



## Quantum Mechanics, Information philosophy & Buddhism

"All processes manifest a tendency toward decay and disintegration"

*(2nd law of thermodynamics)*

*Computational processes are abstract beings that inhabit computers.*

*As they evolve, processes manipulate other abstract things called data.*

*The evolution of a process is directed by a pattern of rules called a program.*

*People create programs to direct processes.*

*In effect, we conjure the spirits of the computer with our spells.*

*A computational process is indeed much like a sorcerer's idea of a spirit.*

*It cannot be seen or touched. It is not composed of matter at all. However, it is very real.*

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*These are notes - so the text might appear sometimes a bit rambling & disjointed.*

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Some of the earliest philosophers saw *immaterial* Mind as the source of eternal Truths about Reality that could not be based on mere phenomena - unreliable sensations emanating from material bodies.

Descartes' dualism reduced the bodies of all animals to living machines, but left room for a non-mechanistic, immaterial, and indeterministic Mind above and beyond the deterministic limits set by the laws of nature. Kant renamed the ancient division of sensible and intelligible worlds, locating God, freedom, and immortality in his noumenal world.

Information philosophy hopes to show that information is itself that immaterial "substance" above and beyond matter and energy that the ancients, Descartes, and Kant were looking for.

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Information is neither matter nor energy. It is sometimes embodied in matter and sometimes is communicated as pure energy. It is the scientific basis for an immaterial, non-physical mind (citta?) that can nevertheless affect the physical world. Information is the modern spirit.

Information is neither matter nor energy, but it needs matter for its embodiment and energy for its communication.

A living being is a form through which passes a flow of matter and energy (with low or "negative" entropy, the physical equivalent of information).

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The Information Interpretation is simply "standard quantum physics" plus information being recorded irreversibly.

Information physics is standard quantum physics. It accepts the Schrödinger equation of motion, the principle of superposition, the axiom of measurement (now including the actual information "bits" measured), and - most important - the projection postulate of standard quantum mechanics (the "collapse" that so many interpretations deny).

"Information physics" is not a new "interpretation" of quantum mechanics.

It is not an attempt to alter the standard quantum mechanics, extending it to theories such as "hidden variables," for example. Information physics simply follows the quantum mechanical and thermodynamic implications of cosmic information structures, especially those that were created before the existence of human observers.

The "conscious observer" of the Copenhagen Interpretation is not required for a projection, for the wave-function to "collapse", for one of the possibilities to become an actuality. What the collapse does require is an interaction between systems that creates information that is irreversible and observable, though not necessarily observed. (Quantum physics existed and has been operating, way before humans appeared - The universe is its own observer).

The Information Interpretation is based on simple premises:

Quantum systems evolve in two ways:

1. the first is the wave function deterministically exploring all the possibilities for interaction,
2. the second is the particle \*randomly (chance)\* choosing one of those possibilities to become actual.

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### **What is random / chance?**

Chance is often defined as the opposite of Necessity.

The English word derives from the Latin cadere - to fall.

The word connotes falling in the sense of decadence.

Chance is need not be a direct cause of human actions. Quantum chance is primarily needed to generate unpredictable and "free" alternative possibilities for action.

The core idea of chance and indeterminism is closely related to the idea of causality. Indeterminism for some is simply an event without a cause, an uncaused cause or *causa sui* that starts a new causal chain.

Chance is closely related to the ideas of uncertainty and indeterminacy.

Uncertainty today is best known from Werner Heisenberg's principle in quantum mechanics. It states that the exact position and momentum of an atomic particle can only be known within certain (sic) limits.

But real chance and uncertainty had already entered physics fifty years earlier than Heisenberg, when Ludwig Boltzmann showed in 1877 that random collisions between atomic particles in a gas could explain the increase in entropy that is the Second Law of Thermodynamics.

He assumed that the directions and velocities of particles after a collision depended on chance, as long as energy and momentum were conserved.

Boltzmann's student Exner's assertion went further:

"It is quite possible that Nature's laws are of thoroughly statistical character. The demand for an absolute law in the background of the statistical law goes beyond the reach of experience." Schrödinger would himself "go beyond the reach of experience" searching for deterministic laws underlying the discontinuous, discrete, statistical and probabilistic indeterminism of the Bohr-Heisenberg school, to avoid the implications of absolute chance in quantum mechanics. Planck and Einstein too were repulsed by randomness and chance. "God does not play dice," was Einstein's famous remark.

