A Hierarchy of Consciousness from Atom to Cosmos

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Introduction

Listening to, or reading, presentations of consciousness studies can often be very confusing. There are several reasons for this. One reason is that the presentation may come from two very different viewpoints. It may be focused on human consciousness or it may be coming from an interest in the idea of an all-pervasive consciousness throughout the cosmos (known as panpsychism). In this respect, experientially, as humans, we could ask – do we, as individuals, have consciousness or does a cosmic consciousness have us (so to speak). Many of us will relate to different personal experiences that suggest that both are true according to how preoccupied we are with immediate everyday concerns about the survival of our physical being and its ego, versus more meditative states, perhaps in nature, of being outside of our selves and 'aware of being aware.' We will come back to this seeming contradiction later.

Another reason for confusion is that the discipline, or background knowledge and interest of the scholar of consciousness may be very different. For example, it may be mystical/religious, philosophical or scientific. Each of these categories may be further subdivided in a way that influences the approach and outcome of the investigation. For example, the scientific approach may involve scholars in psychology or psychiatry (e.g., Velmans, 2017; Beauregard et al., 2018), in quantum mechanics (e.g., Marman, 2018), in Darwinian evolution (e.g., Velmans, 2012), or biology and geology. The approach from biology can be further subdivided into neurology (Koch et al., 2016; Chalmers, 1998) or, as in this article, evolution.

The literature covering the various approaches to the study of consciousness is huge and diverse and often confusing and will not be covered here. In this paper, the approach is limited to a simple mechanistic biological analysis of how consciousness is involved in increasing complexity in evolution – from atoms, to molecules, to tissues and organs, to life forms, to populations of life forms and then, after introducing the life forms into ecosystems, continuing on through solar systems, and galaxies to cosmos. With a few rules governing the nature of the formation of this interconnected hierarchy of evolution it is a scheme that delivers consciousness as primary and defines matter as derivative from consciousness in evolution.

This approach was initiated by the definition of consciousness as given in the Oxford dictionary ('aware of, and responsive to, surroundings', and see below) which, when viewed from

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the author's own experience in biological research, immediately pointed to the view of consciousness known as panpsychism. Panpsychism (defined as consciousness pervasive throughout existence) has been postulated throughout the ages by mystics and philosophers such as Plato, Spinoza, Leibniz, and James (cited, along with many other early proponents of panpsychism, in Goff (2020). It holds that consciousness is present in all natural bodies that have a unified and persisting organization (both pertinent aspects of the players in the scheme presented here).

My own research has involved many levels of biological existence, experimenting in each case towards a greater understanding of the mechanisms of increasing complexity and survival in evolution. In summary, my laboratory research has involved:

1. Atoms – the use of radioactive isotopes of atoms in enzyme substrates to isolate mutants in DNA synthesis to identify the genes involved, and the development of highly sensitive single cell molecular biology to measure specific enzyme activities in single cells (many references in the review by Goto & Monk, 1998, and for clinical relevance see Monk et al., 1987).

2. Molecules – the study of genes, gene modifications and gene expression, involved in DNA replication and repair, gene expression in embryos, germ cells and cancers, regulation of gene expression in development, epigenetic modification directing gene activity, molecular mechanisms of Lamarckian inheritance (see many references in the review by Goto & Monk, 1998, and earlier references e.g., Monk & Kinross, 1972; Monk, 1990; Adjaye et al., 1997; and later references, e.g., Goto et al., 1999; Zuccotti & Monk, 1995).

3. Viruses and plasmids – the study of DNA/gene transfer cell to cell, e.g., transduction in *Pseudomonas aeruginosa*, indirect induction of phage lambda (Monk, 1969), plasmid transfer (see e.g., Holloway & Monk, 1959; Monk & Clowes, 1964).

