from the inside. The Structural Engines engage Reality and are the means for Homunculus to engage Reality. For example, Homunculus generates and sustains a purpose to move to a different location and travels through a terrain to accomplish that purpose.

[Material not available for presentation would compare the conventional view with the alternative view by comparing two versions of a person. One version, the "Mickey Mouse version" is based on Steamboat Willie, the original animated cartoon created by Walt Disney (1901–1966). A series of static images is projected onto a screen and synthesized by the viewer into continuous action. Everything is explicit and known. Fantastic adventures can be shown but the image has no substantial personal character. The other version, Howdy Doody, created by Buffalo Bob Smith (1917-1998), was a marionette and the star of a children's television program that I saw when I was small. Howdy is operated from a secret compartment. Howdy is bound to his physical body, dependent on his operator and can participate in only very limited adventures, but, as part and parcel of those limitations, there is a genuine character, however childish . The two versions support suggestions about differences between the conventional view of persons and the alternative view, leading to the material below).]

...

At the center of the alternative view is a "secret compartment" containing matters presumptively real and unknowable. We want to describe the contents of the secret compartment but synthesized concepts do not enter there. Strict abstinence would require complete silence.

Licentious abstinence allows for some speculation about the contents of a secret compartment but only under constraint. A chief constraint is that the Model has very limited resources in this area: as a result of the focus on objectivity, there is no place in the Model for attachment of matters known only to oneself. In sum, we are talking about matters based on intimately personal experience; and such matters cannot be grounded in a Reality about which agreement among all intelligent persons is compulsory. One among the professors identified in § 1, or millions of other persons, might state reasons for not agreeing and it is proper for them to do so.

I proceed by seeking insight from a poet, Gerard Manley Hopkins, whose work I have long enjoyed. Hopkins leads to a recognized spiritual authority whose teachings fit into other themes of the *Researches* and I incorporate such borrowed teaching in a form adapted to my purposes. The authority is Duns Scotus (c. 1266-1308) ("John Duns of Scotland"), a theologian and philosopher belonging to the Order of monks founded by Saint Francis of Assisi (1182-1226), an Order generally known as the Franciscans.

A detour into medieval philosophy has several justifications. It provides another kind of alternative view that challenges the conventional scientific view. In *Science and the Modern World* (1925) at 76, Alfred North Whitehead (1861-1947) observed that there is a "radical inconsistency at the basis of modern life," namely: "A scientific realism, based on mechanism, is conjoined with an unwavering belief in the world of men and of the higher animals as being composed of self-determining organisms." In contrast, "the men of the Middle Ages were in pursuit of an excellency of which we have nearly forgotten the existence. They set before themselves the ideal of the attainment of a harmony of the understanding. We are content with superficial orderings from diverse arbitrary starting points."

When comparing two systems (e.g., the conventional view and my alternative view), the chief points of interest are agreement and disagreement. With three systems, a wider net can be cast. The following discussion involves a general notion of multiple comparisons and a chief purpose of the discussion is to demonstrate the need for multiple views, based on shortcomings in human intelligence.

Important medieval theologian/philosophers were given particular names of respect and Scotus was called "Doctor subtilis" or "The Subtle Doctor." He was the last of the great systemizers of the Thirteenth Century and he reconstructed his system on foundations established by his predecessors.

Scotus taught a ***Principle of Individuation*** or ***individual nature*** of a person – *haecceitas* or "thisness." Such an individual nature is a person's own character and is not shared with anyone else. The remainder of this section is chiefly directed at a statement of the Principle of Individuation and the way that Principle fits into the theological and philosophical system Scotus constructed. I am suggesting the possibility of including something like a Principle of Individuation in a philosophical system consistent with the alternative view and suggesting how such a Principle of Individuation might illuminate questions that have persisted from earliest times into the modern era.

In attending to the teaching of Scotus, I follow Gerard Manley Hopkins (1844-1889), whose sonnet "As kingfishers catch fire, dragonflies draw flame," provides the Motto of the Researches: "*What I do is me*." Hopkins' is a voice I hear speaking truths about the reality of a secret compartment. The sonnet is an express declaration of the Scotist view of God and nature and of how an individual person fits into that view.

"Unlike St. Thomas Aquinas, official theologian of the Jesuit order, Scotus attached great importance to individuality and personality. The difference, he said, between the concept of 'a man' and the concept of 'Socrates' is due to the addition to the specific nature (*humanitas*) of an individualizing difference, or final perfection, which makes 'this man *this*' and not 'that.' To this final individualizing 'form' (which is, of course, inherent in the object as a whole) Scotus gave the name Thisness (*haecceitas*). Again, whereas Aquinas had said that the 'individual' is really unknowable (only the 'universal' being known), Scotus declared that the 'individual,' on the contrary is immediately knowable by the intellect in union with the senses. By a 'first act of knowledge' the mind has a direct but vague intuition of the individual concrete object as a 'most special image' – a 'particular glimpse,' so to speak, of the *haecceitas*. Further, it is through this knowledge of the singular that the mind, by abstracting and comparing in a 'second act,' arrives eventually at its knowledge of the universal." From the Introduction to the Penguin Classics issuance of the standard collection of Hopkins' "Poems and Prose," by W. H. Gardner, foremost among the early Hopkins' editors.