A major achievement of the Ages of Reason and Enlightenment was to banish absolute chance as unintelligible and atheistic. As Newton's Laws provided a powerful example of deterministic laws governing the motions of everything.

Thanks to Hegel, the philosophy of the Enlightenment was harshly criticized ; and the door to alternative thinking was opened.

The philosopher William James (1842-1910) asserted that chance can provide random unpredictable alternatives from which the will can choose or determine one alternative. James was the first thinker to enunciate clearly a two-stage decision process, with chance in a present time of random alternatives, leading to a choice which selects one alternative and transforms an equivocal ambiguous future into an unalterable determined past. There are undetermined alternatives followed by adequately determined choices.

Chance allows alternative futures and the question becomes how the one actual present is realized from these potential alternative futures.

Modern quantal randomness, unless amplified to the macroscopic world, is often insignificant, not a miracle at all.

David Hume did some critical attack on causality; yet he did embrace it when saying "tis impossible to admit of any medium betwixt chance and an absolute necessity". Indeed, Hume believed strongly, if inconsistently, in necessity.

Even late Bertrand Russel was unwilling to give up strict determinism, saying "Where determinism fails, science fails."

Note that the old western philosophers who allowed the existence of chance, (Aristotle, Epicurus, Lucretius, and Alexander of Aphrodisias), denied a causal chain (ἄλυσις), while maintaining that human decisions were caused by neither chance nor necessity but by a tertium quid - our autonomous human agency.

### **Statistically determinism (aka adequate determinism):**

The core idea of determinism is closely related to the idea of causality. But we can have causality without determinism, especially the "soft" causality that follows an "uncaused" event (a causa sui) that is not predictable from prior events.

Aristotle called such events archai (ἀρχαί) - starting points or "fresh starts" in new causal chains which break the bonds of determinism.

There is actually no strict determinism at any "level" of the physical world. Determinism is an abstract theoretical ideal that simplifies physical systems to allow the use of logical and mathematical methods like differential equations.

When small numbers of atoms and molecules interact, their motions and behaviors are indeterministic, governed by the rules of quantum mechanics.

However, when large numbers of microscopic particle get together in chemically or gravitationally bound aggregates, the indeterminacy of the individual particles gets averaged over and macroscopic adequately deterministic laws "emerge."

The "laws of nature," such as Newton's laws of motion, are all statistical laws, however close they appear to being certain. They "emerge" when large numbers of atoms or molecules get together. For large enough numbers, the probabilistic laws of nature approach practical certainty. But the fundamental indeterminism of component atoms never completely disappears.

**Macroscopic statistical "determinism" is the consequence of averaging over extremely large numbers of microscopic particles. Statistical determinism is a corollary of the probabilistic "law of large numbers" when dealing with a great many independent events.**

Even in a world that contains quantum uncertainty, macroscopic objects are determined to an extraordinary degree. But the macroscopic "laws of nature" are just statistical laws that "emerge" when large numbers of atoms or molecules get together. For large enough numbers, the probabilistic laws approach practical certainty.

Macro Mind is macroscopic enough to ignore quantum uncertainty for the purpose of the reasoning will.

Quantum indeterminacy exists in the world. Sometimes microscopic indeterminism is amplified to produce unpredictable and uncaused events that show up in the macroscopic world to break the causal chains we normally see in adequate or statistical determinism.

(E.g., Geiger counters record the spontaneous radioactive decay of unstable atoms, much of it driven by cosmic radiation, a major source of genetic variation that drives natural selection.)

None of these totally random events interferes in any significant way with the adequate determinism of the macroscopic world.

But it is random events that drive the creation of new species in biology and we can show that they underlie all creativity, all actions that bring new information into the universe, whether the formation of stars and galaxies or the writing of a new play.