4. Cells – bacteria and amoebae, mammalian primordial germ cells, eggs and sperm, preimplantation diagnosis of genetic disease, embryonic stem cells, cancer cells (see e.g., Alcantara & Monk, 1974; Monk, Boubelik & Lehnert, 1987; Monk et al., 1987; Monk & Holding, 1990, and for clinical relevance Monk et al, 1987, Monk & Holding, 2001).

5. Multicellular tissues and organs – cell signaling in differentiation, conglomeration of cells into higher order structures, amoeboid migration, embryonic and fetal development (e.g., Alcantara & Monk, 1974; Monk & Petzoldt, 1977; McMahon & Monk, 1983).

It is not necessary to read all these references for the proposal of consciousness of evolution described here. They are cited only to provide evidence from 'person-at-the-bench' science for the known material mechanisms showing how consciousness drives the evolution of more and more complex conglomerations of matter in existence ascending the hierarchy from atom to cosmos (and, as extinction equals creation, back again). The model presented here is not about the *evolution of consciousness* in humans or other life forms by Darwinian variation (random mutation and selection) – a study that runs into considerable difficulties (see e.g., Velmans,

2014). Rather it is concerned with the *consciousness of evolutio*n. It supports the oft-quoted statement of Max Planck, the originator of quantum physics – "I regard consciousness as fundamental. I regard matter as derivative from consciousness."

Definition of Consciousness

Yet another reason for confusion in consciousness studies is the different definitions and uses of the word 'consciousness' itself. The human centred studies are more aligned with the Cambridge Dictionary definition of consciousness, namely, "*The state of understanding and realizing something."* Certainly that has been the main focus since Descartes who confined consciousness and mind to humans. It is this field of research which is concerned with the so-called 'hard problem' (Chalmers, 1996). The hard problem is human centered and is about how the physical mechanisms of brain processes give rise to subjective feelings – i.e., how the brain gives rise to experience, or phenomenal consciousness, and mental states with phenomenal qualities – 'the neural correlates of consciousness' (Strawson, 1994, Koch et al., 2016). These studies, looking for some uniform neural explanation of a particular experience, may be complicated by the different influences of the variable and interconnected neurological, physiological and psychological (experiential memory) backgrounds of the different individuals in the study (see e.g., Marman, 2018).

The other viewpoint that consciousness is pervasive throughout the universe (panpsychism) proposes that all matter has an element of consciousness. This approach is more aligned with the definition of consciousness from the Oxford Living Dictionary – "*The state of being aware of, and responsive to, one's surroundings.'* Immediately, most readers of this article will see that 'aware and responsive to surroundings' applies to so many things. All life, plant and animal, is aware and responsive to surroundings and thus appears as conscious according to this definition. Recently there has been much debate about consciousness in animals and even in plants.

In this article I will not be concerned with the human centred studies and the hard problem but with the more pervasive view of consciousness extending throughout the cosmos. The approach will be based on what is known scientifically and on the Oxford Dictionary definition of consciousness – aware of, and responsive to, surroundings.

Aware of, and Responsive to, Surroundings

One of the problems of considering consciousness in lower life forms, and non-life forms, is the use of various terms in consciousness studies that seem to apply more to humans. The term 'aware' is certainly more of a human concept and may be taken to include a huge range of consequences of awareness – sensations, feelings, self-reflection, memory, imagination, and so on. But, in biology and geology, when we consider the simple definition – aware of, and responsive to, surroundings – we see that consciousness extends outside of the human realm and, in lower life forms, or even non-life forms, we see 'awareness' more simply as mechanisms of 'detecting' or 'sensing' the surrounding environment. With this broader concept of awareness we can start thinking about consciousness at the level of the atoms, molecules, cells and tissues and work our way up from the micro- to the macro-cosmos, looking for the material mechanisms of

consciousness (sensing environment and responding to change) at each level of increasing complexity.

