Matter-as-Awareness Theory of Consciousness

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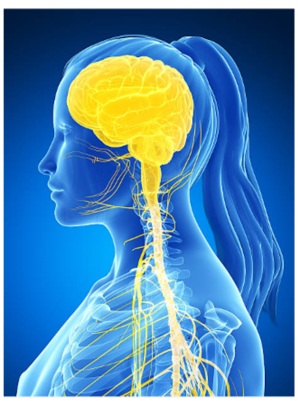

Figure 1

What is the difference between a rug and a sentient being (e.g., an organism)? The difference lies in the structural relationships among their material elements. That is, there isn't anything special about the matter of which the sentient being is comprised. It is not made of special substances. It consists solely of those elements that make up the periodic table; the same as the rug. What is different is that sentient beings have a specialized physical sub-structure, called a nervous system, that enables the organism to maintain internally a representation of its world, both internal physical states and external objects. This internal representation is its consciousness.

The creation and evolution of nervous systems depends on the existence of *aggregate matter*. When you look out at the universe, matter is continually interacting with other matter, creating new relationships and entering into ever more complex interactions. We call this the creation of aggregated matter. Aggregated matter is of greater complexity than the elements of the periodic table. It includes chemical compounds, proteins, amino acids, and lipids that are physically and chemically complex. While there isn't anything special about the components of aggregate matter, its complexity enables it to do more things such as providing a basis for computing: It can assume more states, more quickly, and store information for long durations.

Chalmers (1995) identifies two types of problems for the study of consciousness which he calls: the *hard* problem, and the *easy* problem. The hard problem is explaining subjective experience. How is it that we are aware of a world? What other things are aware and have subjective experiences? Are they aware of the same things as we are, or entirely different things? In contrast, the "easy" problem is explaining how the brain creates *qualia*, the physical instantiation of subjective experiences; qualia that unify processing in diverse parts of the brain into an integrated experience. How is this accomplished computationally? What neural systems and brain structures are involved for distinct subjective experiences?

From the perspective of matter-as-awareness theory, the names of the problems should be reversed. Chalmer's hard problem, where does the awareness in subjective experience come from, is explained by introducing an axiom: All matter has an attribute that is awareness.

The rationale for this axiom is straight forward. I am aware. I am aware of the room I am in, the desk I am at, and many other things. Further, I am a physical being. I and the universe consist only of matter, and since according to Einstein, matter and energy are the same thing—E=MC2 or M=E/C2—matter/energy must have some attribute or aspect that is awareness, since literally there is nothing else for awareness to be.

Recently I read a book by the Dalai Lama in which he states that according to the Highest Yoga Tantra teachings all energy is knowingness or cognizance (Dalai Lama. 2006). Ostensibly, what we are proposing is the same as the Highest Yoga Tantra teachings. We acknowledge that, and adopt their position: All matter is energy, and as such has a cognizance or knowingness aspect associated with it, which we call awareness.

We consider the tantra terminology as equivalent to the term, awareness, according to the dictionary (Merriam-Webster, on-line): Knowing – having or reflecting knowledge, information, or intelligence; Cognizance – having knowledge or being aware of; Awareness - knowledge and understanding that something is happening or exists. In the remainder of the essay, we will use the terms awareness, cognizance, and knowingness interchangeably when referring to the property of matter/energy that enables us to know a world, and we describe this theory as matter-as-awareness.

In the matter-as-awareness theory, it is important to stress that there is no intrinsic agent that is aware, or knows; there is just knowingness. Atoms do not have minds, nor feelings. Rather, matter is the building block from which intelligent systems (i.e., minds and perhaps other things) can be created. These systems appear to be intelligent agents to independent observers, but really are more similar to software routines that are closely coupled to the environment and the changes occurring there. We believe that the subjective experience of matter-as-awareness is a type of knowingness (i.e., a state of matter), and not essentially different from the awareness inherent in the material building blocks. Therefore, this model does not necessarily require a subject who knows, or experiences the knowingness.