We call this kind of determinism "adequate determinism." Despite quantum uncertainty, the world is adequately determined to send men to the moon. Quantum uncertainty leads some philosophers to fear an undetermined world of chance, one where Chrysippus' imagined collapse into chaos would occur and reason itself would fail us. But the modest indeterminism required for free will is no chaotic irrational threat, since most physical and mental events are overwhelmingly "adequately determined."

Adequate determinism provides statistical predictability, which in normal situations for physical objects approaches statistical certainty.

## **The Principle of "Soft" Causality.**

Events are always caused but not always determined. An event is caused by prior and proximate events (technically those within its relativistic light cone from the past), but not every event is predictable. Indeed, as logical philosophers would put it, determinism is not true. The determinism we have is merely "adequate determinism".

Soft causality does not entail strict determinism.

Events are caused by prior (uncaused) events, but not determined by events earlier in the causal chain, which has been broken by the uncaused cause.

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### What are the seven aspects of chance:

1. Chance exists in the universe. Quantum mechanics is correct. Indeterminism is true, etc.
2. Chance is important for free will because it breaks the causal chain of determinism.
3. But chance cannot directly cause our actions. We cannot be responsible for random actions.
4. Chance can only generate random (unpredictable) alternative possibilities for action or thought. The choice or selection of one action must be adequately determined, so that we can take responsibility. And once we choose, the connection between mind/brain and motor control must be adequately determined to see that "our will be done."
5. Chance, in the form of noise, both quantum and thermal noise, must always be present. The naive model of a single random microscopic event, amplified to affect the macroscopic brain, never made sense. Under what ad hoc circumstances, at what time, at what place in the brain, would it occur to affect a decision?
6. Chance must be overcome or suppressed by the adequately determined will when it decides to act, de-liberating the prior free options that "one could have done."
7. To the extent that chance is not completely suppressed by the will, the resulting choice can be considered to have an element of randomness. The agent can still take responsibility for

allowing the choice to be partially or completely random, the equivalent of flipping a mental coin.

One should see the obvious parallel with biological evolution and natural selection, with its microscopic quantum accidents causing variations in the gene pool and macroscopic natural selection of fit genes by their reproductive success.

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Our Macro Mind needs the Micro Mind for the free action items and thoughts in an Agenda of alternative possibilities to be de-liberated by the will. Chance in the Micro Mind is the "free" in free will and the source of human creativity. The adequately determined Macro Mind is the "will" in free will that de-liberates, choosing actions for which we can be morally responsible. Determinism is an emergent property.

The basic idea of emergence is that there are properties - perhaps even "laws" - at the upper hierarchical levels of nature that are not derivable from or *reducible* to the properties and laws of the lower levels.

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"What we see is a world of soft causality and adequate determinism"

Since the physical world is irreducibly indeterministic at the base level of atoms and molecules, there is actually no strict determinism at any "level" of the physical world.

Yet, in a world that contains quantum uncertainty, macroscopic objects are determined to an extraordinary degree. But the macroscopic "laws of nature" are just statistical laws that "emerge" when large numbers of atoms or molecules get together. For large enough numbers, the probabilistic laws approach practical certainty.

The presence of quantum uncertainty leads some philosophers to call the world indetermined. But indeterminism is somewhat misleading, with strong negative connotations, when most events are overwhelmingly "adequately determined." Nevertheless, speaking logically, if a single event is undetermined, then indeterminism is true, and determinism false.

There is no problem imagining that the three traditional mental faculties of reason - perception, conception, and comprehension - are all carried on more or less deterministically in a physical brain where quantum events do not interfere with normal operations.

There is also no problem imagining a role for randomness in the brain in the form of quantum level noise. Noise can introduce random errors into stored memories. Noise could create random associations of ideas during memory recall. This randomness may be driven by microscopic fluctuations that are amplified to the macroscopic level.

Our Macro Mind needs the Micro Mind for the free action items and thoughts in an Agenda of alternative possibilities to be de-liberated by the will. The random Micro Mind is the "free" in free will and the source of human creativity. The adequately determined Macro Mind is the "will" in free will that de-liberates, choosing actions for which we can be morally responsible.

Determinism must be disambiguated from its close relatives causality, certainty, necessity, and predictability.