The starting rules for my hierarchy scheme of consciousness in this paper are views that are well known already – specifically, that everything is interconnected to everything else and everything is in service to its own higher order structure. For example, when I was at Edinburgh University in the early 70s, Henry Kacser taught the concept of interconnectedness as metabolic flux in the metabolome – the intricate interconnected biochemical pathways within a cell (Kacser & Burns, 1973). Also in Edinburgh, Conrad Waddington taught the concept of service as epigenetic programming of different cells in the body to serve their higher order structures – the different tissues and the organs (see Noble, 2015).

As humans, we experience consciousness with our senses of sight, hearing, touch, smell and taste. There are also messages from body to brain (e.g., hunger or pain), and messages from brain to my body for different emotions. And indeed, messages from within the environment of self of mental functions of memory, imagination and the various machinations of the human mind. These are functions of human brain/body communication and a lot (but not all) is known about material mechanisms involving transmission of signals between body and brain via circulating informational molecules binding to specific cell receptors. However, it is evident that all forms of life have consciousness but at different levels of sophistication, and with a very different range of consequences of their consciousness. A worm is conscious in that it detects and responds to changes in its environment. It can feel a harmful stimulus (pain). A snail can remember where it belongs in the territory of the back garden. A bacterium can detect a gradient of sugar involving special receptors on its surface and respond by transferring this information to trigger its means of movement – its flagellae – to swim towards a food source. The degree or sophistication of consciousness at different levels of life's complexity is different. This article is not concerned with mechanisms of evolution of increasing sophistication of consciousness. Suffice to say, it is difficult to see how random mutation and selection over millions of years could bring this about. However, note that Lamarckian inheritance of acquired characteristics by epigenetic modifications of genes passing through egg and sperm (Zuccotti & Monk, 1995) from parents to offspring might well be involved. Evolution by Lamarckian inheritance occurs rapidly by selection of individuals better adapted to their surrounding environment.

The scientific approach in this article is to consider the material mechanisms of consciousness at each level of increasing complexity in the hierarchy of evolution from atom to cosmos. And, indeed, material mechanisms are known at all levels. Surprisingly, with such a materialist approach throughout, the analysis shows that matter is derivative from consciousness and displays a sense of belonging, meaning and purpose of every thing throughout evolution and existing today.

An Example of Consciousness in a Lower Life Form

As an example of consciousness in a lower life form we can look at an area of the author's own research in the early 70s (Alcantara & Monk, 1974), namely, how slime mould amoebae (*Dictyostelium discoideum)* become aware of changes in their environment, and how they respond. Aggregation of the individual free-living amoebae into a multicellular structure is

triggered by their awareness that they have run out of food. The individual amoebae detect the change in environment (due to starvation) and start to emit a signal (pulses of cyclic AMP), which diffuses out into the territory (see Figure 1). The fastest signaling amoebae establish and take control of their territories. Amoebae in a territory, detecting the gradient of cyclic AMP, make movement steps towards the source and emit their own signal to attract amoebae further out to join the aggregation. So the signal is relayed out and bands of amoebae move inwards. They move towards each other as they come closer to the centre to make amazing spirals looking like galaxies.

The aggregate formed in the centre of the territory forms a multicellular slug capable of movement over a greater distance than the individual amoebae could manage. The slug develops phototactic and thermotactic receptors at its tip so that it moves towards the light and heat at the soil surface where it forms a fruiting body. To make the fruiting body, a third of the amoebae in the slug sacrifice their lives to create a stalk which bears the spores (differentiating according to their position in a gradient in the remaining two thirds of the slug) aloft so that they will be distributed to better feeding grounds. It is amazing how clever this organism can be when triggered by the need to move to new pastures. It is a good example of consciousness in a lower organism – how cells sense and respond to their environment at several stages in order to differentiate into a multicellular structure. The material mechanisms are known.