According to D. Downes, *Gerard Manley Hopkins: A Study of His Ignatian Spirit* (1959), Hopkins kept journals in furtherance of the *Spiritual Exercises of St. Ignatius*, a practice of the Society of Jesus ("Jesuits") to which Hopkins belonged. Hopkins even thought of publishing his own *Commentary* on the Exercises. Hopkins wrote about:

> "my selfbeing, my consciousness and feeling of myself, that taste of myself, of I and *me* above and in all things, which is more distinctive than the taste of ale or alum, more distinctive than the smell of walnutleaf or camphor, and is incommunicable by any means to another man ... Nothing else in nature comes near this unspeakable stress of pitch, distinctiveness, and selving, this selfbeing of my own. Nothing explains it or resembles it, except so far as this, that other men in themselves have the same feeling." Downes at 37.

Hopkins combined Ignatian Exercises with studies of Scotus. "Scotus allowed for an intimation of common nature, a kind of visionary sense experience by mean of which insights could be had into the very fixed ideas in the order of nature before their individualization or selfing." *Id*., at 32.

"For Scotus, nature was a living whole, apart from the individuals or selves possessing it; nature was a real entity because it originated as an idea or type in God's mind prior to his will giving it an individuating existence. Individuals were many degrees in the common nature. All degrees in the common nature were summed up in Christ as Man, who personified nature." A. Heuser, *The Shaping Vision of Gerard Manley Hopkins* (1958) at 37.

The "incommunicable" nature of the self is also a chief subject matter for Scotus. There are no "common" nouns available for verbal description of an individual nature and we have only indirect means such as art and poetry. A person's own nature can be known to that person but is not knowable to others through synthetic constructions. One person seeking to know another person's individual nature cannot do so by "abstraction" (what I call synthesis) but only by "intuition," through personal engagement. "Intuition," as I understand the teaching of Scotus, is a distinct human capacity that often works with abstraction, another separate distinct capacity, notwithstanding that neither capacity can engage the whole of Reality. It is through intuition that one can obtain "insights ... into the fixed ideas in the order of nature." In my view, I see such intuition as a kind of concept formation that has developed or matured from juxtaposition, independent and distinct, only sometimes coordinated with abstraction (synthesis), but which, in a conventional view, synthesis is supposed to supersede.

Through analysis of intuition, Scotus addresses matters that cannot be "filled in" or described by synthetic relations, especially suggestive about what is going on inside a "secret compartment" at the center of a person.

Please note that I have never been affiliated with any Church and I do not affirm chief beliefs of Christianity, e.g., the Incarnation or the Resurrection. I do affirm "salvaging the value of human personality, which is one of the postulates of Christianity." *Duns Scotus: The Basic Principles of His Philosophy* (1961) at 63, by E. Bettoni, O.F.M., translated by B. Bonansea, O.F.M.

"O.F.M." stands for "Order of Friars Minor," the name of the Franciscans that states a personal identification with those considered inferior in or outcast from established society. "Friars" are brothers, who stand on a position of equality with all. The "minors" are distinguished from the "majors," who run things. Franciscans sometimes call themselves "little brothers."

According to G. K. Chesterton, St. Francis "has been described as a sort of morning star of the Renaissance." His many legends are "all of them bound up with supreme charity for one's neighbor, with love for all living creatures, even the lowliest, with the tenderest feelings for every aspect of external nature." J. J. Walsh, *The Thirteenth: Greatest of All Centuries* (1913). In his *Tales of St. Francis* (1988), Murray Bodo, O.F.M. collected stories about St. Francis "that have that mysterious, archetypal quality that speak to something profound within us, some deep desire of the human heart. ... Like prayer, they took me along with them and somehow effected in me inner transformations not unlike those experienced by Francis and his companions. And that, no doubt, is what story-spirituality is all about."

St. Francis' way of life was new and original in his time. In an era of constant war and brigandage, St. Francis and his followers refused to hold either property or the weapons needed to defend it. They maintained a Mendicant or beggar means of sustenance (along with manual labor and service, e.g., for lepers and the poor) and they walked barefoot in all weather but with such grace that, in *Paradise*, Dante wrote as if of a marriage: "Poverty and Francis [thou] mayest know. Their concord and their looks of joy profuse, The love, the wonder, and the aspect sweet, Made men in holy meditation muse, So that the holy Bernard bared his feet..."

G. K. Chesterton wrote that in meeting persons, St. Francis "saw only the image of God multiplied but never monotonous. To him a man was always a man and did not disappear in a dense crowd any more than in a desert. He honored all men: that is, he not only loved but also respected them all. What gave him his extraordinary personal power was this: that from the pope to the beggar, from the sultan of Syria in his pavilion to the ragged robber crawling out of the wood, there was never a man who looked into those brown burning eyes without being certain that Francis Bernadone was really interested in *him*; in his own inner individual life from the cradle to the grave; that he himself was being valued and taken seriously, and not merely added to the spoils of some social policy or the names in some clerical document."

St. Francis lived at a time when ancient knowledge was being rediscovered. Schools of translators in Sicily and Spain produced Latin versions of Arabic texts bearing the name of Aristotle. The original Greek sources appear to have been something like lecture notes, but they have stood for Aristotle ever since. (See H. B. Veatch, *Aristotle: A Contemporary Appreciation* (1974) at 10, contrasting the "abbreviated, crabbed, often disconnected and at times downright unreadable" texts of what we have with reports of "rhetorical brilliance and literary excellence of the more regularly published writings," presumably lost.)

The "Aristotelian system" had an integrated logic, science, metaphysics and ethics (and more) with all appearances of truth, comprehension and conceptual power. There was nothing comparable in the West. Institutions with buildings and international communities of scholars engaging in travel, correspondence and disputation – the places and activities that we in modern times associate with medieval Christianity – were only then coming into existence. St. Augustine (354-430), enormously influential, had referred to Greek sources; but "Augustine was not really a philosopher at all" and his works contain "little systematic argumentation." P. V. Spade, "Medieval Philosophy," in A. Kerry, ed., *The Oxford History of Western Philosophy* (1994).

