The Hierarchy of Organising Principles: A Hypothesis that Explains Reality and Human Understanding.

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Abstract

This paper presents a comprehensive hypothesis that seeks to explain the nature of reality and how humans understand it, integrating foundational concepts from critical realism, systems theory, and causality. The hypothesis holds that reality can be viewed as a fractal-like structure, generated by underlying organising principles that operate at various ranks in a hierarchy. Starting from acausal foundational principles, the paper explores how systems interact, transfer matter, energy, and information, and contribute to the complexity observed at different levels of organisation. The hypothesis extends to the idea that human understanding is structured by organising principles that differ from reality's, leading to distinct layers of comprehension reflected in scientific disciplines. The paper suggests that integrating these principles may help bridge gaps between disciplines, such as the disconnect between social sciences and the biological sciences. This unification has the potential to deepen our understanding of both the natural world and human social behaviour, while identifying new pathways for societal change.

1. Introduction

This paper provides an explanation of reality and our human understanding of it. The explanation begins with the foundational principles of critical realism, systems, and causality. It then moves on to a description of reality and our understanding of it. Finally, some of the implications of this explanation are discussed.

2. Foundational Principles

a. Critical Realism

The first foundational principle on which this explanation is based is Critical Realism. This philosophy was founded by the British philosopher of science, Ram Roy Bhaskar (Bhaskar, 2008). Critical Realism asserts that reality exists independently of our perceptions and is the source of truth. However, it is filtered through our cognitive processes, such that our knowledge or understanding of reality can be true or false. Essentially, there are two domains: that of reality, and that of human knowledge and understanding. In other philosophies, one domain or the other can be over-emphasised. For example, Positivism focuses on empiricism, i.e., knowledge gained by observing reality. In the extreme, this can be taken as implying that our understanding of reality is derived entirely from the observation of it. On the other hand, Constructionism focuses on the social sources of knowledge and, in the extreme, this can be taken as implying that all knowledge is so derived. Critical Realism however unites these two sources of knowledge into a single consistent and balanced philosophy.

However, Critical Realism does not hold that the two domains are opposites. Clearly, our knowledge and understanding are also real, even though some may be objectively false. False beliefs are formed of physical connections between our neurones and are, therefore, real. So, the domain of human knowledge and understanding is a sub-domain of reality. There is nothing illogical about this. Referring to the domain of reality, we may say “It is true that all cats are not black”. On the other hand, referring to the domain of knowledge and understanding, we may say “It is true that we believe that all cats are black”. These two statements are logically consistent.

Another aspect of the domain of knowledge and understanding is that it is finite, whereas that of reality is probably infinite. This means that we are limited in our ability to understand complexity, even when it has an underlying structure. A simple demonstration of the limits to our cognitive abilities can be had by trying to remember numbers of increasing length. It is thought that the maximum we can hold in short term memory is about 7 digits (Miller, 1956).

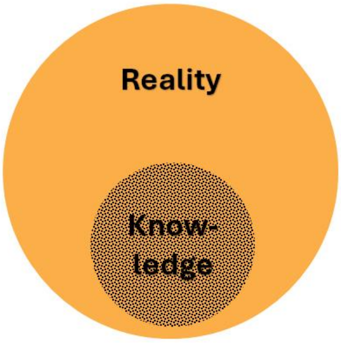

Figure 1. The domains of reality and of our knowledge & understanding.

b. Systems Theory

The second foundational principle is systems theory. Some important features of this theory are explained below. Many are described in more detail in Ludwig von Bertalanffy's book, "General System Theory" (von Bertalanffy, 1968).

- A system at its simplest comprises three main components, its inputs, its process, and its outputs. Everything that is not a part of the system's process is a part of its environment. In the same way as the domains described in critical realism (Bhaskar, 2008), the system itself is also a part of its environment.

Figure 2. A system at its simplest.

- Systems interact with one another via their inputs and outputs. That is, the outputs from one system are always inputs to others. With notable exceptions discussed later, all systems comprise lesser component systems that are also related to one another via their inputs and outputs. Conversely, all systems are components of greater systems. Thus, systems form a nested hierarchy (Meadows, 2008). An example of a nested hierarchy is the way that molecules form cells, cells form organisms, and organisms form ecosystems.

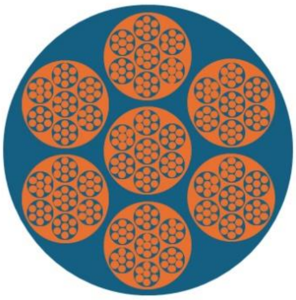

Figure 3. A nested hierarchy.

- The level of organisation or complexity of a system in this hierarchy can be defined by the number of fundamental physical particles that make up its process. As an aside, it is notable that the maximum level of organisation has increased over time since the big bang and probably continues to do so.

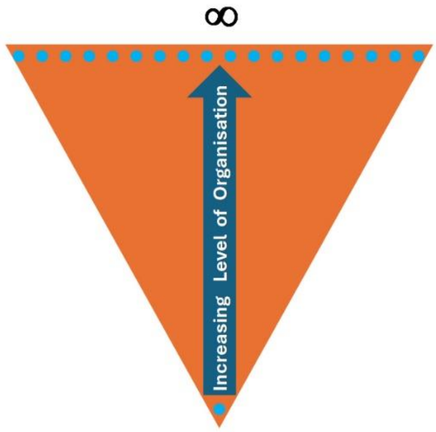

Figure 4. Levels of organisation or complexity.

The blue dots represent fundamental physical particles. Each row represents an entity comprising those particles.

- Outputs from and inputs to systems are themselves systems that, except for information, were once a part of the source system. They comprise matter, energy, or information. However, information is organised energy or matter, and matter is organised energy. So, what is transferred is organised or raw energy. Information differs from matter and energy in that it is organisation within them that can be replicated, and so, may remain in the source even if it is a part of the latter's output.
- The source system causes an existential change to its output. That is, the output is caused to exist.
- An output from a source system or an input to a destination system causes a change of state for both, unless there is a balanced flow of inputs and outputs that maintain those states.
- If the source system and destination system are both components of the same parent system, then the relationship between the two is a part of the parent system's process. If the source system or the destination system are a part of the environment rather than the parent system, then this is not so.
- If an input to a system is retained as an intact component, then the following are possible:

  a) The input can be combined with other components and then output. An example is the manufacture of cars from component parts. Assembly theory may apply if an output was organised partially or entirely by its source system.

  b) The input may be retained and serve a function within the main system such as the generation of outputs or self-maintenance.

- If the destination system does not retain the transferred system intact, but breaks it down into lesser components, then the transferred system experiences an existential change, i.e., it ceases to exist. However, its components can be treated as systems and employed in the manner described above.