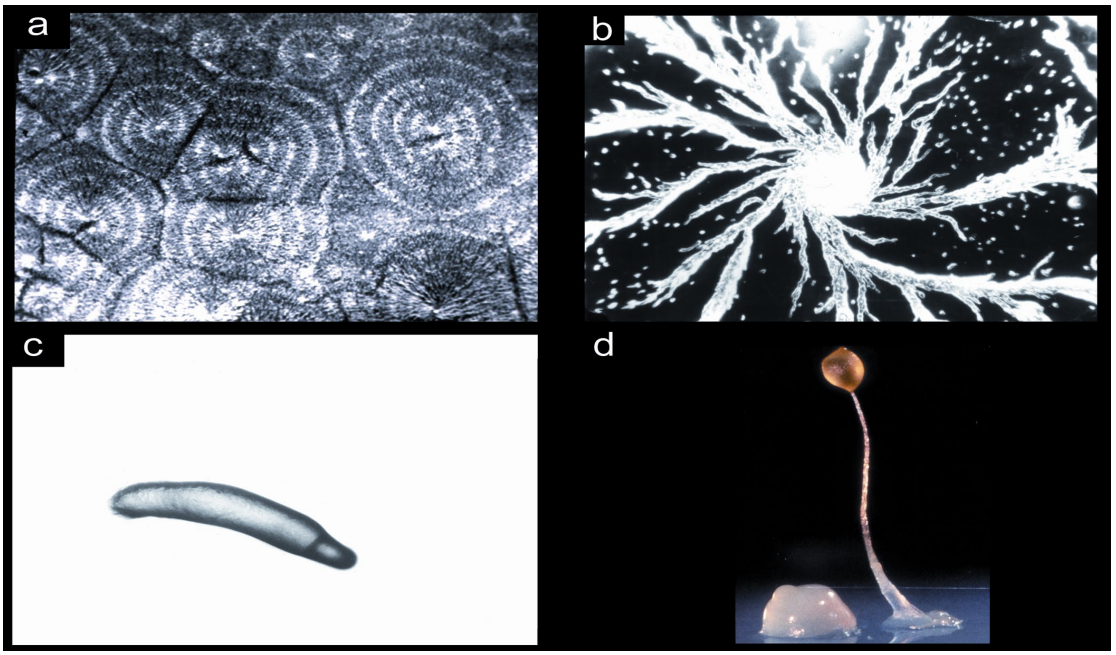

Figure 1. *Aggregation, slug movement, and fruiting body of Dictyostelium after the amoebae detect they have run out of food. a) Individual amoebae in the field, triggered by starvation, start to emit pulses of cAMP and those with the shortest periodicity form territories with surrounding amoebae relaying the signal outward and making a movement step inward towards the source. b) As they approach the centre, amoebae are attracted to each others' cAMP signal to form streams and spirals. c) The slug, measuring several centimetres, has receptors that detect heat and light, and so can detect, and move the distance to, the soil surface. d) At the surface the slug transforms into a fruiting body. A third of the amoebae in the slug sacrifice their lives to form stalk to bear the spores aloft (Alcantara and Monk, 1974).*

This example also demonstrates how consciousness can operate at the level of whole populations of individuals. What about lower and higher levels of complexity – atoms, molecules, cells and tissues, or ecosystems, solar systems and galaxies? Does it make sense to say that the mechanisms of consciousness are still material throughout?

A Hierarchy of Consciousness

In the following model of a hierarchy of consciousness, the mechanisms at each level of complexity depend on interconnectedness (awareness of surroundings) of the parts serving (responsive to surroundings) their higher order structure. A model of interconnectedness of increasing orders of complexity is shown in Figure 2. This is a highly simplified model. It does not include subatomic particles and, with respect to life, there are millions of species of life existing on earth (and an approximately equal number gone extinct) that are linked in various ways by the process of evolution. In the hierarchy model here they are simply presented as flora and fauna. Also, for simplicity, the model of interconnected hierarchy is illustrated as a binary interconnected model limited (for ease of illustration) to only eight orders of increasing complexity from atom to cosmos. The shift to a higher order structure at each level of complexity is due to a conglomeration of multiple members from the level below. The coming together of parts ensures their greater survival. The model as shown is binary although, clearly, at each level more than two parts form the conglomerate that is the higher order structure at the next level. For example, variable numbers of atoms conglomerate to make molecules and there are around 3000 molecules in a cell.

