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Change

Information is neither matter nor energy, although it needs matter to be embodied and energy to be communicated. How can abstract information explain the process of metaphysical change, specifically the change in properties over time?

Changes in various properties from place to place in space, for example density and temperature, may raise even deeper metaphysical questions, like why there is something rather than nothing. But these deep questions we set aside for now.

As most all of us know, matter and energy are conserved. This means that there is just the same total amount of matter and energy today as there was at origin of the universe. But then what accounts for all the change, the new things under the sun?

It is information, which is not conserved and has been increasing since the beginning of time, alongside the increase in disorder that we quantify as thermodynamic entropy.

What is changing is the *arrangement* of the matter into what we can call *information structures*. What is emerging is new information. What idealists and holists see is the emergence of *immaterial* information.

Living things, you and I, are dynamic growing information structures, forms through which matter and energy continuously flow. And it is information processing and biological communication that controls those flows!

Information is the modern spirit, the ghost in the machine, the mind in the body. It is the soul, and when we die, it is our information that perishes, unless the future preserves it. The matter remains.

Information is the *form* in all concrete objects as well as the content in non-existent, merely possible, thoughts and other abstract entities. And the forms of all material are constantly, if sometimes imperceptibly, changing.



The only things that do not change are certain abstract entities, some of which may be instantiated in or abstracted from, material objects in the physical universe.

Information philosophy goes beyond *a priori* logic and its puzzles, beyond analytic language and its paradoxes, beyond philosophical claims of necessary truths, to a contingent and constantly changing physical world that is best represented as made of dynamic, interacting information structures.

Change can be in the internal or intrinsic properties of a thing, or in its extrinsic relations to external objects, e.g., dispositional properties like coordinates. The primary view of change is a real, metaphysical change in a “thing itself.” Some metaphysicians argue that this must be a change of identity. But this is wrong, because modest changes in the material substrate or the information content (shape and form, internal and external communications) do not change the essential relative identity over time of an object.

Because of motions and microscopic physical events, all material things change in time. This is the idea of the Heraclitean “flux” or Platonic “Becoming.”

Such change means that the concept of “perfect or strict identity over time” is fundamentally flawed. Even in the case of a hypothetical completely inert object that could be protected from loss or gain of a single particle, its position coordinates in most space-time frames are constantly changing. All its spatial relations with the other objects in the universe are constantly changing.

Perfect identity over time is limited to unchanging ideas or concepts – Parmenidean “Being.” These are abstract entities like numbers, simple universals, and logical truths.

The Eleatic followers of Parmenides, notably Zeno, invented his motion paradoxes – the Arrow, Achilles and the Tortoise – to deny change. Zeno’s motion paradoxes and claims denying a plurality of beings – the bizarre idea that “all is one” – still appear in today’s elementary metaphysics textbooks.



Aristotle's hylomorphic theory of change argued that what persists over time is an underlying substrate (ὑποκείμενον), which he identified with matter (ύλη). This is Aristotle's anticipation of the conservation of mass (now including energy).

But as with the puzzle of The Statue and Lump of Clay, Aristotle knew that the form (μορφή) is an equal contributor to the essence of a substance (οὐσία).

Aristotle clearly sees a statue as both its form/shape and its matter/clay.

“The term “substance” (οὐσία) is used, if not in more, at least in four principal cases; for both the essence and the universal and the genus are held to be the substance of the particular (ἐκάστου), and fourthly the substrate (ὑποκείμενον). The substrate is that of which the rest are predicated, while it is not itself predicated of anything else. Hence we must first determine its nature, for the primary substrate (ὑποκείμενον) is considered to be in the truest sense substance.