The following example illustrates these concepts, and the terminology used. When one of an organism's cells divides, self-maintenance of the organism occurs, and it undergoes a change of state. The original cell undergoes an existential change by ceasing to exist. The two new cells are its outputs and undergo an existential change by beginning to exist. The matter and energy that comprise these new cells were once a part of the original cell, but the information content of the original cell, i.e., its genome, was replicated into the two new cells.

c. Causality

The important features of causality are described below.

- Causality describes laws in which changes in the state or existence of an entity of one type lead to changes in the state or existence of entities of another type.
- As the Scottish philosopher, David Hume (1711 – 1776), observed, a cause and an effect are always contiguous in space and a cause always precedes its effect (Hume, 1748). So, any causal relationship comprises two entities, the cause, one of its effects, and a common feature that binds them together in space-time. He also argued that causality is not necessarily observed directly but inferred from patterns.

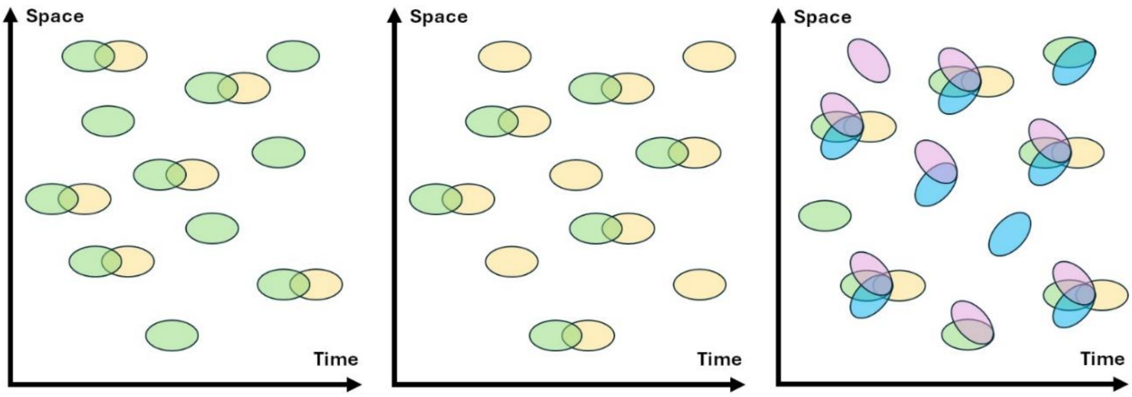

Figure 5. Causes and effects.

The green ellipses represent causes and the yellow ellipses effects. In the left hand diagram the cause is necessary for the effect, i.e., the effect cannot occur in the absence of the cause. In the central diagram the cause is sufficient for the effect, i.e. the effect always occurs in the presence of the cause. In the right-hand diagram several causes are necessary but only together sufficient for the effect.

- Causality forms chains of cause and effect. In any causal chain, causes result in effects, those effects in turn become causes that create other effects. In practice, however, more than one cause may be necessary for an effect, but only together may they be sufficient. In the absence of inhibitors, a root-like structure forms, expanding backwards in time. Also in practice, a cause may have more than one effect. Again, in the absence of inhibitors, a branch-like structure forms, expanding forwards in time. However, to simplify the explanations given in this paper a simple causal chain will be considered.
- As described in the previous section, a causal relationship can have an existential effect or result in a change of state.
- A feature of causality often overlooked is that a cause can either enable or inhibit an effect. Thus, causes can be described as enablers or inhibitors. Both proliferate in nature. An inhibitor will always prevent an effect, irrespective of the sufficiency of any enablers. In the presence of inhibitors, the root and branch-like structures mentioned above can be disrupted. Roots and branches can be pruned to just a few or even just one.

- When causal relationships between entities of one type and entities of another type are the same, and when what they hold in common is also the same, then the relationship becomes a causal law or theory. Providing there are no inhibitors, this law or theory can then be applied to predict the behaviour of the entities whenever that situation is encountered.
- Finally, a causal explanation is cause and effect traced backwards in time.

d. Systems Causality

Systems and causality are related concepts and can be combined into a single theory, referred to here as systems causality. Some of its important features are described below.

- Systems interact such that some matter, energy or information is transferred from one system's process to the next, e.g., …Process – Transfer – Process – Transfer – Process… or, more simply, …PTPTP… .
- Causal relationships comprise causes and their effects. Any effect can, in turn, become a cause with its own effects. So, the structure of a cause must be the same as the structure of an effect.
- Interactions between systems can be regarded as causal. Thus, some part of …PTPTP… must comprise a cause or an effect. There are two ways in which this is possible (see Fig. 6):
    - PTP causality, in which an adjacent process, transfer, and process together form a cause or effect. In this option a cause and its effect have a system's process in common.
    - TPT causality in which an adjacent transfer, process, and transfer together form a cause or effect. In this option a cause and its effect have a transfer between systems in common.
- This is the basis for causal duality, i.e., the potential to frame causes and effects either as PTP or TPT . Depending on the perspective, a causal event may be framed as either PTP (Process, Transfer, Process), where a process alters another, or TPT (Transfer, Process, Transfer), where a system's state change is correlated with another. These perspectives allow different levels of causal reasoning: TPT for pattern recognition and PTP for process verification.
- The shared component is the basis for the requirement that a cause and its effect must share a region of space-time. This shared region is occupied by a common system process, P or by a transfer between systems, T.
- A system's process comprises component systems that are also related by PTP and TPT causality.
- Transfers between systems are also systems. This is because some matter, energy or information is transferred which comprises component systems related as described above. Some, but not necessarily all the organisation in what is transferred will have been brought about by the cause's process. If the same system is transferred from cause to effect in a chain of causality, and is steadily increasing in its level of organisation, then assembly is taking place. Thus, assembly theory applies.
- The transfer of information can also be regarded as the transfer of a system. This is because what is transferred is some energy or matter structured in a way that conveys information. The transfer still involves a physical system. For example, speech is structured energy transmitted via sound waves; writing is ink on paper or pixels on a screen, digital communication is electrical signals or photons that encode and transmit structured data.
- The function of a system's process is to produce its outputs. Failing systems tend to be the exception rather than the rule. So, in the case of TPT causality, by default and unless otherwise stated, we assume that the system is functioning as it should and is producing its outputs.
- Necessity and sufficiency are features of a system's inputs or what is transferred to it. An input may be necessary for the system's process to function and produce its outputs. Without that input the system does not function. An input may also be sufficient for a system's process to function and produce its outputs. With that input the system always functions. Normally, however, several inputs may be individually necessary but only together sufficient for a system's process to function and

produce its outputs. With all of those inputs the system will always function. For example, the necessary inputs for photosynthesis are light, carbon dioxide and water. Only together are they sufficient.