We postulate that the relationship between matter and awareness/knowingness was set during the Big Bang. Each class of particles has a unique quale. When particles are combined, by sharing matter (e.g., electrons), they create atoms which have their own quale. Combine atoms into elements and they again have their own subjective experience. This pattern continues all the way to the creation of very complex physical structures. Taking all these pieces of elementary matter and combining them into a functioning organism is the real hard problem. It is the challenge of evolution.

What are we?

Next, we want to re-emphasize what we actually are. Research has determined that all cells within the human body are replaced within seven years, except for those in the Central Nervous System (CNS) (New York Times. 2005). Further, all atoms, including those in the CNS, are replaced every seven years (Bionumbers.org). *We are not sets of matter; we are configurations* *of matter*. It is the configuration of matter that gives rise to specific perceptual and cognitive capabilities.

The matter that we are comprised of is constantly changing, but the structural configuration of it is not, at least at a macro level. At a micro level there is likely to be change that reflects learning and changes in health (e.g., aging). Further, we are a metabolic process. We extract energy from the environment and use it to create and maintain our structure and ongoing processes. Figuratively, we are similar to dust-devils on land or vortexes in the ocean: constantly spinning while maintaining structure, with material constantly coming and going. Matter/energy doesn't change when it becomes part of a sentient being. It doesn't suddenly become alive or develop a mind, it just plays a role, or fills a slot, in the ongoing process of the sentient being until it leaves through normal processing (i.e., waste removal).

Neuronal Architectures and Consciousness

In the matter-as-awareness model, when discussing individuals, we say they have nervous systems; when discussing species, we say they are characterized by neuronal architectures. A neuronal architecture is a set of species-specific 'blueprints" (probably embodied in the genes) that create sensors and processing capabilities that define what members of a species can know and how they can act. It defines a species-specific structured relationship of aggregated matter that enables the processing of information and defines the range of conscious states a species can potentially experience.

Architectures are created by evolutionary pressure, which has produced a vast variety of species-specific neuronal architectures. These differ in the types of information they process, and in terms of the phylogenetic complexity of the sub-systems (e.g., sensory modalities). More sophisticated architectures have more complex concepts (i.e., more complex brain states) that enable more adaptable behavior. Different species, thus perceive different "worlds" and different aspects of the universe (see Young, 2017 for additional discussion on these issues).

Consider Figure 2. The picture portrays at a high level the process of seeing in two species, human primates and hummingbirds. The process starts with a light source, which can be intrinsic to the object being observed, or external. Figure 2 shows an external source (the sun) which emits waves of electromagnetic radiation. The amount and type of radiation emitted from a sun varies depending upon the class of the star, and its age. In addition, radiation can be absorbed in transit by dust and molecules in space or the atmosphere. Electromagnetic radiation also can be reflected by objects in the environment, as shown by the picture. Radiation encountering an object may be absorbed (slightly raising the temperature of the object), or reflected (and thus potentially visible to the eye), subject to the reflectivity of the object across the wavelength of the emitted spectrum. In Figure 2, the electromagnetic radiation from the sun is reflected off a few flowers. The lower right picture show what a humming bird sees when looking at the flowers, the picture above it shows what human see. Note the difference between the two outcomes. The lower, more violet colored, picture highlights the areas of most interest to the hummingbird, which are the nectaries where the nectar the hummingbird seeks is found. The other picture does not convey this information.

Why do the two species see different things? Because their neuronal architectures are different. The human has three color receptors that absorb electromagnetic radiation from wavelengths of 400 – 700 nanometers (i.e., humans are trichromatic). The hummingbird has similar receptors, plus another receptor which absorbs electromagnetic radiation from 300 – 400 nanometers, which is the ultraviolet part of the spectrum (i.e., hummingbirds are tetrachromatic). That is, while the flowers reflect a wide range of radiation, different species of birds (or other animals) only see specific wavelengths. Usually these are the wavelengths that provide the most useful information to the organism.

