

The Structure of Reality

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<https://www.wohlbier.swiss/reality>

fred@wohlbier.swiss

The workings of nature can be described in terms of two opposite but complementary viewpoints: (1) The *bottom-up approach* begins with elementary particles and the forces that act between them, whereas (2) the *top-down approach* starts with subjects and the values that guide their actions. The common denominator here is information. As quantum physicist Anton Zeilinger writes, “it is impossible to distinguish operationally in any way reality and information ... the notion of the two being distinct should be abandoned... information and reality are basically the same.”¹ And the physicist and philosopher Holger Lyre discusses sympathetically the fascinating notion that “information represents both the building material of the world, and our knowledge of it.”²

I. The Bottom-Up Approach

The bottom-up approach leads to a description of nature in terms of (1) the three families of matter particles, (2) the four types of fundamental forces acting between these particles, (3) the four dimensions of spacetime and (4) the fundamental laws of nature. We are interested here in the general *relations* that exist between the various parameters of nature.

(1) The Three Families of Matter Particles.

The first family of elementary matter particles (Matter 1) consists of four different types: (1) Up quark, (2) down quark, (3) electron and (4) electron-neutrino. The first three belong together insofar as they represent the building blocks of atoms. The fourth particle, the electron-neutrino, is a rather odd entity. Each second, billions of these curious particles pass through our bodies without leaving any trace.

The four types of Matter 1 particles are characterized by a relational pattern that turns out to be a characteristic feature of *all* fundamental parameters of reality. These parameters always come in tetrads (sets of four) that are characterized by a very conspicuous pattern; each tetrad consisting of a triad of parameters that belong closely together in some specific way, plus an odd-one-out parameter which differs greatly from the other three.

In addition to Matter 1, there are two further tetrads of particles: Matter 2 (charm quark, strange quark, muon and muon-neutrino) and Matter 3 (top quark, bottom quark, tau and tau-neutrino). These particles have existed in abundance in the very

early stages of the universe. In both tetrads, it is again the neutrino that represents the odd one out of the set.

(2) The Four Types of Fundamental Forces.

There are a total of four fundamental forces: Electromagnetic force, strong force, weak force and gravity. Here is how the fundamental forces fit the 3+1 relational pattern outlined above:

(i) The electromagnetic force, the strong force and the weak force belong together insofar as they determine the behavior of atoms. The workings of these three forces are well understood and can be described by the so-called 'Standard Model of Particle Physics'.

(ii) Gravity is not part of the Standard Model of Particle Physics and represents the odd-one-out parameter of the forces tetrad. When compared to the other three forces, gravity is a force of almost zero strength. For example, the gravitational force with which two electrons attract each other (on account of their mass) is 10^{42} times weaker than the electromagnetic force acting between them, and causing them to repel each other.

(3) The Four Dimensions of Spacetime.

All events take place in the three spatial dimensions and the dimension of time. The 3+1 pattern is obvious; with time clearly being the odd-one-out parameter of the tetrad.

(4) The Fundamental Laws.

The fundamental physical laws are immutable and valid at any place in the universe. They will be discussed at the end of the following section.

II. The Top-Down Approach

The parameters discussed above describe the workings of nature at the level of physics but cannot make us understand such phenomena as consciousness and ethics which must be studied in terms of the top-down approach, beginning with *subjects* and the *values* that guide their actions. An important aspect here is *emergence*, i.e. the fact that new and unpredictable rules and other lawlike entities can originate from the collective behavior of simple events. These additionally emerging rules, norms, habits etc. differ from the immutable fundamental laws insofar as they are always subject to change and evolution.

(1) The Four Categories of Subjects.

In its broadest sense, the word 'subject' is not limited to human persons but refers to any entity that takes up information from the outside and reacts to it in its own

specific ways. We therefore count as 'subjects' also inanimate entities. This is in line with the fact that the interactions of elementary particles are best understood in terms of communication processes. In this view, subjects can be classified by the ways in which they take up and process information, and by their ability to acquire knowledge and learn from past experiences. It turns out that a total of four categories of subjects can be clearly distinguished:

(i) *Inanimate subjects* react to perceived information in accordance with the fundamental laws of physics but the reaction does not change them in any way; there are no learning effects, no acquisition of knowledge.

(ii) *Unconscious living subjects* are guided not only by the fundamental laws but also by additional rules, habits and principles that serve the survival and reproduction interests of the subjects or the respective species. These lawlike entities have been acquired by means of trial and error learning during the evolutionary process.

(iii) *Subjects with conscious feelings*: Higher animals are capable of *conscious* information processing which leads to the acquisition of *autobiographical* knowledge. It is not only the species that acquires life-sustaining knowledge but each individual learns its own specific ways of reacting to changes in the environment.

(iv) *Rational and responsible subjects*: In the realm of human culture, it becomes even possible to act in line with rationally acquired knowledge, including knowledge in the realms of aesthetics and ethics. The decisive feature of these subjects is that they take on *responsibility* for their actions.

The four categories of subjects fit the same 3+1 relational pattern as outlined above. The odd-one-out position is clearly held by inanimate subjects, whereas unconscious, conscious and rational living beings make up the closely connected triad of parameters; all three types belonging to the realm of life.

(2) The Four Fundamental Values.