- If a system is functioning and producing its outputs, then it must be receiving sufficient necessary inputs. So, in the case of TPT causality, it is also assumed by default that the system is receiving those inputs. The focus of attention in TPT causality is therefore functioning processes.
- However, different functioning processes can produce the same output. Thus, as explained by the epidemiologist, Ken Rothman, in his "Sufficient Component Cause" model, different combinations of system process can produce the same set of outputs required for an effect (Rothman, 1976). Rothman's perspective is therefore one of TPT causality in which processes are assumed to be functioning as they should. As a consequence, knowledge of what is transferred between the systems becomes unnecessary or can be overlooked.

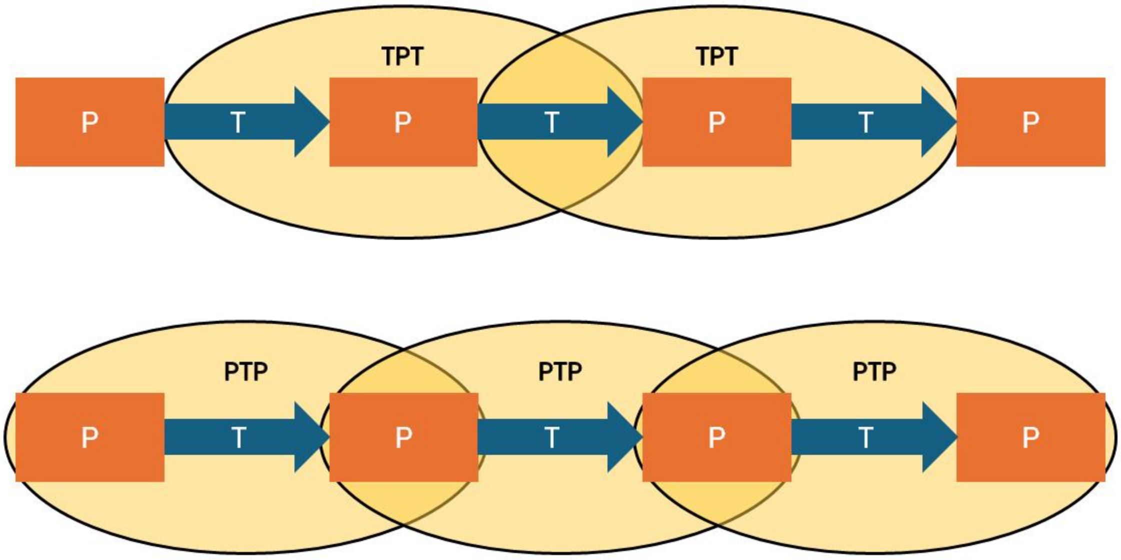

Figure 6. Systems in a causal chain.

P is a system's process. T is a system's output or input. The orange ellipses are both causes and effects. In each linked pair, the left-hand ellipse is the cause and the right-hand ellipse the effect.

In summary, both system processes and what is transferred between systems are organised entities or systems in their own right. What is taking place is the breaking of old structures and the creation of new ones. At all levels of organisation, new entities are constantly formed, whilst existing ones change their state or expire. Thus, reality comprises ever-changing forms of organisation at all levels (Holland, 1998). The unification of causality and systems theory into systems causality describes this ongoing process.

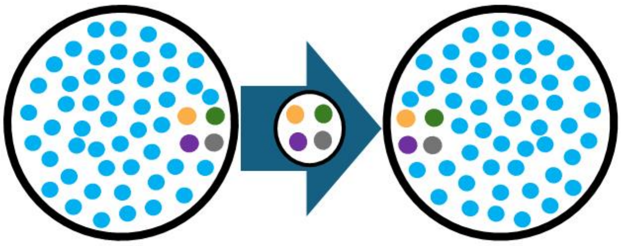

Figure 7. Systems causality as the breaking of old structures and the making of new ones.

Note that every circle in this diagram represents a system.

3. Reality

a. The limits of causal explanation.

All organisation can be causally explained in terms of lesser forms of organisation. This progresses backwards in time, in the form of the causal root structure described above. However, this backward progress cannot continue ad infinitum. The universe is believed to have had a finite life beginning with the "Big Bang". Space, time, the fundamental particles and their properties are all thought to have come into existence at that point, and all are necessary for any causal explanation. Thus, at the point of the Big Bang, backward causal explanation ceases. What remains must be a fundamental set of acausal organizing principles.

This set of principles together with systems causality are what ultimately defines all organisation in the universe.

b. Acausal organising principles

Acausal organising principles can variously be thought of as: a) fundamental systems; b) systems that were not previously a part of greater systems; c) effects with no cause; d) outputs with no source process; e) inputs with no source process; and f) systems with no inputs. They lie at the origin of every causal chain.

There are at least seven:

Space-time. The medium in which those things described below exist.

Energy. Energy cannot be created or destroyed. It merely exists and can only be transformed.

Spin. This is a form of angular momentum in particles that can be quantified and that distinguishes fermions from bosons.

Electric charge. This is a property of quarks, leptons, and bosons that distinguishes them from one another and determines how they interact with the electromagnetic force.

Colour charge. This is a property unique to quarks and gluons. It determines how the strong nuclear force can bind Quarks together to form other non-fundamental particles.

Generations. Quarks and leptons are grouped together into a hierarchy of three families or generations of increasing mass and instability. The more massive less stable ones can decay into less massive more stable ones.

Interaction with Forces. This characteristic determines whether a particle of a particular type can or cannot interact with the strong or weak nuclear force, or with the electromagnetic force.

The only theory that might explain these principles from more fundamental ones is String Theory. To date, however, there is no experimental evidence for this theory. It remains speculative and unproven, therefore. Ultimately, strings may or may not be proven to exist. However, irrespective of the outcome, string theory employs more dimensions than those of space-time, and so, any mechanism involved cannot be causal. This is because causality operates in and is dependent on space-time. So, these seven principles can, for the present at least, be regarded as acausal.

As an aside, it is worth noting that they are physical but, because they are acausal, they do not comprise components as would be the case if they had a causal explanation. Each principle is therefore one physical thing and indivisible, despite manifesting at different spatial locations in different particles. This may contribute to the explanation of what Einstein referred to as "spooky action at a distance". That is, the ability of particles that have been entangled but are now separated to instantly mirror changes in one another's spin.

c. Fractals and fractal-like structures.

Before moving on to an explanation of reality, the concepts of fractals and fractal-like structures must be described. A fractal is a geometrical figure or pattern in which the same feature is repeated at all scales. The American mathematician, Benoit Mandelbrot (1924-2010), first coined the term and first used computer graphics to demonstrate fractals (Mandelbrot, 1982). Fractals are often observed in the natural world, for example in the structure of fern leaves. Mandelbrot described fractals as "… a way of understanding the world around us, a way of seeing the beauty in nature, and even in our everyday lives."