With random motions at the base level, what emerges at the higher level of the macroscopic physical world and the human mind is adequate determinism. Determinism is an abstract theoretical idea that simplifies physical systems enough to allow the use of logical and mathematical methods on idealized abstract "objects" and "events." The apparent "determinism" of classical physics is the consequence of averaging over extremely large numbers of microscopic particles.

Adequate determinism "emerges" when we have large enough objects to be averaging over vast numbers of atoms and molecules.

Emergence supports the idea of mental causation in particular and the more general problem of downward causation.

Information is neither matter nor energy, but it needs matter for its embodiment and energy for its communication.

A living being is a form through which passes a flow of matter and energy (with low or "negative" entropy, the physical equivalent of information). Genetic information is used to build the information-rich matter into an overall information structure that contains a very large number of hierarchically organized information structures. Emergent higher levels exert downward causation on the contents of the lower levels.

An example of downward causation is when the earth turns, or revolves about the sun, or travels with the sun through the spiral arms of our galaxy, everything on earth is carried along with it.



The problem of mental causation is a specific case of downward causal control that is central to the philosophy of mind.

## Mental Causation

Mental causation is a specific case of the more general problem of downward causation, for example the downward control of the motions of a cell's atoms and molecules by supervening biological macromolecules.

Is the molecular biology of a cell reducible to the laws governing the motions of its component molecules, or are there emergent laws governing motions at the cellular level, the organ level, the organism level, and so on up to the mental level?

Supervenience as a concept in philosophy was first introduced as a description of properties in a complex system that supervene on the lower-level (called "base" or subvenient) properties of the system's components. For example, the laws and properties of chemistry are consistent with, but supervenient on, the laws of physics.

More specifically, the properties of molecules supervene on atoms, the properties of biological cells supervene on molecules, plants and animal supervene on cells, etc.

*\*\*This is not to claim that the upper level emergents can be completely explained by and are reducible to the subvenient or "base" properties.\*\**

Reductionists are those who claim that causal laws of nature in the base level must causally determine the laws of the emergent level. These thinkers usually have a highly simplistic, materialistic, and deterministic view of the most fundamental laws of nature, namely the laws of classical physics.

Supervenience is seen as the last hope for a nonreductive physicalism, which does not reduce the mental to the physical, the psychological to the neurophysiological.

Davidson set two requirements:

- a domain can be supervenient on another without being reducible to it (non reduction)
- if a domain supervenes, it must be dependent on and be determined by the subvenient domain (dependence)

It is hard to see how the mind, if causally determined by the subvenient brain, is not therefore reducible to it. So we might assume that Davidson's point #2 implies a kind of "one-way causality," with mental causing physical, but not vice versa.

Can emergent properties or laws at the higher levels of a physical-chemical-based biological system prevent those higher levels from being reduced to the properties and laws of the base physical level?

The locus classicus of discussions of mental causation is Donald Davidson's 1970 essay "Mental Events," which was revisited in his 1993 essay, "Thinking Causes".

Davidson claimed three things:

1. That mental events are causally related to physical events
2. That causal relations are normally backed by strict (deterministic) laws
3. But that there are no such strict laws for mental events acting on physical events

Davidson's goal is to deny the reducibility of mental events to physical events in the lower levels, even to deny the physicist's claim that the motions of the atoms and molecules at the lowest level are causally determinative of everything that happens at higher levels.

**Information philosophy (actually information physics and biology), understands mental events as immaterial thoughts, which are normally only unrealized possibilities for action. Thoughts are embodied in the neural information structures of the brain, where they are stored along with memories of past experience. As such, they are physical and are temporarily even material, in some sense.**

But when they are transferred (communicated) to other parts of the brain, out to other minds, or for storage in the external environment, thoughts are converted from a material substrate to various forms of energy. Temporarily, they are quite non-material, as philosophers for centuries have imagined thoughts in an immaterial mind might be. Once stored, they are again embodied in matter.

Of course, thoughts or ideas can be unpredictably altered before storage, by noise in the communication. They can also be altered randomly by irreducibly indeterministic errors in the retrieval of the information. Here lies the basis for creative mistakes, to be evaluated by a process of intelligent selection. (As Augustine noted, the Latin *intelligere* means "to select.")