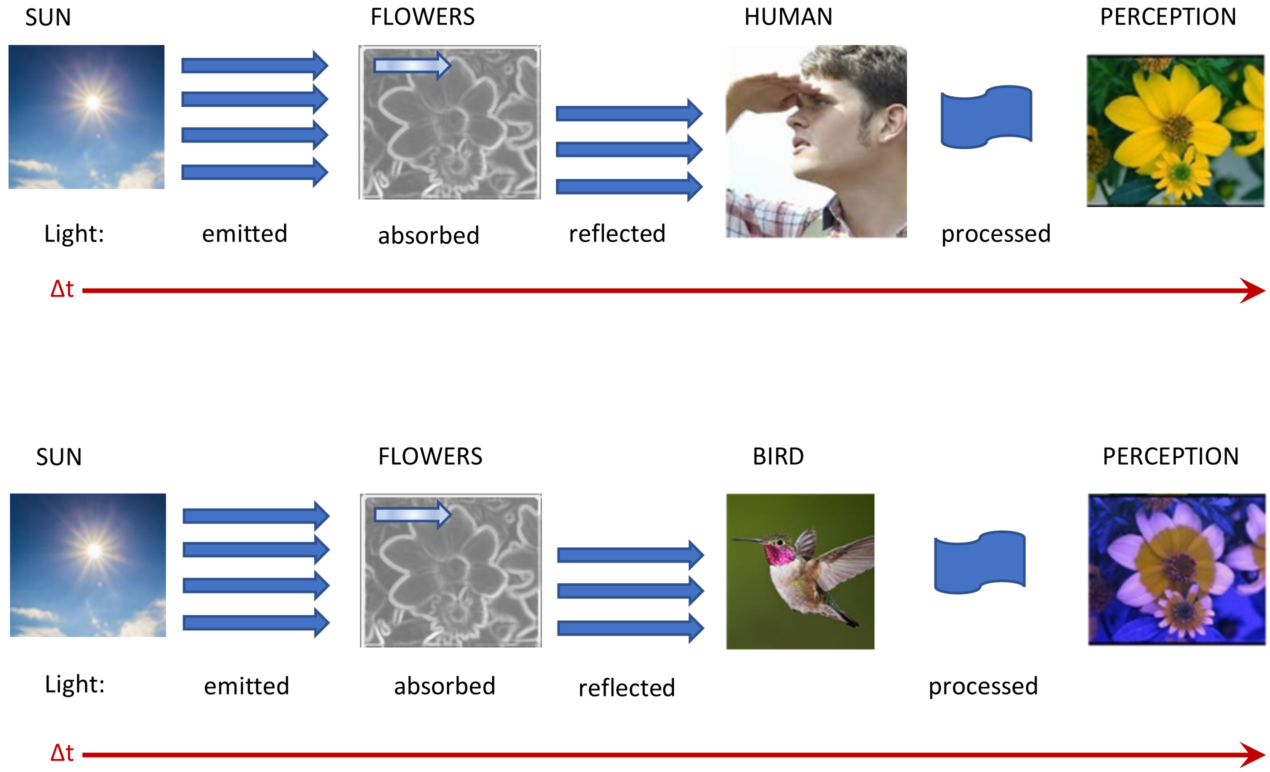

Figure 2

Note that the observer does not see the external world, but rather each creates a very limited version of relationships among matter in its brain. These relationships convey meaningful information to the organism. This world created—which is unique to the species—is the outcome of neuronal architecture processing. Note further, that since light needs time to travel from one object to another, and then be processed locally by nets of neurons, we are always perceiving things as they were instead of as they are now. The delay is not long, probably from 5 – 500 milliseconds depending upon the action (in the lower range for reflexive action, and in the upper range for processing a visual scene), but it is additional evidence that we live in a world we create.

Aggregate Matter and Consciousness

The complexity of matter has been increasing since the beginning of time (i.e., since the Big Bang). This increase in complexity, in turn, has supported the ongoing evolution of consciousness by continually providing new varieties of aggregate matter that can be used by organisms to create new types of sensors and sophisticated information processing methods, which are experienced in the matter-as-awareness framework as new varieties of consciousness.