If a causal rule is repeated at all levels of organisation, it is also possible to generate a more abstract and more dynamic fractal-like structure. It can be difficult to comprehend such structures, but it becomes easier with familiarity. Mandelbrot is, for example, also quoted as saying of fractals: "Here is the curious thing: the first night I saw the set, it was just wild. The second night, I became used to it. After a few nights, I became familiar with it. It was as if somehow I had seen it before. Of course I hadn't. No one had seen it." In saying this, he was of course referring to the Mandelbrot set, which is a two-dimensional fractal image generated by a simple mathematical rule.

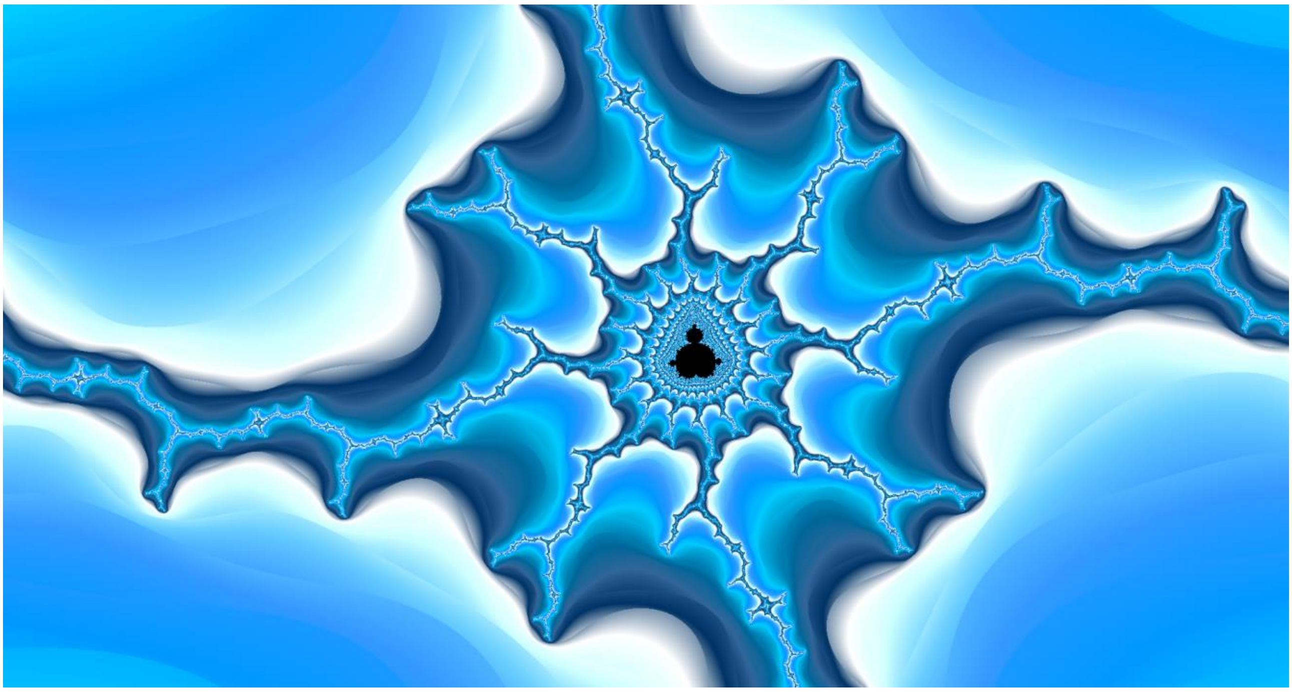

Figure 8. Detail from a visualisation of the Mandelbrot set.

Every fractal has a **generator**. That is, a rule that is applied at all scales. Every fractal-like structure also has a generator or **organising principle**. That is, a rule, law, theory, or set of them that apply at all levels of organisation. Both fractals and fractal-like structures manifest in a **domain**. For example, the domain of the Mandelbrot set is the two-dimensional field of complex numbers. Its generator manifests the fractal everywhere and at every scale in this domain. The domain of reality is, of course, space-time. An organizing principle results in, and thus, explains the fractal-like structure at every level of organisation.

Fractals can be vastly complex, but a notable feature is the repetition of patterns or **isomorphisms**. Here the term isomorphism is not used in its strict mathematical sense to describe an exact structural correspondence between entities. Rather, it is used in a more general sense to describe functional similarities in much the same way as the term **metapatterns**, used by Volk and Bloom. (Volk & Bloom, 2007). One of the main proponents of systems theory, the Austrian biologist Ludwig von Bertalanffy (1901 – 1962), suggested that the search for a General Theory of Systems should focus on the identification of such isomorphisms across disciplines (von Bertalanffy, 1968).

In the Mandelbrot set, as can be seen from the above diagram, these isomorphisms are ubiquitous. Fractal-like structures also display isomorphisms, but because these structures are more complex than fractals, such isomorphisms are less frequent.

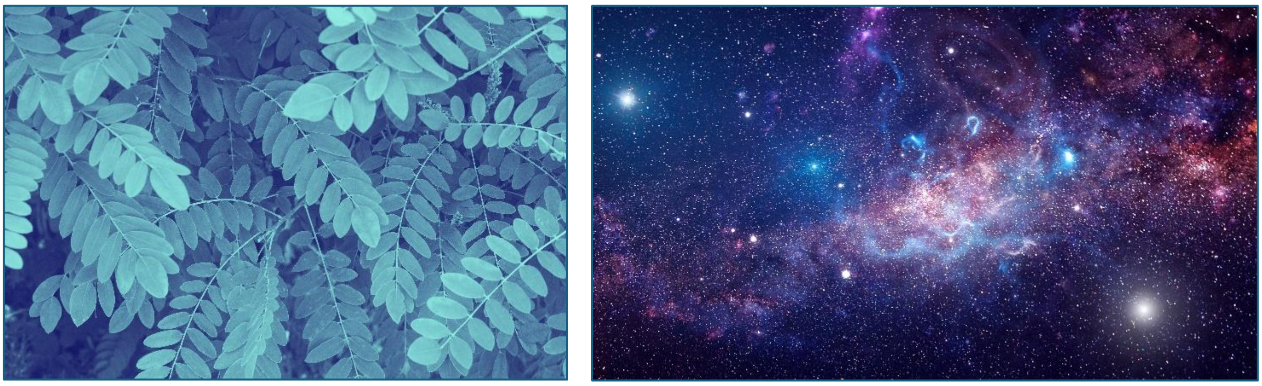

Figure 9. Isomorphisms in nature.

d. Reality as a fractal-like structure.