**+++ The information solution to the mind-body problem can be interpreted as providing a non-reductive physical interpretation of mind. This model of mind supervenes on the neural brain structures that embody the information (while it is being stored). But the intellectual content of the information is not the resultant of whatever physical processes are coming from lower layers in a hierarchical structure. The physical brain is a plastic storage medium adequately determined to store the information content of these immaterial thoughts, and normally to store it accurately. +++**

With reference to popular (if flawed) computational theories of mind, we note that the "software" contents of a computer program, as well as the execution of the program, is in no way determined or "caused" by the computer "hardware." Similarly, ideas are not determined by the ink on a printed page or the pixels on a computer screen, but by the human minds (citta) that put them there.

Moreover, since some "mental events" are large enough information structures to be adequately determined, these mental events can act causally on lower biological and physical levels in the hierarchy, in particular, the mind can move the body and all its contained physical particles, thus solving the mind-body problem.

A specific example of the mind causing an action, while not itself being caused by antecedent events is the following. Faced with a decision of what to do next, the mind considers several possible alternatives, at least some of which are creatively invented based on random ideas that just "come to mind." Other possible alternatives might be familiar options, even habits, that have frequently been done in earlier similar situations.

All these alternatives show up as "neural correlates" - brain neurons firing. When the alternatives are evaluated and one is selected, the selected action results in still other neurons firing, some of which connect to the motor cortex that signals muscles to move the body.

Apart from the occasional indeterministic generation of creative new alternative ideas, this whole causal process is adequately determined and it is downwardly causal. Mental events are causing physical body events.

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### The Three Kinds of Information Emergence

- the order out of chaos when the matter in the universe forms information structures
- the order out of order when the material information structures form self-replicating biological information structures
- the pure information out of order when organisms with minds externalize information, communicating it to other minds and storing it in the environment.

Information philosophy claims that everything created since the origin of the universe over thirteen billion years ago has involved just two fundamental physical processes that combine to form the core of all creative processes.

Step 1: A quantum process - the "collapse of a wave function."

Step 2: A thermodynamic process - local reduction, but cosmic increase, in the entropy.

This two-step core creative process underlies the formation of microscopic objects like atoms and molecules, as well as macroscopic objects like galaxies, stars, and planets. (Note that the formation of self-organizing physical systems in conditions far from equilibrium that are the subjects of chaos and complexity theories are this basic, non-teleonomic form of emergence.)

With the emergence of teleonomic (purposive) information in self-replicating systems, the same core process underlies all biological creation. But now some random changes in information structures are rejected by natural selection, while others reproduce successfully.

Finally, with the emergence of self-aware organisms and the creation of extra-biological information stored in the environment, the same information-generating core process underlies communication, consciousness, free will, and creativity.

The two physical processes in the core creative process are quantum cooperative phenomena and thermodynamics.

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### Entelechy vs. Teleology

Since modern quantum physics shows that the universe is indeterministic, with profound effects on microscopic processes at the atomic scale, we will find it valuable to distinguish pre-determinism from the adequate determinism that we have in the real world.

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### Some additional notes of interest

Information philosophy provides distinct answers to these two ontological questions. Material objects exist in the world of space and time. They are information structures embodied in matter and interacting with energy.

Abstract concepts (like redness) are pure information, neither matter nor energy, although they need matter for their embodiment and energy for their communication.

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It is quantum interactions that lead to new information in the universe - both new information structures and information processing systems.

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Our Macro Mind needs the Micro Mind for the free action items and thoughts in an Agenda of alternative possibilities to be de-liberated by the will.

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When you hear or read that electrons are both waves and particles, think "either-or" - first a wave of possibilities, then an actual particle.

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Free will is a two-stage process of "free" (random generation of alternative possibilities), followed by "will" (adequately determined selection of the best action).

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Causal connection between motives, feelings, reason, character, values, etc. and the actions chosen from freely generated possibilities.

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Our actions are determined by our motives.

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We have shown that it is the interaction of light and matter, both on their own time reversible, that is the origin of irreversibility.

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Classical interactions between large macroscopic bodies do not generate new information. Newton's laws of motion imply that the information in any configuration of bodies, motions, and force is enough to know all past and future configurations. Classical mechanics conserves information.