According to Big Bang theory, initially at the start of the universe, there was minimal aggregate matter. There was a lot of energy and only four elements: hydrogen, helium, lithium, and beryllium (Economist, 2015). This limited the complexity of things that could be built. The creation of other elements requires nuclear fusion, which can create elements up to iron (# 26, out of approximately 118 known elements). Stars are where most elements are created; they are essentially nuclear fusion balls that create new elements by burning nuclear fuel (i.e., squeezing more protons and neutrons into the element's core). To create elements heavier than iron requires the massive explosions of supernovas. Populating the universe with a full range of elements of the periodic table (element #1 to #118) takes billions of years. And, creating elements is just the beginning.

Elementary matter continually aggregates together to create more complex compounds. If you look at matter today, here on planet Earth, scientists have discovered nine million organic (carbon-based) compounds and sixty-six million other compounds (Hazen, 2019), and they are adding around twelve thousand new compounds each day. Matter is becoming more complex, and more aggregated over time, seemingly in violation of the second law of thermodynamics.

The continual increasing complexity of matter over time is brought about in many ways beyond stellar activity (Hazen, 2019). Physical changes are brought about when minerals interact, creating new minerals which then interact with existing minerals and create even more novel minerals. The initial process started with elements interacting and creating compounds, which then combined to create more complex compounds. Further, major macro events such as changes in solar radiation, which changes temperatures on earth, have enabled new minerals to form since compound formation may be temperature dependent. Other physical processes that provide an opportunity to form new minerals include comets and asteroids striking the earth, raising the temperature slightly and potentially bringing new material to the planet; and volcanism triggered by plate tectonics.

Finally, the remains of organisms (both plants and animals) add additional physical complexity to the environment. The simplest example is the hydro-carbons that comprise oil. They are the plant and animal remains from the Age of Reptiles, and there are a lot of them. Biological events alter the environment and create new opportunities for minerals compounds to get together (Hazen, 2019). For example, the increase of oxygen in the atmosphere due to its release from organisms as a waste product enabled the formation of many new minerals (and new life forms). New aggregate matter is probably also produced in organisms as part of the evolutionary process.

Organisms and the Tree of Life

The proliferation of aggregated matter eventually created a new environment which enabled a new class of matter, commonly called an organism, to emerge. Following Boden (1999), we define an organism as activity that employs metabolic processes to autonomously create and maintain itself for a period of time. Organisms are considered living things, although the definition of *living* is not generally agreed upon.

There are several competing definitions for the term organism. Depending upon the author, different principles are considered key to the development of organisms. In a review paper, Boden (2001), lists ten principles: self-organization, emergence, autonomy, growth, development, reproduction, adaptation, responsiveness, evolution, and metabolism. Of these terms, three are central to our discussion: self-organization, metabolism, and reproduction. As described by Boden (2001), self-organization is a process that creates organization and structure out of a state that is less ordered by means of autonomous development. Essentially, self-organization is "negative entropy" through which an organism creates a complex structure and then maintains that complexity for a period of time (normally as long as it is alive). Metabolic processes extract energy from the environment and use it for construction and maintenance of a physical body, accomplishing behavior, and reproduction (Boden, 1999). Reproduction is the process which enables this class of organisms to propagate and evolve into different species throughout time.

The matter-as-awareness theory postulates that organisms possess consciousness. We propose that all organisms create an internal representation of the world; this representation is their consciousness. It is what is subjectively experienced as the world that organism knows. Further, consciousness varies in a phylogenetic fashion: More complex organisms, in general, experience more complex worlds. Complexity of experience is determined by the range of energy an organism can transduce along with its ability to process data and produce behavior. More sensors and enhanced processing produce more sophisticated consciousness. For example, the hummingbird can see more frequencies of light, while humans have more capability to process and correlate it. All creatures, however, are quite limited in what they can experience compared to the range of information available to them. Humans, for example, can see about 4% of the electromagnetic radiation spectrum and process around 12% of sound frequencies; and humans have the most complex nervous systems of all known species.