The Aristotelian system, "secular, rationalist, and naturalist" was and is in serious conflict with Christianity. At various times during the Thirteenth Century, and depending on the attitude of authorities, teaching the Aristotelian system was prohibited at then-fledgling Universities in Paris and Oxford. M. B. Ingham & M. Dreyer, *The Philosophical Vision of Duns Scotus, An Introduction* (2004) at 4.

St. Thomas Aquinas (1224-1274) ("Doctor angelicus" and "Doctor communis") famously constructed a synthesis of Aristotle and Christianity. In an erratic progression, the teaching of Thomas' synthesis was variously prohibited, discouraged, allowed and, finally, compelled as Church doctrine. F. Copleston, S. J., *A History of Philosophy*, Book One, pt. II, vol. 2 at 144-155 ("Aristotle and St. Thomas: Controversies"). Thomas was a Dominican and Dominicans championed his system.

"In his series of lectures, the *Collationes in Hexameron (1273)*, Bonaventure [1221-1274, the Minister General (highest authority) of the Franciscans, a first-rank theologian/philosopher – "Doctor seraphicus" – and later canonized] excoriated Aristotelian philosophy as a most serious form of error. He much preferred the more Christian-friendly Platonic vision [of St. Augustine] with its Ideal world, the creation myth in the *Timaeus* and the defense of the individual knowing as recollection. Indeed, Augustine's philosophical journey in the *Confessions* had shown that Platonic thought was a prelude to Christianity." Ingham & Dreyer, supra, at 4.

As moderns, we enjoy easy access to surviving works of Plato and Aristotle. These works demonstrate that anyone attempting to synthesize ancient Greek philosophy with Christianity faces a severely daunting task.

Christianity is based on a believer's ***faith*** in Persons and events; and matters of faith are stated but not explained in dogma. There are "mysteries of faith" that are not within the reach of rational discourse. A belief that philosophy provides insight into dogma is "gnosticism" and is in at least potential conflict with doctrine that declares the ***universality*** of Christ's Redemption, available to all persons regardless of intellectual aptitude or acquisition of knowledge. The principle of universality was personified in St. Francis, who derogated book-learning.

(Notwithstanding the Founder's derogation, Franciscan groups became major participants in burgeoning university communities. Mendicancy (begging and manual labor/service) faded into the background as the Order matured.)

Of course, the Persons and events that are at the center of Christianity were completely unknown to the ancient Greeks. Greek city-states were civilizations still youthful and rapidly changing during the era of the philosophers while, in contrast, Christianity was born and developed in regions that had long histories and depths of stagnation. History was longer and stagnation deeper during the medieval period.

In terms of persons, Greek society was defined by strict hierarchical divisions between classes, including large slave populations; and neither Plato nor Aristotle saw value in inferior persons, other than as providers of goods and services. Greek philosophy developed into a tool for the powerful. Aristotle's father was a physician at the court of the King of Macedonia, to which Aristotle returned when he tutored Alexander the Great as a boy. Plato favored an elite ruling corps of "Guardians" and has been accused of "idealization of Sparta–the model for the perfect state of *Republic.*" Sparta was a slave society, where the citizens maintained a "barracks existence" to suppress insurrections that were rampant among the conquered peoples, "*helots,*" that Sparta cruelly ruled. K. Quincy, *Plato Unmasked: The Dialogues Made New* (2003) at 234. Similar considerations led Sir Karl R. Popper to find origins of modern tyrannies in Plato's teachings, as noted in § 1, above.

In contrast to the ***personal*** nature of the Christian experience and the Christian belief in Creation carried out by a deity acting intentionally, Greek philosophy was built upon a premise of impersonal law. Greeks found truth, not through faith, but through logical demonstration. Out of the *kosmos* comes forth the Law, *nomos*, with objective truth to be sought through mathematics. (See G. de Santillana, *The Origins of Scientific Thought from Anaximander to Proclus 600 B.C.–500. A.D.* (1961), finding in Heraclitus (c. 500 B.C.) a seer of the "Logos in the Lightning" who made the primal statement of *nomos* as reality behind opposing appearances. "Who says 'law' says 'command'; the *Logos* steers things in a way which cannot be really immanent to their nature, since they have no individual nature to speak of.") Teachings about impersonal law were combined with that of Pythagoras (c. 550 B.C.), who declared that ***numbers*** are behind all of Reality.

In Piaget's language discussed above in § 3, the Thirteenth Century saw a ***juxtaposition*** of two conceptual systems, namely, Christianity and the Aristotelian System, that have serious conflicts in the premises. The theologian/philosophers of the Thirteenth Century were put to the task of constructing a ***synthesis***. Scotus is important here because his synthesis was grounded in Franciscan theology and practice, personal as a matter of first principles, and because he stated a Principle of Individuation that reached beyond previous attempts, e.g., that of Thomas.

In recent years, Scotus has become a subject of considerable research. From a modern perspective, he investigated foundations of physics. See, e.g., R. Cross, *The Physics of Duns Scotus: The Scientific Context of a Theological Vision* (1998, Oxford University Press). The beginnings of modern science were in the air. Scotus was younger than Roger Bacon (c. 1212 - c. 1292 – "Doctor mirabilis") who, like Scotus, was an Oxford Franciscan; and Roger Bacon had "interest in and respect for experimental science and the application of mathematics in science ... combined with a typically Franciscan emphasis on mysticism." F. Copleston, supra, at 442. Copleston quotes another authority: "when we speak of the Baconian reform of science, we should refer to the forgotten monk of the thirteenth century rather than the brilliant and famous Chancellor of the seventeenth," namely, Francis Bacon (1561-1626).