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It is of the deepest philosophical significance that information theory is based on the mathematics of probability. If all outcomes were certain, there would be no "surprises" in the universe. Information would be conserved and a universal constant, as some mathematicians

mistakenly believe. Information philosophy requires the ontological uncertainty and probabilistic outcomes of modern quantum physics to produce new information.

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No knowledge can be gained by a "conscious observer" unless new information has already been irreversibly recorded in the universe. That information can be created and recorded in either the target quantum system or the measuring apparatus. Only then can it become knowledge in the observer's mind.

The measuring apparatus is quantal, not deterministic or "classical." It need only be statistically determined and capable of recording the irreversible information about an interaction. The human mind is similarly only statistically determined.

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The information interpretation of quantum mechanics explains clearly why quantum superpositions like Schrödinger's Cat are not seen in the macroscopic world. Stable new information structures in the dying cat reduce the quantum possibilities (and their potential interference effects) to a classical actuality. Just before opening the box, quantum mechanics provides the two possibilities of "live" and "dead" cat, with calculable probabilities. Upon opening the box and finding a dead cat, an autopsy will reveal that the time of death was recorded and in some sense "observed." A human experimenter is not needed to collapse the wave function. The macroscopic cat is its own measuring apparatus and observer.

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Information structures have stability over time scales of the same order as the age of the universe. Parts of DNA have not changed in 2.8 billion years.

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Randomness is used by living systems to escape the trap of determinism.

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Theories are probable.

Experiments are statistical.

Epistemology, the study of what we know, is fundamentally probabilistic.

Ontology, the study of what exists, is fundamentally statistical.

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In the 1870's Maxwell noted the occurrence of singular points in hydrodynamical flows and argued that something like them in the mind might allow living creatures to escape from strict determinism.

After the discovery of quantum uncertainty, some scientists (Arthur Stanley Eddington, Arthur Holly Compton, John Eccles, Henry Margenau) proposed quantum randomness as the source of free will.

*Our thesis is that quantum mechanics leaves our body, our brain, at any moment in a state with numerous (because of its complexity we might say innumerable) possible futures, each with a predetermined probability. Freedom involves two components: chance (existence of a genuine set of alternatives) and choice. Quantum mechanics provides the chance, and we shall argue that only the mind can make the choice by selecting (not energetically enforcing) among the possible future courses.*

*(Einstein's Space and Van Gogh's Sky - Henry Margenau).*

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Whereas the total amount of matter is conserved, the universe is continuously creating new information - by rearranging existing matter into new information structures.

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Humans are conscious of their experiences, because they are recorded in (and reproduced on demand from) the information structures in our brains.

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The world of information is abstract, not concrete, intangible, yet with causal power as Aristotle thought. The material world is made up *in part* of information structures. (Most of the matter in the universe is chaotic and contains little or no information.) Material information structures can be perceived and their abstract information content represented as information structures in the mind/brain. To the extent that the information in the mind is isomorphic with the information in the object, we can say that the subject has knowledge of the external world. To the extent that information in other minds is isomorphic, we have *intersubjective* shared knowledge, something impossible to show with words or even logic alone.

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The fundamental question of information philosophy is cosmological and ultimately metaphysical. What is the process that creates information structures in the universe?

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Information philosophy shows that without the expansion of the universe and ontological chance arising from quantum uncertainty, no new information could have come into existence from an assumed original state of thermodynamic equilibrium. There would be no galaxies, no stars, no planets, no life, no minds, no creative new thoughts, and in particular, no telos.

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Organisms are not machines, and minds are not computers, says Deacon, criticizing cognitive scientists who seek a one-to-one correspondence between conscious thoughts or actions and neuronal events. Machines are assembled from parts, whereas organisms self-assemble, he insightfully observes.