From a matter-as-awareness perspective, conscious organisms are the "products" of the aggregation of matter and evolution. There are two overarching hypotheses about the beginning of life, and then a variety of specific proposals (Fry, 2000; Scientific American 2018; Smith & Szathmary, 2009). We will briefly consider the two overarching models. One hypothesis is that organisms initially came into being when some proteins folded in such a way that they could store and use energy to replicate themselves. Changes in the genetic code that enabled proteins to better replicate themselves were selected for, and over (evolutionary) time more complex organisms developed to adapt to the continually changing environment. There are a variety of models that take this general approach, but differ in terms of specifics (Fry, 2000; Scientific American 2018; Smith & Szathmary, 2009).

An alternative proposal for the creation of organisms is the *metabolism first* model which uses a thermodynamic scheme. This proposal postulates the formation of chemical reaction networks that increase in complexity when forced to adapt to changing environments (Shapiro, 2007). The process begins with the formation of a compartment which segregates material between inside and out, thus enabling the material inside to become more complex, or more structured, over time as it adapts to the environment. From a probability perspective, this model appears more plausible because it relies on the initial formation of simpler cells than the protein-folding model. Both of these proposals are biologically based and depend upon readily observable biological structures and principals. (For a deeper discussion of these issues, including additional hypotheses about how life started cf. Fry, 2000; Scientific American 2018; Smith & Szathmary, 2009).

Regardless of which model framework is correct (and there will probably be several newer models created before the truth is fully uncovered), the creation of what might be called *energy productions methods* only occurred a few times on earth. All plants and animals, for example, employ the adenosine triphosphate (ATP) energy-carrying molecule to store and utilize energy. This sharedness strongly suggests that this process was invented once and then passed on to all descendants.

In summary, new forms of complex aggregated matter provide a continually changing environment that supports the ongoing evolution of consciousness by providing new opportunities for growth. It is highly likely that only a small percentage of aggregate matter is actually useful to organisms, and organic matter seems to play a very significant role. The aggregate matter that is useful enhances fitness by enabling the creation of more complex and faster processing of information, along with new behavioral routines.

Dirt, Plants, and Animals: What Possesses Consciousness?

Two of the cornerstones of the matter-as-awareness theory of consciousness are that all matter has an attribute that can be considered to be awareness or knowingness, and that the structural relationships among matter determines what type of behavior specific matter can manifest. If we consider various forms of dirt, plants, and animals, they define a continuum of increasing sophistication from being "just awareness", to advanced forms of perceptual/cognitive processing systems and behavior. Further, one can describe physical stuff from multiple perspectives, from its sub-atomic particles up to an independent organism, consisting of many sub-systems. For this discussion we focus on the components of aggregate matter (amino acids, proteins, RNA, lipids, compounds of various types, etc.). We crucially distinguish awareness, which is present at all levels, from consciousness, which is a property of higher organization of matter.

Generic dirt contains approximately 40-45% inorganic matter (molecules not consisting of carbon atoms), 5% organic matter (molecules that include carbon-hydrogen bonds), 25% water (H_2O), and 25% air (primarily nitrogen and oxygen, some argon and carbon dioxide, and trace amounts of helium, neon, methane, krypton, and hydrogen). Dirt does not contain any of the structural components such as a primitive nervous system that would enable it to interact selectively with other aspects of the physical universe. Further, it does not maintain a representation of the external world. Dirt is awareness, but there are no sensors, no effectors, nor self-awareness (i.e., “I am”) associated with it. Physical effects such as changes in thermal characteristics or gravitational effects affect the whole object (Holt, 2007). Dirt is not conscious.

Plants are alive: They use self-organization and metabolism to create and maintain complex dynamic structures. Physical plant structures separate the plant from the rest of the universe and enable the creation of an inner world of meaning. Plants can discriminate; this enables plants to sense and respond to the environment, and adapt their behavior accordingly.