Scotus dealt with additional meaningful issues that I briefly note. In common with Piaget, Scotus believed that: "Man does not receive knowledge, nor does he create it; he constructs it. Knowledge is an intimate and vital exchange between subject and object, the unique and indivisible product of the meeting of soul and external reality." (Bettoni, supra, at 118.) In contrast to a passive Aristotelian intelligence, intelligence for Scotus has "vitality. The act of understanding, precisely because it is a vital act, is above all an act of the soul." *Id*., at 111. Vital activity of intelligence defines "the problem of the primary object of our intellect" (*Id*., at 27) as involving a ***fitness*** of the object for the purposes of the intellect, so that "the object is almost like an instrument of the intellect." *Id*., at 112. Carrying out an "investigation of the possibility of the knowability of its object," Scotus "points out both the possibilities and boundaries of human cognition." Ingaham & Dreyer, supra, at 206. On the basis of such principles, I see the general stance of Scotus on important matters as quite similar to my own.

"Scotus' philosophical legacy, then, can be summarized as attention to personal, subjective awareness in the light of rational principles. These principles link logic, ontology, and ethics to form a whole whose unifying principle is the person in the act of self-reflection. ... As a Christian philosopher Scotus bring to the fore the conditions required to defend human dignity as created by God" Ingaham & Dreyer, supra, at 208 and 212.

In reaching toward an appropriate statement of Scotus' Principle of Individuation, I narrow attention to the "Problem of Universals" (similar to what I call ***Ideals***). "Universals" was the most famous problem of medieval philosophy and is the focus of A. Freemantle, *The Age of Belief* (1974), in the series *The Great Ages of Western Philosophy*. See also Copleston, supra, vol. II, chap. 14. My approach is selective and aimed at my conclusions.

The problem of Universals was based on Aristotle's *Categories* and part of that work came to the West early on through a number of intermediaries especially Boethius (c. 480 - 524), a courtier of Gothic king Theodoric and executed by him in a Christian schismatic dispute. Boethius wrote of *The Consolation of Philosophy* while in prison, helpfully reiterating concepts from another intermediary, Porphyry, that served as a statement of the Aristotelian system for medievals.

Employing the translation in Freemantle at 67-68, Boethius wrote (adding emphases as pointers):

"[I]n all things there was a first nature, from which all others arose as from a fountain, ... [namely,] subsistents ... called...by the name of ***genus***. But nothing could be a genus unless certain other things were contained in it, and these [are] called ***species***, but no genus could be the genus of only one species but must be of several. Yet many species could not be multiplied unless some distinction separated them. For were there nothing dissimilar among them, there would seem to be but one species, not many. These divisions and dissimilarities of species are called by the name of ***difference***, and it follows from this that every difference appears first in the seed and occurs also in the ***substance***, so that neither can there be ***accident*** without substance or substance without accident. In order that color, which is an accident, exist, it must be in a body which is a substance. ... Thus it is that neither is there a substance beyond accident, nor can there be an accident abandoned by substance. ... Porphyry speculated about these things, that is, accident and substance, genus, species, property and accident and difference, and what genus is of and by itself, and what difference plainly is. And he began principally to deal with genus, species, difference, property and accident. Now the knowledge of these five things is for us a sort of root and many-sided source which flows into all parts of philosophy. For in order to define a thing, you must first give its genus. In order to define what is man, you must first say man is an animal. Then, when you define man as an animal, the genus animal and man, a species, is defined for you, but it does not suffice only to give its genus. For if you merely say man is an animal, do you define a man any more than a horse, a cow or a donkey? ... Let this be a definition of man. Man is an animal, that is his genus, but man is a species, reasoning, that is the difference, capable of laughter, that is his property. So far in this definition no use has been made of accidents. But there is no doubt that accident adds nothing to definitions. For a definition seeks to describe substance, and accident does not describe substance, so accident is useless in a definition."

According to Copleston supra at 137-138, Boethius considered "two ways in which an idea may be so formed so that its content is not found in extramental objects precisely as it exists in the idea. For example, one may join arbitrarily man and horse, to form the idea of a centaur ... and such arbitrarily constructed ideas are 'false.' On the other hand, if we form the idea of a line, i.e., a mere line as considered by the geometer ... all we have done is to isolate the line and consider it as an abstraction ... an idea which is true, even though the thing conceived does not exist extramentally ... the ***ideas of genera and species are ideas of the latter type, formed by abstraction***. Consequently, '***genera and species are in individuals, but, as thought, are universals'***." (Emphases added.)

This statement, later refined and ramified, is suitable for purposes here. The chief defect in the Aristotelian system is the claim of comprehensive power as to all matters, both those known and those only potentially knowable. As stated by Boethius, supra: "[I]n ***all*** things there was a first nature, from which ***all*** others arose... " (Emphasis added.)

Aristotle's categories claim to be comprehensive but they incorporate an important limitation. They apply only to ***populations*** and are inapplicable to ***individuals***. The restriction of categorical thinking to populations is an important feature in much of current scientific thought including, of course, biology, especially that calling itself "Darwinian."

As stated at p. 35 of S. R. L. Clark, "Ancient Philosophy" in Kenney ed., *Oxford History*, supra, summarizing Aristotle's system: "Unfortunately, a merely individual, unrepeated instance cannot be described at all. Individuals cannot be known in their own individuality; only a shared form is knowable (even if the form is only potentially shared)." Similarly: "For Plato the only realities in the full meaning of the term were ideal essences. The multiplicity of individuals was for him a degradation and devaluation." Bettoni, supra, at 63. The supposed Reality of the Platonic Forms was repeated in the Aristotelian system. "The Categories, however, were not in Aristotle's mind simply modes of mental representation, moulds of concepts: they represented the actual modes of being in the extramental world ... They have, therefore, an ontological as well as a logical aspect." Copleston, supra, Book One, Vol. I. at 279.