The foundational principles will now be used to provide a description of reality. That is, the physical universe that we inhabit and of which we are a part. Reality is far more complex than the Mandelbrot set. It occupies the four dimensions of space-time, rather than the two dimensions of complex numbers.

In summary, part of this hypothesis proposes that reality is a single fractal-like structure generated by the organizing principle, OPR 3, that is described below.

There is a hierarchy of organizing principles that comprises ranks. Note however that an organising principle's rank or OPR is not the same as a level of organisation. The ranks are as follows.

OPR 0

OPR 0 comprises the acausal principles described above.

OPR 1

OPR 1 is an organizing principle that generates a fractal-like structure. Every causal relationship involves the transfer of the same system from source to destination, irrespective of the level of organisation of the source.

Because what is transferred cannot exceed the level of organisation of its source, then, in the domain of physical reality, only fundamental particles could be transferred were this principle to apply.

If reality were as simple as one formed by OPR 1, it would be governed by a single rule that repeats across all levels of organisation. However, reality is clearly more complex than that.

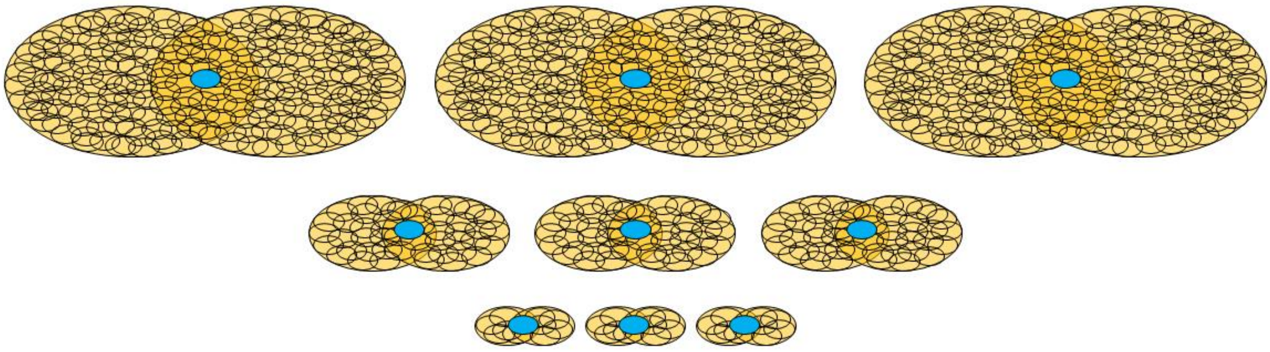

Figure 10. OPR 1

The relationship between any two systems is always the same.

OPR 2

OPR 2 is an organizing principle in which every causal relationship involves the transfer of any one of a set of systems from the source to the destination. In other words, one of several causal laws applies. Isomorphisms, i.e., repetitions of the same or similar structure, can occur at any level of organisation. Also, if one system transfer predominates locally, then a fractal-like structure can occur at that location. However, the same constraint applies as that described for OPR 1, and only fundamental particles can be transferred. This is closer to reality but still does not accurately reflect it.

Systems theory, causality, and systems causality are all fractal-like and based on OPR 2, i.e., members of the same set of laws apply at all levels of organisation.

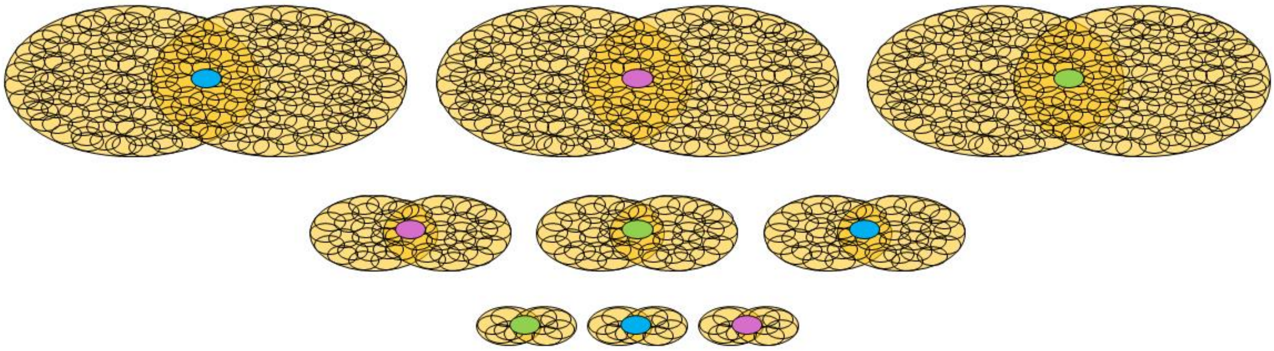

Figure 11. OPR 2

The relationship between any two systems is always one from a set of possible relationships.

OPR 3

OPR 3 is an organizing principle in which every causal relationship involves the transfer of a system whose fundamental components are related as described in OPR 2. Providing this rule holds, then what is transferred between systems can be of a level of organisation limited only by that of the source. In other words, systems with a greater level of organisation can be transferred. The greater the level of organisation of the source, the greater can be that of the system transferred. Isomorphisms can occur at similar levels of organisation, but less frequently than for OPR 2. Again, if one type of transferred system predominates locally, then a fractal-like structure can occur at that location. Such occurrences will be less frequent than for OPR 2. Nevertheless, in reality, we observe that isomorphisms, e.g., stars and people, do still occur.

We also observe that genuine fractal-like structures, frequently occur in nature. Examples include: coastlines; mountains; tree branching; leaf structures; and the structure of lungs, blood vessels and neural networks in the brain. Large scale structures in the cosmos, such as galaxies, appear to exhibit a fractal like distribution. The energy spectra of electrons in certain quantum states (e.g., in systems under the influence of a magnetic field) display fractal structures (Hofstadter, 1976). Ecologists have found that ecosystems often follow fractal patterns, especially in the distribution of species and resources. For instance, the distribution of trees in a forest, the branching of river networks, and predator-prey dynamics can all exhibit fractal characteristics.

It is hypothesized, therefore, that OPR 3 generates reality and that, if one type of transferred system predominates locally, the generator may revert to type OPR 2. However, when elsewhere the generator returns to type OPR 3, the fractal-like structure is less easily observed, thus obscuring the underlying fractal-like nature of reality.

