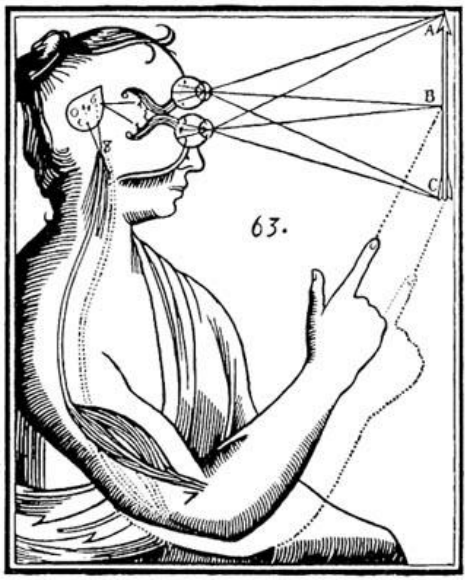
Statistical entropy is a probabilistic measure of uncertainty or ignorance; information is a measure of a reduction in that uncertainty

Matter-Energy and Information

“I believe that consciousness is, essentially, the way information feels when being processed.” – Max Tegmark

The ancient Greeks, Hindus, Buddhists, and Medieval Alchemists thought the universe was composed of five classical elements: air/wind, water, Earth, Fire, and Aether/Space. Recently, I came across the most basic way to categorize everything in our universe into two eleements, matter-energy and information.

In the realm of physics, everything is matter-energy, a single element that takes two basic forms as explained in special relativity. Then Cybernetic systems came along, which described systems in terms of matter-energy interactions, but added the element of information, which creates a feedback loop for the system. Throughout history, some philosophers and theologians have considered information processing a separate element, the soul, but we know this Cartesian Dualism is a conceptual illusion.



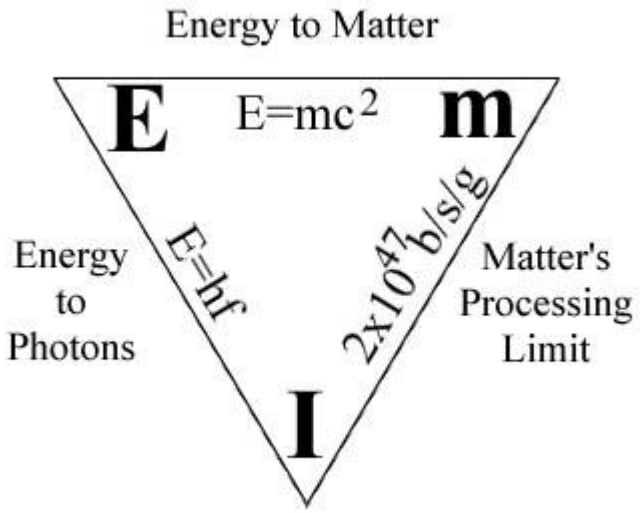
Cartesian Duality

Roundworms do calculus to find food or avoid unpleasantness. Computers do calculus too. They do this with logic-gates inside the arithmetic logic unit (ALU), an electro-mechanical sequence of events in the circuitry that produces a result we read on a screen and understand through an electro-biochemical sequence of events in our brains, two very different matter-energy systems understanding the information in very different ways, but interfacing nonetheless.

Photons reflected off our surroundings hit the retinas of our eyes, which signal the brain via the optic nerve, where 100 billion neurons make sense of the image and decide how to react. It is unacceptable to write this symphony of interactions off as information. It seems as though we are simply labeling “information” what we cannot yet explain through matter-energy mechanisms in detail.

Can information be reduced to matter-energy, and return us to only that single element? Matter and energy were once considered two separate and distinct elements, until Einstein came along and proved they were the same thing with the $E=mc^2$ equation.

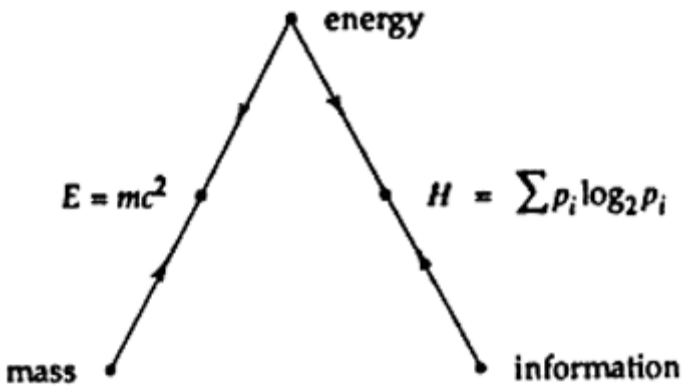
Stuart A. Umpleby published a paper in the journal Systems Research and Behavioral Science titled Physical Relationships among Matter, Energy and Information, which attempts to connect these three concepts. Using Einstein’s established mass-energy equivalence formula, the relationship between the frequency of light and photon energy, which is observed in the photoelectric effect, and Bremermann’s limit, which is the maximum rate at which any system can compute based on E=mc2, 2×1047 bits/second/gram, Umpleby comes up with the following triangle connecting the dots:



Energy-Matter-Information Triangle

Information is difficult to define in this context. It’s not the words on a sign, as the photons being reflected from the symbols exist regardless of there being an observer to see them. It’s not data, as numbers, charts, statistics are only meaningful at the moment someone sees their patterns in real-time or brings them into awareness from memory. Information is processing, an action, a verb. It does not exist when there is not a brain or computer to create it. Information and consciousness are synonymous, the merging of data and the immediate awareness of its significance.

Another diagram I found online, makes this relationship linear rather than triangular, information comes from matter, through energy:



Energy-Matter-Information Transformations

There is little else I could find on this question, and nothing concrete. All of this is still vague, speculative. Humans started out working primarily with matter through agriculture, then we began producing massive amounts of energy with the Industrial Revolution, now the Information Revolution is putting this question right in our collective face, and, in doing so, brings the possibility of answering it.