There is another simplification in the model of hierarchy as shown in that there is one exception to the general rule of conglomeration of parts to form a higher order structure. This is in the transition from populations to ecosystems. It is clear that ecosystems are not simply an aggregate of populations of living organisms (flora and fauna). In order to progress towards cosmos, I have introduced a stage (ecosystems) including elements from another hierarchy of increasing complexity of non-life forms – soil to rocks to mountains, rivers to lakes and oceans – in which to place the populations of animals and plants. The aim is to present an image representing the linking of all levels of increasing complexity into one interconnected structure where every existing organised structure is interconnected and aware of immediate surroundings and so on throughout the evolution of existence.

Analysis of this hierarchy of interconnectedness will show that, at each level, the parts are in service to ensure the survival of their higher order structure in evolution – the electrons to the atom, the atoms to the molecule, the molecules to the cell, and so on (although remembering that equally there is extinction from cosmos to atoms in the other direction). The parts in service at each level are conscious in that they detect and respond to their surrounding environment. The mechanisms are material and known at all levels of complexity as we will now examine – starting with the atom

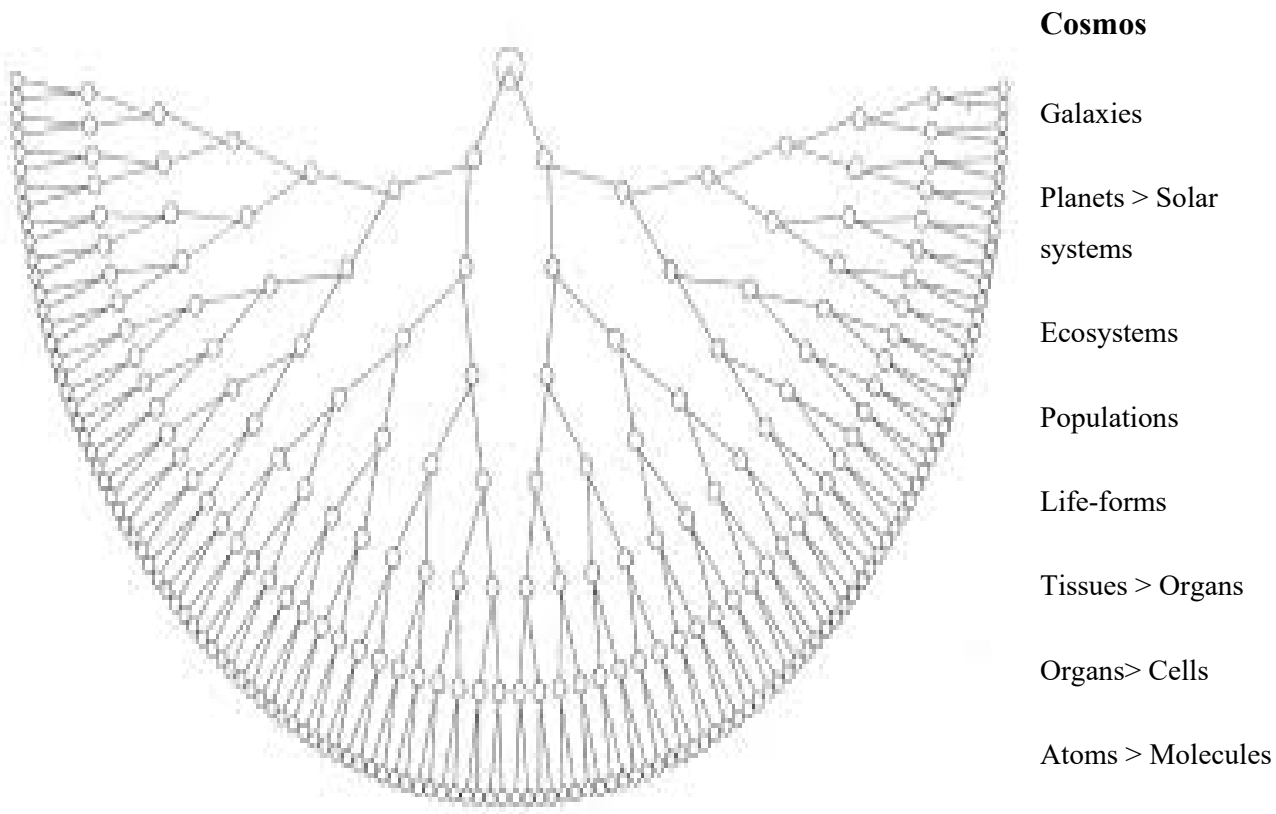

Figure 2. *A diagrammatic representation (an inverted ancestry model from Gregoire, 2014) of an interconnected hierarchy of increasing complexity in evolution. This is a binary model for simplicity – the number of atoms making a molecule, or molecules making a cell, and so on, is greater than two. It shows a path of increasing complexity going through life forms. A similar hierarchy could be created for non- life and the step from populations to ecosystems in this diagram brings soil, rocks, mountains, rivers, lakes and oceans into the ecosystems in this scheme of interconnectedness. The hierarchy also operates in the other direction from cosmos to atoms with extinction approximately equal to creation*.

Atoms to Molecules to Cells

Atoms consist of a balanced number of neutrons and positively charged protons in the nucleus and negatively charged electrons in their orbits (Bohr, 1923). For example, a carbon atom has six electrons and six protons, an oxygen atom has eight protons and eight electrons. When the balance of protons, neutrons and electrons is disturbed, the atom decays. The components or parts of the atom are in service to their higher order structure – the atom.