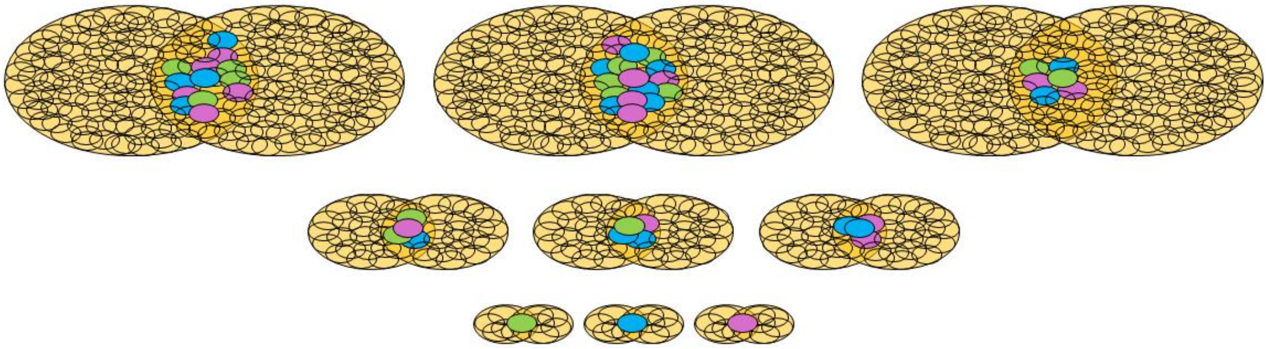

Figure 12. OPR 3

The relationship between two systems is itself a system that comprises fundamental components that are always related by one of a set of possible relationships.

4. Knowledge and understanding

a. Introduction

This hypothesis also proposes that, despite reality being a single fractal-like structure generated by an OPR 3, our understanding of it can comprise different fractal-like layers each generated by a different OPR 2. These layers are defined by the *apparent* emergence of meaningful entities and laws or theories at certain levels in the hierarchy of organisation. These layers also approximate to our scientific disciplines. The sections that follow will provide an explanation for this part of the hypothesis and will discuss some of its implications. The explanation uses two important concepts, emergence and intension. So, they will be described first.

b. Intension

In formal logic, any physical entity can be described in either of two ways. The first is known as **extension**. In systems terms, this means describing an entity using the components that form it. For example, a car comprises wheels, seats, an engine, bodywork, and so on. The second is known as **intension**. In systems terms, this means describing an entity using those of which it is a part. Any collection of entities has a common characteristic, and so, in practice, intension means defining the entity by specifying its characteristics. An orange, for example, is a fruit, has an orange-coloured skin, is sweet tasting, is segmented, and so on.

Using characteristics in this way specifies not just one entity but many. For example, the description of oranges also specifies tangerines, clementines, mandarins, etc. The more characteristics we give, the fewer the number of entities we specify. Conversely, fewer characteristics specify more entities.

The German Mathematician, Gottfried Leibnitz (1646 – 1716), who first recognised the importance of extension and intension in logic, regarded intension as the more “natural” form of human understanding (Leibnitz, 1765). Certainly, to predict their behaviour, we intuitively classify things by their characteristics rather than by their components. So, it is not unreasonable to regard extension as lying in the domain of reality and intension as lying in the domain of human knowledge and understanding. That is, intension is a cognitive tool that we use to understand reality.

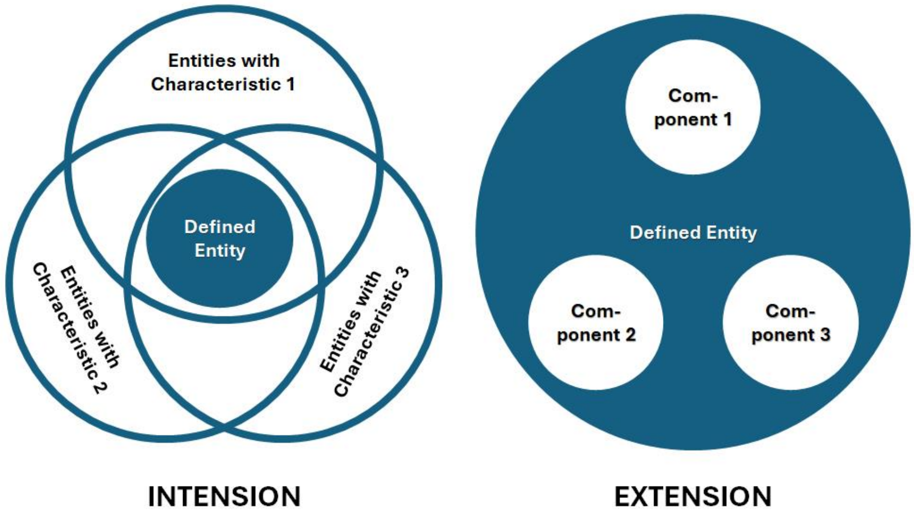

Figure 13. An entity defined by intension and extension.

c. Emergence

The term emergence refers to characteristics, arising from the interaction of simpler components in a system, that defy prediction based solely on the properties of those individual components.

Both causal laws and processes can be emergent. In other words, there can be both entities and also relationships with emergent properties. This is because emergence can occur in that which is transferred from one system to another during PTP causality, and also in the systems process involved in TPT causality.

Although we observe emergence it is not thought to be **acausal**, i.e., not an effect with no causal explanation. Rather it is the consequence of complex causal interactions between components. These interactions often involve feedback loops, non-linear relationships, and complex dependencies. Some emergent properties can be explained. For example, Georgio Parisi has explained murmurations of starlings as due to the distancing of each bird from its immediate neighbours (Parisi, 2023). Complex adaptive systems can be explained by informational feedback loops. An example of the latter, as it applies to human consciousness, is given by the author at (Challoner, 2024).

However, the causal background to other instances of emergence can be so complex that they defy explanation. So, new properties, and thus new entities and relationships, merely *seem* to emerge at various levels of organisation. Previous relationships merely *seem* to vanish. For some philosophers the difficulty of finding a causal explanation, especially for consciousness, has resulted in speculation that emergent properties may be genuinely acausal. However, no satisfactory scientific explanation for such emergence has ever been offered.

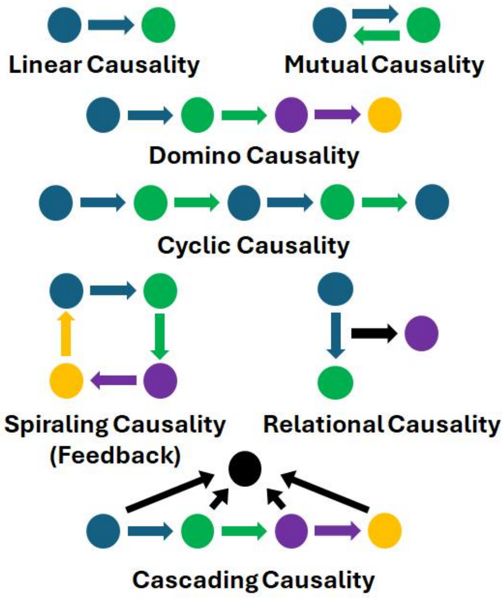

Figure 14. Causal interactions

This diagram shows some known causal interactions. However, an effort to identify more complex ones would yield benefits.