“Now in one sense we call the matter (ύλη) the substrate; in another, the shape (μορφή); and in a third, the combination. Both matter and form and their combination are said to be substrate. of the two. By matter I mean, for instance, bronze; by shape, the arrangement of the form (τὸ σχῆμα τῆς ιδέας); and by the combination of the two, the concrete thing: the statue (ἀνδριάς). Thus if the form is prior to the matter and more truly existent, by the same argument it will also be prior to the combination.”¹

In some writing, Aristotle regards matter as individuating form. In others, it is the form that is essential. An active agent impresses the form on the matter. The matter assumes/acquires the form. The form of a cat impressed on undifferentiated matter actively gives the matter the form of a cat. The matter changes shape (μορφή).

In other cases, a passive patient is “informed,” by perceiving a form. A perceiver thinking about something acquires the form without the matter. Acquisition of the form is by impressing that form onto the material brain, embedding the information as an experience that is recorded (our ERR).

1 Aristotle, *Metaphysics*, Book VII, § vii



Cosmic Change as the Growth of Information Structures

While we can say little about the coming into existence of the material and energy content of the universe some 13.74 billion years ago, we can show how the changing arrangement of matter over those years, together with the transformation of energy into matter and back from matter into energy, grounds the explanation for all the particular changes that we experience every day.

There could be no visible change if every new thing created was instantly destroyed and reduced to chaos. Any structure that visibly appears to be an arrangement of matter we call an information structure. Change can then be defined as a changing arrangement of the matter, a change of the information in a structure.

By information we mean a quantity that can be understood mathematically and physically. It corresponds to the common-sense meaning of information, in the sense of communicating or informing. It also corresponds to the information stored in books and computers. But it also measures the information in any physical object, like a stone or a snowflake, in a production process like a recipe or formula, and the information in biological systems, including cell and organ structures and the genetic code.

Information is mathematically related to the measure of disorder known as the thermodynamic quantity called “entropy.” The information we mean is a measure of the “order” or “negative entropy,” the departure of a physical system from pure chaos, from “thermodynamic equilibrium.”

“Negative entropy” is simply the difference between the maximum possible entropy (where all the particles in a physical system are in a maximum state of disorder, there is no visible structure) and the actual entropy.

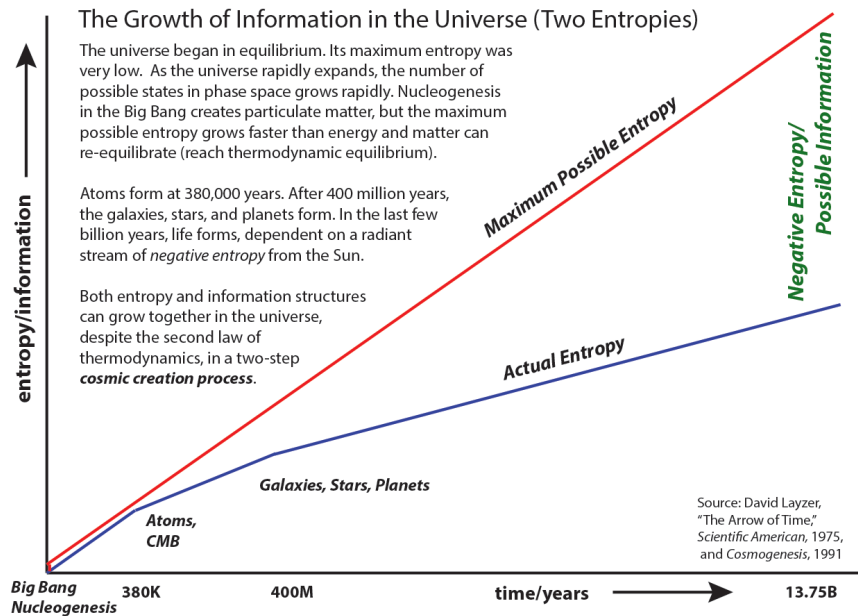
In a state of thermodynamic equilibrium, there is only motion of the microscopic constituent particles (“the motion we call heat”). The existence of macroscopic structures, such as the stars and planets, and their motions, is a departure from thermodynamic equilibrium. And that departure we call the “negative entropy.”