Next, we have the molecules which consist of several atoms joined together by covalent bonds formed by a sharing of electrons in their outer orbits. The stability of molecules is variable depending on the strength of bonding between the atoms and the possibility, or not, of their bonding with another atom or molecule. One could say that the atoms are in service to the molecule and the mechanisms by which they bond and form the molecule are understood.

Molecules interact in an interconnected way to form cells. There are approximately 3000 biochemical pathways, with their associated enzymes and cofactors, interconnected in every cell. This is called the metabolome. Interconnectedness means that a change in any part (substrate, product, enzyme, cofactor) of any biochemical pathway affects all the pathways in the cell. The interconnected changes in all pathways is called metabolic flux, which can be observed by mass spectrometry. For instance, one can distinguish a starvation metabolome, from an addiction metabolome, from a sugar eating metabolome, and so on. Metabolic flux shows the interconnected pathways detecting and responding to a changing environment – our definition of consciousness. The molecules are serving their higher order structure – the cell. Mutation any of the key genes supporting growth and survival of the cell leads to cell death.

Cells to Tissues to Organs to Life-Forms and Populations of Life Forms

Referring back to Figure 2, we see that the next items in increasing levels of complexity are tissues and organs. In the case of a mammal (e.g., a mouse) as an example of a life form, all cells in the body have the same 20,000 genes. The differentiation into over 100 different cell types in the body is directed by signaling from the different environments of the cells in the developing fetus to programme their genes to be on or off, up-regulated or down-regulated. The programing is by epigenetic mechanisms – modifications superimposed on the DNA of the genes to regulate their expression (for example, methylation of cytosine in the DNA, Lindsay et al, 1985). In computer language the genes are the hardware and the programming is the software. The cells detect information from their environment in the developing fetus and respond by differentiating into cells with the required function (bone, muscle, blood, skin, nerve, and so on). In this sense they are conscious and serving the tissues and organs of the body. Studies on other life forms in the laboratory – e.g., nematode worms, flies, fish – show similar material mechanisms governing differentiating cells to establish the required functions for service of the cells to the different tissues and organs. If the cells cease to serve their tissue, for example by epigenetic deprogramming (Monk et al, 1987) due to cessation of informational signaling, the tissue may be lost (e.g., to death or cancer).