According to Jabr (2010): “Plants cannot think or remember, these borrowed terms do not accurately describe how plants function. However, like most organisms, plants can sense the world around them, process information from their environment, and respond to this information by altering their growth and development. In fact, plants respond to changes in their environment in ways that many would find surprisingly sophisticated”.

Van Volkenburgh (in Jabr, 2010) also argues against anthropomorphizing plants and saying things such as they are intelligent, know what they are doing, and/or think. She argues that these terms do not apply to plants. Plants do not have a self that knows what they are doing and chooses specific behavior after considering different options.

Even without a self, plants exhibit complex behaviors like gravitropism (where roots always grow down), phototropism (where leaves turn towards the sun), and heliotropism (where a plant actively tracks the sun to ensure its leaves receive maximum light exposure during a crucial period of growth (this is a more sophisticated form of phototropism). They also have a circadian rhythm mechanism that enables them to change many activities to account for seasonal changes like fluctuations in the length of day and changes in mean temperature. This capability enables some plants to flower when the days are getting longer and others when the day length is getting shorter.

Finally, while plants do not have nerves, many plants have structures similar to nerves that can generate electrical impulses similar to the action potential found in an animal’s nervous system. What role these structures play in the controlling plant behavior is not well understood (Jabr, 2010). Research suggests they might modify and regulate all kinds of biological processes in plant cells, but there is currently no consensus that associates nerve-like structures with specific plant functions.

The matter-as-awareness model argues that plants possess consciousness because they have a (limited) world representation. That representation is their consciousness. Plant consciousness includes all the dimensions mentioned in the previous description, plus others. This allows plants to be aware of and respond to the changing of the seasons, and to discriminate the different amounts of gravitational pull that exist in the different directions. Plant consciousness is likely to be distinctly different from animal consciousness due the differences in reaction speed and limited “cognitive” capability.

Animals are alive, and they are conscious. They employ self-organization and metabolism to create and maintain complex dynamic structures. Animal structures, especially nervous systems, separate them from the rest of the universe and enable the creation of an inner world of meaning and familiarity. Animals can distinguish objects in the environment, while individual species see and respond to specific classes of things.

Animals differ from plants in the variety and extent of their perceptual and cognitive processing capabilities. If one looks at the phylogenetic history of animal species one sees a near continuous development of new capabilities, punctuated by occasional periods very rapid progression and diversification of species. Growth in animals proceeds across many dimensions. For example, many new types of sensors (e.g., visual, infrared, ultraviolet radar, tactile, olfactory), have been created. Unknown numbers and types of computational mechanisms have been formed to look for food, stay alive, and reproduce.

What makes animals distinct from plants is their mobility and a sense of self, or *I-ness*. These function in concert to create huge opportunities for evolution-driven growth. Several of the key differences between plants and animals were brought about by mobility, or the lack thereof.

I-ness is the sense that oneself exist. It enables an organism to collect and organize information relevant to itself and then use this information to enhance fitness. For a mobile organism (as opposed to immobile plants), there would be significant advantage in knowing many things about yourself and the environment. How big am I, and what is my shape? Can I fit into that space? Is my skin thick or thin? What information do I store internally about the environment? What types of mobility behavior can I execute? What "cognitive" skills can I acquire? For example, can I plot a route to food that avoids predators and can I follow it without forgetting it? The list goes on and on, and changes, usually becoming more sophisticated, as species evolve.

As a consequence of the evolutionary reaction to mobility and I-ness, animals, in general, have more sophisticated internal representations of the world than plants. They have a nervous system evolved to send signals (relatively) long distances quickly. In contrast, while the plant control system has several characteristics in common with nerve cells (e.g., sheathing and bundling of select plant cells), it operates at a much slower pace, in concert with the plants behavior. Consequentially, one expects plant states of consciousness to usually change more slowly than animal states of consciousness. Further, because animal behavior is typically much more extensive (i.e., animals have more options) than plant behavior, you would expect to see a richer central nervous system with sophisticated algorithms to evaluate and execute behavioral options in animals. Sophisticated behavioral responses (mobility) combined with faster signal transmission contributed to the arising and differentiation of animals from their joint ancestor with plants.