The second law of thermodynamics says that the entropy (or disorder) of a closed physical system increases until it reaches a maximum, the state of thermodynamic equilibrium. It requires that the entropy of the universe is now and has always been increasing.

This established fact of increasing entropy led many scientists and philosophers to assume that the universe we have is “running down” to a “heat death.” They think the universe began in a very high state of information, since the second law requires that any organization or order is susceptible to decay. The information that remains today, in their view, has always been here. There is nothing new under the sun.

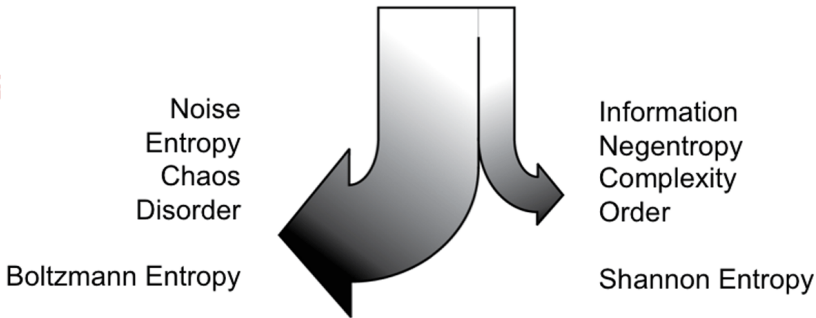
But the universe is not a closed system. It is in a dynamic state of expansion that is moving away from thermodynamic equilibrium faster than entropic processes can keep up. The maximum possible entropy is increasing much faster than the actual increase in entropy. The difference between the maximum possible and actual entropy is potential information, as shown by DAVID LAYZER.²



2 Layzer (1991). *Cosmogogenesis: the Growth of Order in the Universe*.



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.



As the universe expands, both positive and negative entropy are generated. The normal thermodynamic entropy, known as the Boltzmann Entropy, is the large black arrow. The negative entropy, often called the Shannon Entropy, is a measure of the potential information content in the evolving universe.

But how does an information structure emerge?

Ex nihilo, nihil fit, said the ancients, Nothing comes from nothing. But information is no (material) thing. Information is physical, but it is not material. Information is a *property* of material. It is the form that matter can take. We can take a lump of clay and make a statue. We can thus create something (immaterial) from nothing! But we shall find that it takes a special kind of energy (free or available energy, with negative entropy) to rearrange matter.

All changes in time are rearrangements of matter and energy, even if only the translation in space of an intrinsically unchanging object from one place to another, the change we call motion.

Cosmologists know that information is being created because the universe began some thirteen billion years ago in a state of minimal information. The “Big Bang” started with just the most elementary particles and radiation. Many changes are needed to produce a galaxy with a star like our Sun shining down on life on Earth



The first changes were combinations of the simplest forms of matter. Elementary particles, quarks and gluons, combined to form protons and neutrons in the first few minutes. These later combined with electrons to change into atoms, but not for an amazingly long 380,000 years! Vast numbers of atoms became clouds of matter that gravity condensed into galaxies, stars, and planets, but that was over 400 million years after the origin.

How matter formed into information structures, from atoms to galaxies, stars, and planets, is the beginning of a story that will end with understanding how human minds emerged to understand our place in the universe.

Note that the creation of all these material structures does not in an important sense process the information that they contain.

A qualitatively different kind of information creation was when the first molecule on earth replicated itself and went on to duplicate its information exponentially. Here the prototype of life was the cause for the creation of the new information structure. Accidental errors in the duplication provided variations in replicative success. Most important, besides creating their information structures, biological systems are also information processors. Living things use information to make their changes.

The third process of information creation, and the most important to philosophy, is human creativity. Almost every philosopher since philosophy began has considered the mind as something distinct from the body. Information philosophy can now explain that distinction.

The brain, part of the material body, is a biological information processor. The mind *is* the *immaterial* information in the brain. The stuff of mind is the information being processed and the new information being created. Mental events have causal powers that can make changes in the material world. As some philosophers have speculated, *mind is the software in the brain hardware*.