Onto an Aristotlean root stem, Scotus grafts a personal nature.

In its origin, Scotus' "theory of knowledge is profoundly Aristotelian." Ingaham & Dreyer, supra, at 25. "Through abstraction the human mind, an immaterial substance, knows material objects in the extra-mental world by means of the immaterial essence or *quidditas*." There is a cognitive process that "involves various moments of intellectual receptivity and activity, as the mind interacts with its object" culminating "in the fullest light of intellectual activity birthing into the conceptual order. The entire process involves moments of mediated representation." *Id*., at 26.

"Universals such as humanity, rationality, and animality, as well as the essence (or *quidditas*, the whatness) of common natures belong to this abstract, conceptual order. ... The existence of such a scientific, conceptual order depends radically upon the extra-mental world, sense experience, and the intelligible *species*. However, once generated, the body of abstract knowledge is independent of sense data, insofar as it abstracts from the actual existence of the beings known. In this way, sciences like metaphysics and theology both pre-suppose and transcend common experience. They transcend it because the objects of reflection lie in the conceptual order beyond the physical world." *Id*., at 27.

In addition to the foregoing, "the Franciscan [Scotus] identifies a second act of cognition, belonging to both the senses and to the intellect. This act is immediate, with no representational species to mediate the mind's encounter with the object. Scotus calls it ***intuitive cognition*** and explains that it is like a vision (*visio*), an immediate awareness of an object in its entirety at present and existing." *Id*. (emphasis added). This is "an indubitable act ...[i.e.,] accompanied by certainty of the object's existence." *Id*., at 27, 28.

The *visio* recalls St. Augustine's *beatific vision* of direct, immediate knowledge of God. "Rather than appeal to the Augustinian tradition and to re-instate it within a type of reactionary return to the past, Scotus sees that Aristotle himself admits of other interpretations. He shows how one can successfully correct philosophical positions from within the Aristotelian perspective." Ingaham & Dreyer, supra, at 204.

The changes in the Aristotelian system suggested by Scotus are far-reaching. "In Duns Scotus' system not only sensations, but all the acts that constitute our interior life are grasped intuitively. The intuition of our interior acts is particularly important to him because it helps solve the problem of scientific knowledge, which is above all a problem of certitude and evidence." Bettoni, supra, at 123,

Scotus thus classifies activities of thought into (1) those involving abstraction and birthing into a conceptual order and (2) those that are intuitively immediate. "Despite its immediacy and the certainty of the presence of the object, intuition has its limits." Ingaham & Dreyer, supra, at 29. "Thus, neither act reaches the particular in all its essential particularity. What the intellect does understand, via both intuitive and abstractive activity, would be the universal or nature of the object, along with those accidents that are proper to it (via abstraction) and as it is presently existing (via intuition)." *Id*., at 30.

"Taken together, intuitive and abstractive cognition explain how the mind is present to reality, both as to extra-mental and internal states of affairs. This two-fold act of presence is simultaneous and progressive, moving from the senses to the concept." After the process is complete, there remains a "memory of the act of mutual presence between the mind and the object." *Id*., at 31.

Thus equipped, Scotus "approaches the problem of the relation between the structure of thought and the structure of fact." Scotus proposes different distinctions made by the mind that are not important here and then, on the basis thereof, "Scotus seeks to draw up a list of the varying degrees of unity and the corresponding degrees of distinction. The loosest kind of aggregate is a mere unity of aggregation, in which things happen to be together, or to be thought of together, but there is no structural principle which makes them an intelligible unity. Such is a heap of stones... The next kind of unity is unity of order, in which different things are connected by some intelligible principle of structure. ... Then comes the unity of qualification ... Still closer is the unity of essential principles ... A fifth kind of unity is described as unity of simplicity..." D. J. B. Hawkins, *A Sketch of Mediaeval Philosophy* (1968) at 121-122. Scotus defined relationships between "continuity" and "various sorts of part-whole relationships: substantial, organic, accidental and aggregative." Cross, *Physics*, supra, at 139.

Diverse mental constructions are supportable on the basis of objective reality. For Scotus, objectivity is grounded in the principle that, "in opposition to the Thomists, Scotus asserts that ***being is univocal***." Hawkins at 123 (emphasis added).

"Our earlier reflection upon the modes of intellection (abstraction and intuition) revealed the ... distinctions that are based upon objective reality. Both ... distinction[s] point to an objective order to which the mind is present ... and its own activity reveals, at a most basic level, its ***primary object, <u>being</u>, whose presence to the mind is a necessary condition for any knowledge.*** For Scotus, the primacy of being as a ***univocal concept*** is revealed as the necessary condition for metaphysics, for any language about God and for any science of theology." Ingham & Dreyer at 39 (emphasis added).

In other words, "the primary object of the intellect is being in general and not simply material essences," i.e., *quidditas*. Copleston, supra, Vol. II at 496. "Duns Scotus denied the distinction between essence and existence, because neither accounted for the individuality of real things." Freemantle at 183. "In fact, for Duns Scotus, the individual is the ***only*** existing thing, and it is not the being of ***being***, but the being of the individual which is investigated by philosophy." *Id*., at 184 (emphasis in original).

Univocity means that being speaks "with a single voice" and highlights that unity. Univocity "also suffices as a syllogistic middle term, so that where two terms are united in a middle term that is one in this fashion, they are inferred without a fallacy of equivocation to be united among themselves." Ingham & Dreyer at 39. E.g., "the idea of wisdom as applied to God and to creatures must be sufficiently the same for equivocation to be avoided." Copleston, supra, Vol. II at 503.