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Ernst Mayr writes: "(there is a) failure to discriminate among very different processes and phenomena, all labeled "teleological." The most important conclusion of the recent research

on teleology is that it is illegitimate to extrapolate from the existence of teleonomic processes (that is, those directed or controlled by the organism's own DNA) and teleomatic processes (those resulting from physical laws) to an existence of cosmic teleology. There is neither a program nor a law that can explain and predict biological evolution in any teleological manner. Nor is there, since 1859, any need for a teleological explanation: The Darwinian mechanism of natural selection with its chance aspects and constraints is fully sufficient. It is my belief that the pervasive confusion in this subject has been due to a failure to discriminate among very different processes and phenomena, all labeled "teleological." The most important conclusion of the recent research on teleology is that it is illegitimate to extrapolate from the existence of teleonomic processes (that is, those directed or controlled by the organism's own DNA) and teleomatic processes (those resulting from physical laws) to an existence of cosmic teleology. There is neither a program nor a law that can explain and predict biological evolution in any teleological manner. Nor is there, since 1859, any need for a teleological explanation: The Darwinian mechanism of natural selection with its chance aspects and constraints is fully sufficient".

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Shannon's analysis of information capacity provides an example of the critical role of absence. The way of measuring information is a function of its relationship to something absent. Without reference to this absent background of possible alternatives, the amount of potential information of a message cannot be measured. In other words, the background of unchosen signals is a critical determinant of what makes the received signals capable of conveying information.

No alternatives = no uncertainty = no information.

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The early universe does not contain the information of later times, just as early primates do not contain the information structures for intelligence and verbal communication, and infants do not contain the knowledge and remembered experience they will have as adults.

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Whereas the total amount of matter is conserved, the universe is continuously creating new information - by rearranging existing matter into new information structures.

The story of evolution from a matter-free universe origin to the information-processing brain/mind can be told in three major emergences:

1. the first appearance of matter, some of it organized into information structures,
  2. the first appearance of life, information structures that create and transmit information by natural selection, variation, and heredity,
  3. the appearance of human minds, which create, store, and transmit information external to their bodies.
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Rather than simply ask "Do abstract entities like numbers and properties exist," a metaphysicist prefers to ask in what way they might exist that is different from the way in which "concrete" objects exist.

Concrete objects can be seen and touched by our senses. They are material, with causal relations that obey the physical laws of nature.

Abstract entities are immaterial, but some of them can still play a causal role, for example when agents use them to decide on their actions, or when chance events (particularly at the quantum level) go this way instead of that.

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All the cosmic information structures (of the early cosmic creation,) are informationally passive. Their interactions follow simple laws of "bottom-up reductionist physics.

But the biological structures of life on Earth are far from passive. They have the extraordinary active and emergent, "top-down" capability of replicating and processing information, then communicating vital information among their parts. Immaterial information is a causal force managing the matter and energy in a living information structure.

Living organisms exhibit purposeful behavior called teleonomy or entelechy, not the teleology many philosophers and theologians think must pre-exist their existence. Living things, you and I, are dynamic growing information structures, forms through which matter and energy continuously flow. And it is **information processing** that controls those flows.

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The mind (manó) is not a computer, although like a computer, it is an information processing system which acquires, creates, stores, and manages the information needed to guide the actions of its body.

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In terms of information philosophy, living systems are complex information-processing systems. They feed on other information-rich living systems. Living systems can be described as having a form or shape through which passes information-rich matter and energy with low entropy. The incoming matter and energy exit the living system as matter and energy, but now with high entropy. The information input is degraded in the process of maintaining the living system in its highly ordered information state.

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Material particles are the first information structures to form in the universe.. They are quarks, baryons, and atomic nuclei, which will combine with electrons to form atoms and eventually molecules, when the temperature is low enough. These material particles are attracted together by the force of universal gravitation to form the gigantic information structures of the galaxies, stars, and planets.

Material information structures formed in the early universe - the elementary particles, atoms and molecules, galaxies, stars, and planets - all as the result of gravitation and quantum

cooperative phenomena. But it is not until the emergence of life that information replication and information processing begins. In a deep sense, biology is information processing. It is not until the emergence of life that information replication and information processing begins. In a deep sense, biology is information processing.

#### Information Processing IS Biology

*Understanding the origin of life is to understand the concept of living information structures - biological agents that some call "interactors."*

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#### Information-Processing Structures Enable Downward Causation

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Information Philosophy identifies the immaterial mind (mano + citta,) with the incredible biological information processing going on in the brain. This processing operates on two levels.

The human mind is the most highly evolved form of the biological information processing that goes on in all organisms. Information philosophy sees the mind as a biological information processing system.