Understanding how overt behavior is controlled by the nervous system is difficult. It is difficult to isolate specific information processing systems in the brain, and understand how they work. In the early 20th century, the science of ethology (i.e., the study of animals in their natural environment) flourished and provided much behavioral data that could be correlated with brain states. However, the field seemed to wither when newer techniques such as computer modeling became popular and the majority of researchers shifted to other methodological approaches and/or fields of research. Further, at most universities, ethology was not a stand-alone department and seemed to have difficulty competing for resources. Nevertheless, there is sufficient data to delineate some high-level capabilities.

An example high level cognitive capability found in animals, but not fully explored, is *episodic memory* (Tulving, 1983). Episodic memory is a collection of fragments of perceptual–conceptual-affective material that was present during a goal-directed activity and which can be recalled. Another postulated capability is *mental time travel* (MTT) (Boyer, 2008). MTT is a form of recall that allows you to reexperience the (attenuated) emotional aspects of situations previously encountered. These two capabilities combined with self-reference effect (SRE) algorithms, which make it easier to recall events that are associate with one's self-concept (Klein, 2012), may play a role in creating new behavioral scripts by strengthening associations, or linkages, among memory elements. That is, they might help human primates in adapting to new environments by developing new behavior. Whether other animals have similar capabilities is currently unknown.

Terminology

In discussing the matter-as-awareness model with colleagues, some individuals have suggested that my definition of consciousness in terms of awareness is circular. That is, *I am aware of*, and *I am conscious of*, essentially mean the same thing. I agree. The adjectives *aware* and *conscious* are commonly used to describe the same situation, in which an entity is alert to its surroundings. This causes some confusion for our discussion here. Also, the term *knowingness* is often used in Buddhist writing with the same meaning as awareness. Therefore, we develop this set of terms:

aware / conscious – an organism is cognizant of information that has meaning to it. The information may arise from the senses or mental processes, and forms part of the organism's world.

awareness / knowingness –an intrinsic characteristic of matter/energy that brings a unique flavor to subjective experience. The matter-as-awareness theory of consciousness is a dual property theory. It argues that to fully understand matter, you must study it from multiple perspectives, to include both physically (matter) and cognitively (awareness). When you combine matter and consider it from a physical perspective it creates compounds of various complexities, joined together via chemical bonds. When you combine matter and look at it from a cognitive perspective, awareness/knowingness becomes more complex; thus combining matter creates the potential for new experiences (i.e., qualia, or a moment of knowingness).

consciousness – the world experienced by an organism that is delineated by the set of information in the nervous system of animals (and the functionally comparable information processing systems in plants); this consciousness represents the organism's world in a meaningful way.

Please note that *aware* and *conscious* are synonyms in this framework, while *awareness* and *consciousness* are not. Awareness/knowingness is a characteristic of energy/matter. Ordinary matter has awareness, but it is not aware/conscious. An organism can be aware/conscious. This state of being conscious derives from its consciousness, the world created via the neuronal architecture, and primarily embodied in its nervous system. It is the qualia component of living things (e.g., what is it like to be a bat).

Summary

Like some of the world's great religions (e.g., Hinduism, Buddhism) the matter-as-awareness theory of consciousness maintains that energy is simultaneously matter and knowingness. An organism is matter in a structural relationship that creates and maintains itself by extracting energy from the environment. The complexity of the structure, to include the complexity of the aggregate matter, determines how intelligent, flexible, and adaptable the organism is. Consciousness is an internal representation of an organism's world. Consciousness varies across species (and individuals). The neuronal architecture (i.e., the blue prints for nervous system) determines what an organism can experience and do. Species differ in how much of the world are represented and what aspects of the world is represented (e.g., what parts of the electromagnetic spectrum can be perceived, how much internal processing there is) and at what speed information processing occurs (i.e., consciousness changes at different speeds in different organisms). In this essay we have provided an overview of the matter-as-awareness theory of consciousness and explored some of the ways it provides answers to contemporary science questions.

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