The next level I have included in Figure 2 is populations. Populations of multiple members of a species can form a higher order structure – for example, the slime mould slug (Alcantara & Monk 1974), the beehive, or the Portuguese Man O' War jelly fish. Here we have a colony of organisms taking on different roles and working together for the sake of survival of the greater whole (and themselves). Again, the material mechanisms of service are known in populations of individuals in service. For example, in the beehive the genes of different worker bees – nurse, farmer, forager, warrior – are epigenetically programmed to differentiate them to perform their specific tasks. If they do not serve their higher order structure, the beehive will die and so will the bees. Anarchic behaviour in worker bees causes destruction of the beehive and death of the bees.

Ecosystems, Planets, Solar Systems and Galaxies

As the model moves from populations to ecosystems in Figure 2, it will be obvious to the attentive reader that we have departed from the concept of conglomeration of multiple parts into a higher order structure at each level. Ecosystems are not an aggregate of populations of flora

and fauna. Here, another hierarchy of increasing complexity of non-life is introduced – the soil, rocks and mountains, and rivers, lakes and oceans of the ecosystems – in which to place the living populations of animals and plants. Beyond ecosystems the model returns to conglomeration of parts to make a greater whole – ecosystems to planets, planets to solar systems, solar systems to galaxies.

Also, at this point, it is time to observe two further 'rules' I have postulated within the system. We have been looking so far at two rules – interconnectedness within and between levels of increasing complexity, and service of parts to their higher order structure at each level. A third rule is that, even though the parts are in service to their higher order structure at each level, the parts do not know what they are serving. However, if they do not serve correctly the higher order structure will not survive. The fourth rule is that the whole is looking after its parts at each level.

The next level of complexity included in this hierarchy is the ecosystem. An ecosystem is an interconnected biological community of interacting life forms and their physical environment. It will have the right pastures for the herbivores, the correct herbivore to predator ratio, it will have rivers (and maybe an ocean) and mountains and forests. The parts are in harmonious interconnected service to the whole for survival of the ecosystem. The mechanisms are known. As we know, if the forests are destroyed, if a river is diverted, if the top predator is removed (e.g., the wolves in Yellowstone Park), these disturbances can unbalance the whole interconnected system leading to the destruction of the ecosystem.

And the case is the same with the next level – our solar system. Although we trust that our planet will safely look after us in the future, a glimpse at the past is not so reassuring as it contains inhospitable ice ages and a meteor that wiped out the dinosaurs. And now, our planet is threatened by climate change and the melting of the ice caps or, possibly, a solar flare. Indeed, only last year, Nature published a report of a distant star spitting out a giant flare that packed 100,000 times more energy than any seen from Earth's sun (Argiroffi et al., 2019). This is the first clear detection of a remote star emitting a kind of eruption known as a coronal mass ejection that until now have only been seen from our sun. The authors state – 'such explosions may wreak havoc on surrounding worlds.'

Consequences of this Model of Aware (Interconnected) and Responsive (Service) Consciousness

We have reached our galaxy and the cosmos, and we can summarise the preceding arguments in the following key points:

1. A view of a hierarchy of interconnectedness between, and within, levels of increasing complexity from atom to cosmos. There is a survival advantage, which drives evolution, in increasing complexity due to the coming together of parts into a greater whole. Everything exists in a field of belonging. Outside that field the parts cannot exist.

2. At each level the parts are conscious – aware of, or detecting, or sensing, their surrounding environment, and responsive to change, in service to their higher order

structure. The material mechanisms of service are largely established and known at each level of complexity.