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The Problem of Mental Causation is solved by showing how the information-processing system of life emerges from matter, and mind in turn emerges from life. In both cases we show that there is clear downward causal control of the component atoms by the higher-level information-processing system.

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We can agree that there was no "information processing" before living things and their machines, and no information controlling any interaction. But information structures - from the newly formed atoms and molecules to the galaxies, stars, and planets - were major players with an active role in everything happening in the pre-biological universe. Quantum cooperative forces and gravitation were controlling everything, but information was being created continuously from time zero, despite the unstoppable increase in overall entropy. This increase in information did not depend in any way on intelligent beings, although we now can see it and we benefit enormously from those pre-biological information structures.

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Information processing, not other laws of physics, is the key feature distinguishing life from physics and chemistry.

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Stonier saw correctly that "not only is information not a uniquely human attribute, but information processing is not either."

"Information exists. It does not need to be perceived to exist. It does not need to be understood to exist. It requires no intelligence to interpret it [to exist]. It does not have to have meaning to exist. It exists".

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Replication, even "self-replication," is not enough to produce the biological world. Billions of years before human beings invented machines, especially our computing machines, complex biological processes evolved that process information and construct new information structures, in ways that resemble how our computer-controlled machines process abstract information and manufacture new material objects, including new "machines."  
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Imagine now that the new molecule might be even more efficient than the original molecule at replicating itself (it has greater reproductive success). Note that the new molecule has more information in it than the original. Now we might say that this is the beginning of Darwinian evolution, which appears to have a goal or purpose of building richer information structures.  
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As the universe evolves, the increase in the total entropy, the disorder and chaos, is unstoppable. Fortunately, there are important places where the entropy is reduced locally, leaving behind information structures, pockets of negative entropy or cosmos.  
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Creation of information structures means that in parts of the universe the local entropy is actually going down. Creation of a low entropy system is always accompanied by radiation of entropy away from the local structures to distant parts of the universe, into the night sky for example.

(for instance, a tiny fraction of the solar energy falling on the earth gets converted into the information structures of plants and animals. Most of it gets converted to heat and is radiated away as waste energy to the night sky and the cosmic background).

Entropy and information can thus increase at the same time in the expanding universe. There are generally two entropy/information flows. In any process, the positive entropy increase is always at least equal to, and generally orders of magnitude larger than, the negative entropy in any created information structures. Positive entropy must exceed negative, to satisfy the second law of thermodynamics, which says that overall entropy always increases.  
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Knowledge of the present did not all exist in the past. We have only a rough idea of the exact future.  
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In a state of thermodynamic equilibrium, there is only motion of the microscopic constituent particles ("the motion we call heat"). The existence of macroscopic structures, such as the stars and planets, and their motions, is a departure from thermodynamic equilibrium. And that departure we call the "negative entropy."  
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We replace the vague "patterns of reality" with the more concrete "information structures" Modern quantum mechanics put an end to atomism. The so-called "fundamental" entities

(such as electrons, quarks, or gluons) represent patterns of reality, yet they are not building blocks of reality. They are not primary, but rather secondary and derived, in the same sense as solitons are localized excitations of water, and not building blocks of water.

There is a bewildering diversity of concepts of matter. Certainly no substantial advance in the mind-matter problem can be achieved without a clear characterization of what we mean by matter. Fortunately we can find a modern answer to the question What is Matter? in Pauli's (1954) contribution to the International Symposium:

*"Matter has always been and will always be one of the main objects of physics. . . . even light has become matter now, due to Einstein's discoveries. It has mass and also weight; it is not different from ordinary matter, it too having both energy and momentum."*

*"Taking the existence of all these transmutations into account, what remains of the old ideas of matter and substance? The answer is energy. This is the true substance, that which is conserved; only the form in which it appears is changing."*

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In many ways, Plato's theory of immaterial forms existing outside space and time and providing the shape of material things is consonant with information philosophy's focus on immaterial information as the basis for

thought, for mind, for knowledge, and for the abstractable elements of information structures in the real world.

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*These notes come from Bob Doyle's site on [Information philosophy](#).*

*Echt Buddhism seems to agree with the above - (not necessarily with everything else on his site).*