Univocity is the ground for ***common natures*** in Reality on which the Principle of Individuation acts to produce singular beings, such as individual persons. Univocity is not violated by activity of human cognition that constructs differences. "Outside the intellect, nature has *per se* unity insofar as it subsists in itself. As we have seen, this unity is less than numerical and indifferent with regard to singularity or universality." Ingham & Dreyer at 106. "Since universality as well as singularity are determinations that do not belong essentially to nature, it is not contradictory for nature to be independent of them." *Id*.

While being is "simply the most universal" of all concepts, being is also "the poorest in content of all notions ... it has no positive content and is equivalent to what is not nothing." Hawkins at 123. Aristotelian categories, mental distinctions and constructions of various aggregates etc. are all insufficient and are not the best we can do. "[T]he human intellect must always act in a way that is inferior to its capacity." Bettoni at 41-42. See also Copleston, supra, at 489-490 (dependency of human intellect on diverse devices "due to the order established by divine wisdom, either as a penalty for original sin or with a view to the harmonious operation of our various powers.")

"[F]or Duns Scotus a concrete thing is ... a composite of a specific ***common nature*** and of a ***principle which contracts nature into singularity*** ... the cause of the singularity is to be found in something within the thing itself. This is known in history as the problem of, or the quest for, the ***principle of individuation***." Bettoni, supra, at 58 -59 (emphasis added).

"For Scotus recognizes that all elements which he has hitherto revealed, all that can be attributed to things, including being as he understands it, are of themselves universal. The individuality of real things is not yet accounted for. Hence, beyond all that in reality corresponds with universals or combinations of universals, he claims that things exhibit a principle of individuality, a thisness, which is not reducible to any other factor. 'The singular adds an entity over and above the entity of the universal. Consequently the apprehension of the universal is not the complete ground of an apprehension of the singular adequate to the whole knowability of the singular.'" (*Id*., at 124, quoting a Scotus text.)

"Thisness is not a universal like other universals, for it is precisely the principle of individuality.

The thisness of this is by its very notion different from the thisness of that. *Haecceitas est de se haec*." *Id*., at 125, roughly translating: "Thisness is of itself just this."

As stated in Bettoni, supra, at 121 -123:

INTUITIVE KNOWLEDGE OF THE SINGULAR

> An individual is a being that is richer than its specific essence. *Haecceitas* is in effect the last perfection of a thing... Only the individual exists in the complete sense of the term. ... Yet it must be recognized that in his present condition man in unable to grasp a thing's "haecceity," even though he knows things in their concrete existence, and therefore as individuals. This amounts to saying that man knows the individual but not singularity, understood as the precise reason that makes the individual characteristics inhere in a thing. More specifically, he does not know the reason why these characteristics are the individuating notes of this particular thing rather than of another. Knowledge of the haecceity of all things would constitute full knowledge of all reality: an impossible task for our intellect in its present condition.

Bettoni contrasts the formation of a concept by "abstraction" and compares it with that formed by "intuition": "human knowledge always starts from the intuition of the concrete thing. The product of this first meeting of the intellect and thing is ... the idea of the individual thing. This idea is quite proper to the object that stands before me .... However, as soon as my intellect tries to find out exactly what the thing is and looks for its definition, it has recourse to universal concepts, precisely because it is incapable of grasping the haecceity. ... I know the thing only in a confused manner ('a thing is known confusedly when only the meaning of its term is known')." *Id*. (quoting and citing to Scotus).

"Thus Duns Scotus attributes to man intuitive knowledge along with abstractive and conceptual knowledge. It is by no means a perfect intuition, for it is only an initial and confused kind of knowledge; yet it is not thereby less important. For the human intellect it is a necessary starting point, its first way of getting in touch with reality. It is like a spiritual sense by which we intellectually perceive the reality that affects our senses." *Id*.

For Scotus, justice, juridical law, freedom and morality all involve multiple forms of knowledge dependent on univocity for actualization. In his *Duns Scotus* (1999) at 91-92, R. Cross suggests that "justice" comes in multiple forms, namely, "justice_1" and "justice_2" such that "Justice_1 binds God by inclining him *deterministically* ("in a quasi-natural manner") to render his own good what is due to it" (emphasis in original) while justice_2, although not subject to determinism, commands "a practical truth that is in harmony (*consonum*) with the principles and conclusions of the law of nature" (quoting Scotus).

Bettoni, supra, at 177-78 sees multiplicity in what I call juridical law: "Besides natural law, Duns Scotus discusses positive law and what he calls confirmatory law. ... Positive laws [are] integrations of the natural law, required by its indeterminateness as to the changing conditions and complex situations in which men find themselves in concrete life. ... Such laws would lose all value if they contained anything contrary to the natural law. ... The act by which the legislator promulgates the law that he has decreed in his prudence is the foundation or source of the law's binding force. ¶ Positive confirmatory law has in common with all positive laws the fact that it is promulgated by a legislator. However, its content is identical with the natural law taken both in its strict and broad sense."

Values that shape action similarly stand on two legs. Philosophers other than Scotus, such as "Aquinas, following Aristotle, give[] an account of human actions directed to our natural self-fulfillment in happiness." Scotus finds, in addition, "an inclination to justice. Scotus .... calls these inclinations, respectively, the *affectio commodi* (affections for the beneficial or advantageous) and the *affectio iustitiae* (the affection for justice). ... The idea is that these inclinations explain the fact that the will has two different modes of operation: one in which it seeks self-fulfillment in happiness, and one in which it seeks justice. ¶ Scotus argues that the presence of both these inclinations is necessary for freedom." Cross, *Dun Scotus*, supra at 86-87.