For human beings, entities can be meaningful or meaningless. A meaningful entity is one that we observe as being of a type that recurs, i.e., one that has a particular form of organisation between its components. All other entities are meaningless. The organisation of their components can appear to be random, and they are not observed to recur. Our ability to recognise recurring entities of a type is an evolutionary trait. It enables us to learn, from experience, what opportunities and threats such entities pose, and to react accordingly if we encounter them in the future. We encode them as visual images in our memories. We also name them so that we can share our experience with others of our species.

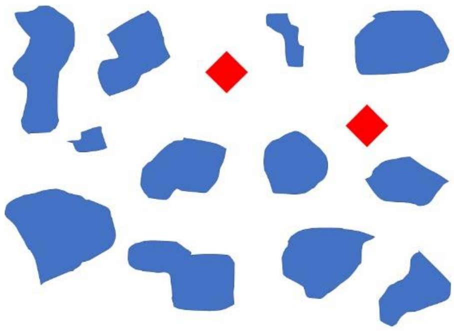

Figure 15. Meaningful and meaningless entities.

Recurring entities of a type are, of course, isomorphisms in the fractal-like structure of reality. However, isomorphisms occur less frequently in fractal-like reality than in the Mandelbrot set. So, they are not recognised at all levels in the hierarchy of organisation, only at specific levels. Thus, even though causal explanation remains theoretically possible, properties seem to emerge acausally at these levels. Unfortunately, however, our mental ability to understand complexity is finite and limited. So, between these levels, as the number of interacting meaningful entities increases, the situation becomes increasingly complex and difficult to comprehend until it becomes apparently chaotic. This state persists until the next specific level is reached and a new set of meaningful entities emerges.

There is the question of why certain isomorphic entities exist in reality and not others. The explanation may lie in the concepts of Assembly Theory, i.e., the step-by-step assembly of entities based on what has been assembled before (Sharma, 2023); Metapatterns, i.e., those systems that serve a useful function (Volk & Bloom, 2007); and Big History, i.e., the formation of ever more organised structures as time from the inception of the universe increases (Christian, 2018). Together these concepts suggest a process of selection. Those recurring entities that we see in reality tend to be those that are both easier to assemble and occupy stable, advantageous positions within a broader historical and evolution-like context. Conversely, absent objects may represent combinations of high complexity, inefficiency, or unfavourable historical conditions. However, this idea will not be pursued further here.

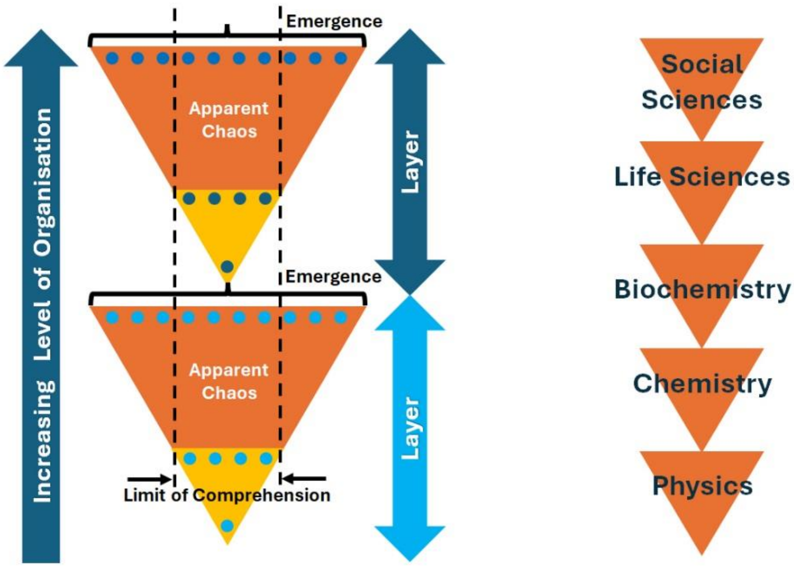

Figure 16. The layering of disciplines.

d. The layering of disciplines

A *layer of organisation* can be defined as the range of levels of organisation that exist between one level of emergence and the next as we ascend. The aim of science is to discover the theories that apply to a layer or discipline. This process of discovery involves observation of the layer but not necessarily its every detail.

So, in practice, we develop the theories in a scientific discipline by observing reality rather than by using causal explanations based on fundamental principles. There are two main reasons for this.

Firstly, emergent properties are, in practice, unpredictable. Even though a causal explanation is theoretically possible, the complexity of a system with emergent properties and its sensitivity to initial conditions make prediction impossible in practice. Thus, new properties *seem* to emerge acausally.

Secondly, until relatively recently, we were unable to observe sub-atomic particles and had no concept of them. Thus, our understanding of reality has developed based on what we have been able to observe. That is, entities at the human scale and distant entities in the visible cosmos. Because the theories that we develop within a discipline are created in this way, those from a lower-level discipline can *seem* to vanish acausally.

Systems causality spans all the scientific disciplines and will, therefore, be considered first. Causes, systems, and effects are all the same thing. Their only characteristics are that they are physical entities in which relationships are either made or broken. That is, they describe the dynamic nature of reality. These are characteristics one of which applies to everything, and so, systems causality applies to entities at all levels of organisation. It is therefore of type OPR 2.

Turning now to the theories that we develop for scientific disciplines; these relate one type of entity to another. To specify these types, we apply characteristics. If a scientific theory is successful, then the relationship between any two entities of a type is always the same. The types of entity and the relationships between them can be many. So, the organizing principle for a scientific discipline is of type OPR 2.

In some cases, we specify only the entities that first emerge. The organizing principle for a discipline of this type is referred to as OPR 2a. In a discipline of this type's layer, only relationships between the first emergent entities can be described and, as we ascend the layer, they become ever more numerous until they appear chaotic.