3. The parts do not know what they are serving.

4. The higher order structures are caring for their parts.

Some important consequences flow from this scheme as follows:

a. Interconnectedness means that reverberation (or flux) can move through the whole system, top down or bottom up or middle out. For example, a solar flare, or human interference, might disrupt ecosystems, scattering populations to new environments, leading to cellular adaptation and reprogramming of genes. Or the human race could become extinct leading to recovery of damaged ecosystems.

b. Flux through the system leads to events that do not seem to have a material mechanism because consciousness – awareness and response to change in surroundings – is happening across several levels of complexity. This allows the possibility that aspects of the paranormal might be explained in this way – certainly in space (e.g., remote viewing). However, it is not so clear how paranormal events happen across time, for example telepathy between previously interconnected elements in the hierarchy. Here, connections made between individual aspects in the interconnected system due to flux must be recorded in some way and recoverable later. What could be the mechanism of recording previous events in time and re-membering?

c. Service of parts to the higher order structure to which they belong is essential for survival at all levels of complexity and ensures development in evolution. However, it is important to note that this is not an imperative because it is also essential that there is turnover – the replacement of the old with the new. Extinction is equal to creation – for all species that exist on earth today an approximately equal number have become extinct. So, equally, the hierarchy model can be seen in reverse orientation as the higher orders of complexity return to molecules and atoms. The rule is that death equals birth. One wonders whether this implies that birth and death apply to our whole cosmos.

d. This scheme of things establishes consciousness as the unity of everything, and the belonging to the unity of all things in service to their higher order structures and the whole. It shows that consciousness is primary and that matter is derivative from consciousness (as defined in this paper). It fits with the experience of individual consciousness of the individual part located at its particular position in the hierarchy, and the experience of consciousness of the whole through the interconnectedness and belonging to everything else. It celebrates *belonging*, and *meaning*, and *purpose*, for everything on planet earth and beyond. This creates a sense of a spiritual context even though the scientific approach is material.

e. In humans, unconditional service, often imbued with the sense of unconditional love, is an evolutionary selectable in that it activates the pleasure centres of the brain. Beyond that,

unconditional love for all beings and every thing works to support the flourishing of all. Loss of service, or anarchy, leads to loss or, in this scheme, extinction.

Conclusions

In the introduction, it was suggested that individual humans personally experience that they possess their own consciousness but sometimes they can have a sense of belonging to a much greater consciousness of the whole. The same could apply to our dual experience of free will and predestination. In the scheme presented here, both could be true depending on the viewpoint – whether the observer is viewing self from their own particular location in the hierarchy or, in dropping the mind, has gone outside of self into possible experience of the reverberating interconnected whole (a 'peak experience'). One might ask what does it mean to drop the mind? Observation of our own human mind activity shows that it seems to exist in past and future. Indeed, projection of past into future could be seen as an imperative for survival of the physical self and its ego. Dropping the mind has an experience of presence - no past and no future.

We also observed that the study of consciousness was complicated by whether the analysis was from the viewpoint of the human mind or from a perspective of pervasive consciousness throughout existence (panpsychism). The latter view, followed in this paper, was prompted by the Oxford Dictionary definition of consciousness as 'aware of, and responsive to, surroundings' and the author's own experience as an experimental biologist. In addition, we noted that consciousness studies are further complicated by the many approaches depending on the background discipline of the scholar – religious/mystical, philosophical, psychological, quantum physics, geological and biological.

The approach here is not concerned with quantum mechanics. My observer relationship in this scheme does not alter the understanding of the biology of increasing complexity in the hierarchy of evolution. It derives purely from my own experience in biological research at many levels of study - observing and playing with evolving life forms. It is just another view to add to the already existing multiple views of consciousness. It may be simplistic but it does however remove what is clearly known from reproducible science from the darker areas of confusion created by quantum mechanics and philosophical and psychological analyses of consciousness.

Finally, can we draw a line at the top of this hierarchy? Remembering that parts cannot know who or what is being served at all levels, and that the higher order structures are looking after their parts, we cannot yet know the next higher order structure beyond cosmos. It is plausible to argue that beyond this entire scheme of all that is known to exist, beyond cosmos, there may be a yet higher order of complexity.

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