Multiple capacities for different kind of knowledge and respect for persons are the keys to Scotus' reconciliation of scientific and spiritual aspirations. Single-minded "philosophers are wrong, he argues; ordered love, not knowledge, defines and perfects human rationality. Human dignity has its foundation in rational freedom. In contrast to the philosophical, intellectualist model of human nature and destiny, the Franciscan offers and strengthens the Christian alternative, centered not merely on knowledge but on rational love. ... The Franciscan consistently defends a position wherein the fullest perfection of the human person as rational involves loving in the way God loves, rather than knowing in the way God knows. His position in this overall project can best be understood within Franciscan spirituality, which emphasizes the will and its attraction to beauty, love, and simplicity." Ingham & Dreyer at 8.

Two-fold cognition thus reappears in the "objective order of moral goodness." "Rational goods such as truth, life, or integrity are appropriate objects for human desire and reveal the objective ground for moral judgments. Because the natural order is rational, the goodness of its various elements is apparent to human reason." There are, first, "useful goods, the *bonum utile*, such as money or power" and second, "there are goods whose value is intrinsic and independent of use ... valuable for themselves alone ... goods of value, *bonum honestum* ... truth, integrity, the person, God. These goods ... are the standard for human judgments and choice." Ingham & Dreyer at 119-120.

"As the [prior] discussion ... also made clear, the rational will in its two-fold affections is oriented toward these two orders of goods. The affection for justice is directed to goods of value, while the affection of possession is directed toward goods of use. ... As Augustinian thought informed Franciscan theologians, a marked aesthetic approach framed this tradition's discussion of the human journey of desire and love toward the highest good. For Alexander of Hales, father of the Franciscan intellectual tradition, *bonum honestum* was synonymous with sensible beauty. ... When [Scotus] likens the moral conclusion to an esthetic judgment, this has little to do with matters of personal taste. Beauty is an objective reality that belongs to the harmonious whole of creation, insofar as it is whole. The judgment of beauty has an objectivity in the same way that judgments of truth and goodness are objective. In the judgment of beauty, one recognizes and loves the whole as an integrated whole, where nothing is lacking." Ingham & Dreyer at 177.

Central to Scotus' view of moral science is "the act of *praxis* in the will. The act of volition is the essential starting point for Scotus' discussion of the domain of a practical science, from its ultimate first principle to the concrete act of judgment." Ingham & Dreyer at 127. *Praxis* is intuitive because "In the moment of judgment and choice, the moral agent brings forth the act as a type of giving birth. The moment of birthing requires the immediacy of moral knowledge and free choice." *Id*. In addition, *praxis* is abstractive or synthetic because: "The truths of moral science are necessary truths about contingent states of affairs. These truths can be ascertained by noticing the patterns that obtain in the created order, in the same way that scientists identify patterns of cause and effect in nature." *Id*., at 127.

Thereby, "all levels of moral awareness and judgment, from the highest levels of principle to the concrete matter at hand, are brought into dynamic relationship within the will. In this way, the act of *praxis* lies completely within the power of the will and the moral domain is entirely framed by freedom." *Id*.

"In some ways, Scotus's discussion of the science of *praxis* reverses that of Aristotle. The Stagirite [Aristotle] understood the natural order as existing of necessity. There can be only one world and this is it. Against this background of metaphysical necessity, he presented ethics as a science of the contingent whose truth is defined by its object, a contingent state of affairs framed within a larger order of natural necessity. By contrast, Scotus understands the larger frame to be contingency, not necessity. This world does exist, but its existence is contingent. It is the result of a free act of choice on the part of the Creator and might have been different. Indeed, what currently exists might be other than it is. This larger frame of contingency influences the way Scotus seeks to ground moral science on logical necessity of first principles, and upon the divine will in contingently creating this sort of world with natures of these sorts and relationships of the kind that we find." *Id*., at 129.

Scotus thus harmonizes clashing elements and advances in his mission to construct a science based on Aristotle that stands beside and strengthens intuitive insight so as to better guide an individual person.

"Moral science is grounded logically in its first practical principle, *Deus diligendus est* (God is to be loved). This first truth of practical reasoning is, according to Scotus, a necessary proposition, self evident (*per se nota*) to all rational agents. All moral propositions, all precepts of natural law, contained as well in the Decalogue, stand in harmonious relationship to this first, necessary, practical truth. As foundational to rationality, the first principle and all those derived from it are, as it were, 'written on the human heart.' They reveal themselves in human reflection and judgment. They are never lost, not even in the damned." Ingham & Dreyer at 119.

This interpretation of Scotus is suggestive. In imitation, I might suggest that there is a love of freedom that dwells in every human heart, even in the hearts of slaves. There is also a capacity for exercising such freedom that is shared by all intelligent adults. The freedom that is loved by all and that can be exercised by all is an objective kind of freedom. Such freedom is not inherent in Reality but is a result of the ways our human intelligence operates. That all persons love freedom and that all persons seek to exercise freedom are facts that are, or should be, self-evident to all intelligent adults. Hence, universal love for freedom and the shared capacity to exercise freedom are bases for practical acts and support moral propositions and percepts of natural law.

§ 12 Idealization of Reality: an objective kind of freedom

Development of a Model of an Ideal Brain leads to definition of conditions in Reality that such a Brain can successfully engage. Success is more likely as conditions in Reality approach Ideal conditions. Conversely, as conditions diverge from Ideal conditions, the Ideal Brain fails to engage Reality successfully. Under what conditions the Ideal Brain fails and how it fails become subjects for further investigation.