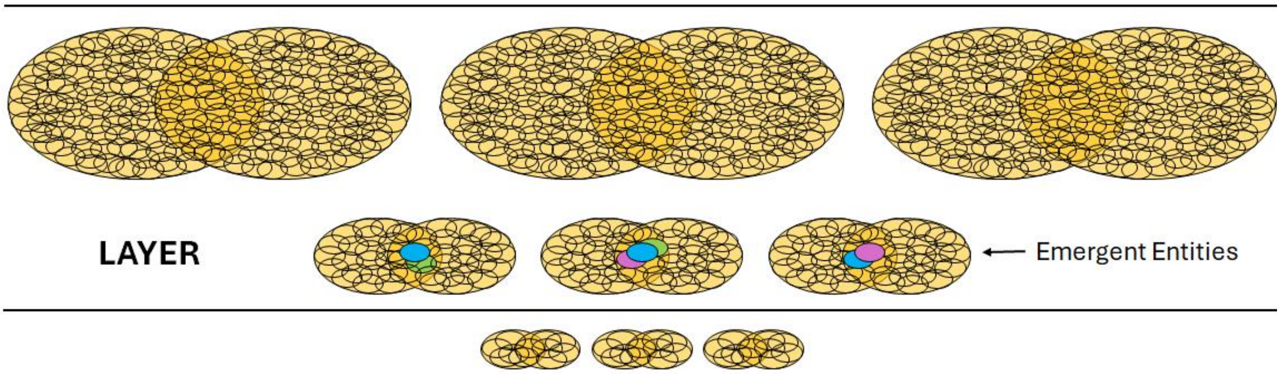

Figure 17. OPR 2a

Only the relationships between the first emergent entities in the layer can be described and the relationships between types are each one of a set.

In other cases, we use characteristics specify entities at all levels of organisation in the layer, e.g., types of chemical compound or social holons at all levels of organisation. The organizing principle for a discipline of this type is referred to as OPR 2b. In this case the problem of apparent chaos is reduced. However, it can be difficult to identify characteristics that apply at all levels of organisation in the layer.

If the theories that we develop are successful, they will explain the discipline up to a level of organisation at which a new discipline emerges.

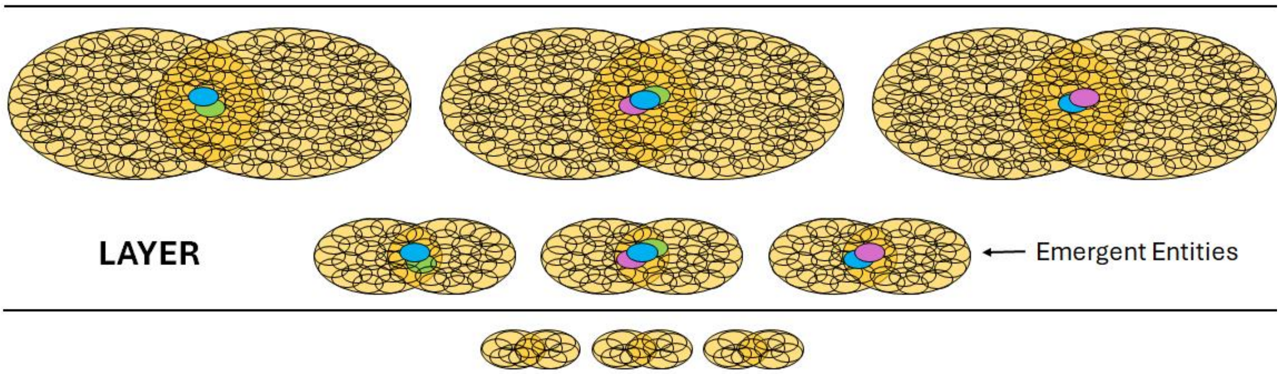

Figure 18. OPR 2b

The relationships between all entities in the layer can be described and the relationships between types are each one of a set.

Many theories are developed relatively independently for each layer. Others may have been developed in layers below. Together they act as the OPR 2 generator for that layer. Theories developed for a layer do not always apply to layers below, however. This is because they may involve greater levels of organisation than that of the layers below.

As well as forming a hierarchy, different disciplines can also occupy the same or similar levels of organisation. Isomorphisms depend on the way that components are related. So, as the level of organisation increases, different arrangements of components can form different disciplines on different branches. For example, life and stars lie on different branches.

5. Summary and implications.

Causality and systems theory can be combined into a single systems causality tool for understanding reality. Its organizing principle is OPR 2. However, if an OPR 3 explanation, like that of reality, is simplified by reducing the number of characteristics that describe entities to a bare minimum, then an OPR 2 explanation, like systems causality, will result. Furthermore, if any knowledge that we hold is true, then it exists both in the domain of reality and, in a symbolic form, in the domain of our knowledge and understanding. It is only false beliefs that exist in the latter but not the former. Thus, if systems causality is true, as seems to be the case, then it can be regarded as existing in both domains.

The hypothesis holds that reality has a single but highly complex fractal-like structure that is generated by an OPR 3. This reality defines what is true. Generally, the OPR 3 generated structure is so complex that our cognitive limitations prevent us from perceiving its fractal-like nature. However, when a relationship of a particular type predominates locally, then the structure becomes more like that of one generated by an OPR 2 and we are then able to observe a fractal-like structure.

Our scientific disciplines, on the other hand, are based on the observation of isomorphisms within that reality. They are therefore generated by an OPR 2. They are, of necessity, not based on explanation using a combination of the fundamental organizing principles and systems causality. So, each discipline can comprise a different fractal-like structure occupying a layer in the hierarchy of organisation and may approximate the truth.

If theories within a discipline *are* approximations, then it is also possible for there to be disconnects between them. In other words, the fractal-like structures that comprise each layer or discipline may differ, and the theories of a discipline at a lower level of organisation may not explain those of one at a higher level.

Certainly, in the early development of the physical and biological sciences, such disconnects did exist. But as our knowledge has grown, they have steadily reduced. However, although efforts are ongoing to reduce it, a strong disconnect remains between the social sciences and the physical and biological ones. This may be hampering us in our efforts to gain a deep understanding of human social behaviour and the threats that we face.

To help address this problem, it is suggested that a single discipline, social science, whose branches include psychology, sociology, anthropology, economics, politics, etc. be developed so that it occupies a single fractal-like layer. The key emergent property is human cognition and our ability to recognise and process information. At present, this discipline is broken down into specialities. So, it is suggested that some students be provided with a more cross-disciplinary education together with training in systems theory. This would better enable them to identify any isomorphisms across the specialities, and thus, aid the development of social theory. The principal difficulties likely to be faced in such a unification of disciplines are differences between the language, concepts, and research methods employed in each. Any cross-disciplinarians would therefore need to address this over time.

Addressing any disconnect between the social sciences and physics is probably too complex an issue to be practicable. However, more effort to address the disconnect between the social sciences, biology, and ecology may bear fruit. Social science is, of course, part of a yet greater potential layer, life science, whose branches also include biology and ecology. The key emergent properties are (a) self-maintenance or autopoiesis and (b) the reproductive aspect of evolution. The natural selection aspect appears to have emerged earlier. Again, a more general approach could lead to greater recognition of isomorphisms, thereby enhancing the social sciences.

Finally, theory is the generator for a layer. Because the generator creates complexity in the layer, it is not necessary to understand the detail of this complexity, just the theory. If the theory is true, it explains the detail. So, to change society, for example, one must change the generator, and we can identify any necessary changes and how best to make them by looking at reliable theory.

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