A chief characteristic of an Ideal Brain is that its operations are reducible in principle to a mechanical model. A mechanical model can be sometimes stated in several equivalent forms, e.g., algorithmically or in the form of differential equations. Here, the Thermal Model is stated in the form of a mechanical model. The chief difference between the Thermal Model and mechanical models is that the Thermal Model can be made to operate under less than Ideal conditions and the operations of the Thermal Model under such conditions are different from those of mechanical models.

The chief concept of the Ideal Thermal Model is ***covariant continuous differentiability*** of diverse domains. For example, under Ideal conditions, it is possible to coordinate hand and eye with sufficiently fine detail and exactitude to accomplish purposes. E.g., any motion of the eye in following a moving object can be matched by a motion of the hand and vice-versa. We do our best to provide Ideal conditions to young children who are learning coordination skills.

The Thermal Model does not engage Reality continuously but only episodically. In approaching Ideal engagement (which would be continuous), episodes are sequenced and an image of continuous engagement is constructed. Typically, to accomplish this, an environment is created so that there are only a few attachments to Reality. A premise of an Ideal engagement is that, e.g., for ***any*** variation in the object dynamic pattern, the Ideal Brain can respond with an adjustment in the act dynamic pattern so as to maintain an invariance (purpose). This premise is illustrative rather than definitional. Thus, under other circumstances, the Ideal Brain can respond to a variation in an act dynamic pattern with a change in an object dynamic pattern, such as shifting gears in an automobile so as to maintain a nearly constant number of "revolutions per minute" shown on a tachometer.

To illustrate, suppose we construct a device called "Homun 1." Homun 1 has an "eye" constituted by a horizontal row of light detectors and a "foot" that rotates the device with respect to the environment a step at a time. In other words, Homun 1 can take 1 step clockwise or take 1 step counterclockwise or not step at all. I suppose that a fairly large number of step are required to return to an original position, 16 or 32 steps would be convenient.

The eye has a number of detectors arranged to generate a variable that has a 0 center and a number of gradations of either side. To specify Homun 1, 7 gradations on either side would be convenient. A value of the variable at 0 means that Homun 1 is centered on the source of light. Any value other than 0 means that the Homun 1 is off-center, with a larger number indicating greater deviation from center.

Homun 1' s purpose in this world is to keep a source of light centered on the eye. This is easy when Homun 1 is stationary with respect to the light source. A more interesting investigation involves putting Homun 1 on a model train car with the source of light at the center of layout. Then Homun 1 is tested by being driven around on the train.

The task is easily approached through many different means. Modern computers run algorithms and/or run differential equations; equations and/or algorithms involved in Homun 1 are not "complex" in any way. The actual inspiration for Homun 1 is *Machina speculatrix*, an "artificial animal" invented and turned into a house pet by pioneer neuroscientist and cybernetician W. Grey Walter and discussed in his book, *The Living Brain* (1953). *M. speculatrix* had a phototube, motors on wheels, two relays and two vacuum tubes; the creature moved toward light and would nuzzle up to any lamp. Walter's fanciful species, *Machina*, were machines. Homun 1 is not a machine but a thermal device.

The operations of a Thermal Model depend on "fluctuations." Here, the fluctuation is a step taken at random by Homun 1 according to a "set of fluctuation probabilities," in this case exceedingly simple. After a step, Homun 1 checks the centering of the light source. If miscentering is more severe, the step is reversed, otherwise not. The centering is monitored and the set of fluctuations probabilities varied according to some strategy. Variations in strategies are matters that can be investigated.

When Homun 1 or mechanical equivalents is put onto the model train and driven around, failure can be investigated. Failure in Homun 1 can be induced by concealing the light source behind an obstruction or by driving the train at high speed around a curve. Let us suppose that, as a matter of design, Homun 1 recovers from failure by continuous stepping in one direction until light is detected and then continuing to step in that direction until countered by loss of centering.

So far, there is no deviation in function between Homun 1 and a machine. The conditions are Ideal in that all activities are based on principles of covariant continuous differentiability (as represented equivalently in many ways); that is, variations in two quantities, each continuously differentiable, can be coordinated. These are the conditions that enable Homun 1 (using thermal principles) and machines (using mechanical principles) to produce results that coincide.

Next, I modify the problem to construct a successor to Homun 1, Homun 2. The model train layout is turned into a three-dimension track *á la* monorail and Homun 2 can also tilt a neck holding the phototube array so that the array is directed at a variable angle of elevation above or below the horizon. From a mechanical viewpoint, the chief matters are the "equation" that defines the track of the monorail and the speed of the train but Homun 2 cannot directly identify such matters. All Homun 2 can do is turn clockwise or counterclockwise and tilt the neck up or down.

It should be possible to educate Homun 2 (in both thermal and mechanical forms) by providing Homun 2 with substantial experience in easy, repetitive conditions, e.g., a part of the monorail track that has a large circle with a single large hump and where a light source is put into the center, around which Homun 2 is driven, slowly at first. Kindergarten for homuns. Perhaps Homun 2 can learn that the aggregate number of up tilts is always just about the same as the aggregate number of down tilts. (This is not necessarily the case with right and left turns.) Does this fact reflect something about the nature of Homun 2's world? From the outside, it would appear so, but this fact also reflects something about the way Homun 2 engages that world.

What happens when there is failure for Homun 2? E.g., when there is loss of contact with the light source. One possibility is that loss of contact will be temporary and that contact will be regained. I suppose that in the recent past prior to the loss of contact, Homun 2 was tracking train travel with compensatory turns and tilts and, because the path of a monorail track is described by continuously differentiable variables, that Homun 2 can successfully extrapolate from this activity, at least for a short time.