It is practically undisputed that the universe began with elementary particles and that the awareness of values occurred billions of years later. This can lead to the conclusion that such phenomena as consciousness and ethics are incidental side effects of the expanding universe. A rising number of philosophers disagree. In their view, the concept of value is just as elementary as physical particles are, or even more so. According to biologist and philosopher Stuart Kauffman, values are not some idealized hypothetical conceptions but "real features of the universe"³.

Among the dozens of values that come to mind, four are clearly fundamental: freedom and the ideals of the true, the good and the beautiful. These four ideals have all intrinsic value, i.e. they are not necessarily good for something, but simply good in, and for, themselves. Here is how the four fundamental values fit into the 3+1 structure of nature's principal parameters:

(i) Freedom is the odd-one-out parameter because it is present in *all* events, including those involving only inanimate entities. This is actually surprising because

classical physics had taken it for granted that all physical events are fully determined by the fundamental laws. Quantum physics has shown us that it is these very laws that include a principle of freedom of action. As quantum physicist Anton Zeilinger writes, “We have tried for centuries to look deeper and deeper into finding causes and explanations, and suddenly, when we go to the very depths, to the behavior of individual particles of individual quanta, we find that this search for a cause comes to an end. There is no cause. In my eyes, this fundamental indeterminateness of the universe has not really been integrated into our worldview yet.”⁴

(ii) The other three ideals are usually discussed together; and for good reasons. In the words of philosopher Rudolf Steiner, “Through all the ages of man's conscious evolution the true, the beautiful and the good have expressed three great ideals: ideals which have instinctively been recognized as representing the sublime nature and lofty goal of all human endeavor”⁵. Or, in the words of Mortimer J. Adler, the founder of the *Great Books of the Western World* series, the ideals of the true, the good and the beautiful are sometimes called ‘transcendental’ because “everything that *is* is in some measure or manner subject to denomination as true or false, good or evil, beautiful or ugly.” These three values “form a triad of terms which have been discussed together throughout the tradition of western thought.”⁶

(3) The Four Categories of Laws and Lawlike Entities.

The Nobel Laureate Robert B. Laughlin has recently proclaimed the arrival of a new scientific era in which we shall leave behind the reductive way of thinking and enter the new ‘Age of Emergence’⁷. He suggested that we should begin here with the classification of the emergent rules and principles that govern such astounding phenomena as life and consciousness. How can we classify the different types of laws and rules? Three criteria turn out to be especially suited: (i) Freedom of action, (ii) meaningfulness and (iii) learning capability. With these criteria, the laws and lawlike entities that are operative in nature can be clearly grouped into four categories:

(i) The *fundamental laws* allow for some freedom of action (in the sense of non-determinedness), as quantum physics clearly shows. But these laws do not *mean* anything to a given particle, or set of particles. Furthermore, they do not encapsulate any learning effects; there is no acquisition of knowledge.

(ii) *Life-sustaining rules guiding unconscious living beings*. These rules are meaningful to a given subject insofar as they effectively result in the preservation or reproduction of life. They permit the acquisition of genetically-encoded adaptive knowledge about the environment, and allow an enlarged degree of freedom of action: Nobody knows what a fly will do next.

(iii) *Rules and principles involving phenomenal consciousness* (subjective experiences): The concept of meaning here refers not only to the preservation and reproduction of life but also to the well-being and well-feeling of the individual creature. Phenomenal consciousness accords an animal a completely novel type of

(autobiographical) learning aptitude and enables it to evaluate a given situation emotionally prior to initiating an action. This results in a much enhanced degree of freedom of action.

(iv) *Rules and principles involving rational consciousness*: In human societies, with their linguistic capabilities, emerges the phenomenon of self-conscious rationality which allows humans to act in sensible and *responsible* ways. Moreover, we find a practically unlimited potential for the acquisition of knowledge, including knowledge in the realms of ethics and aesthetics, and a degree of freedom of thought and action that can hardly be surpassed.

The four categories of laws and lawlike entities fit the same pattern that we have observed in all other parameter tetrads of nature. The fundamental and immutable laws of physics represent the odd-one-out parameter of this tetrad, whereas the other three categories of laws and lawlike entities belong together insofar as all three refer to the realm of life and are known to change and evolve in accordance with environmental changes.

III. The Tree of Everything

As we have seen above, the bottom-up approach leads to a set of immutable fundamental laws of physics, whereas the top-down analysis yields three additional sets of *subjective* laws and lawlike entities (rules, habits, norms etc.) that govern the realm of life and are characterized by change and evolution. Considering the two views to be complementary to each other, we arrive at a surprisingly uniform and self-consistent tree-like pattern of the main parameters of nature; tentatively called 'Tree of Everything' (Figure 1 & Table 1).

The Tree of Everything can be regarded under the following three aspects: (1) The eight primary parameters of nature (four pairs of large red circles in Figure 1), together with the top of the tree representing Reality as a whole, form the *primary structure*. (2) Each of the primary parameters refers to four individual parameters (small green circles) which together make up the *substructure*. (3) The tree also features a *superstructure* which refers to the historical aspect of the universe and is formed by four vertically-aligned triads of primary parameters which we have labelled *Matter*, *Events*, *History* (sum of all events) and (hypothetical) *Theme* of the universal story.

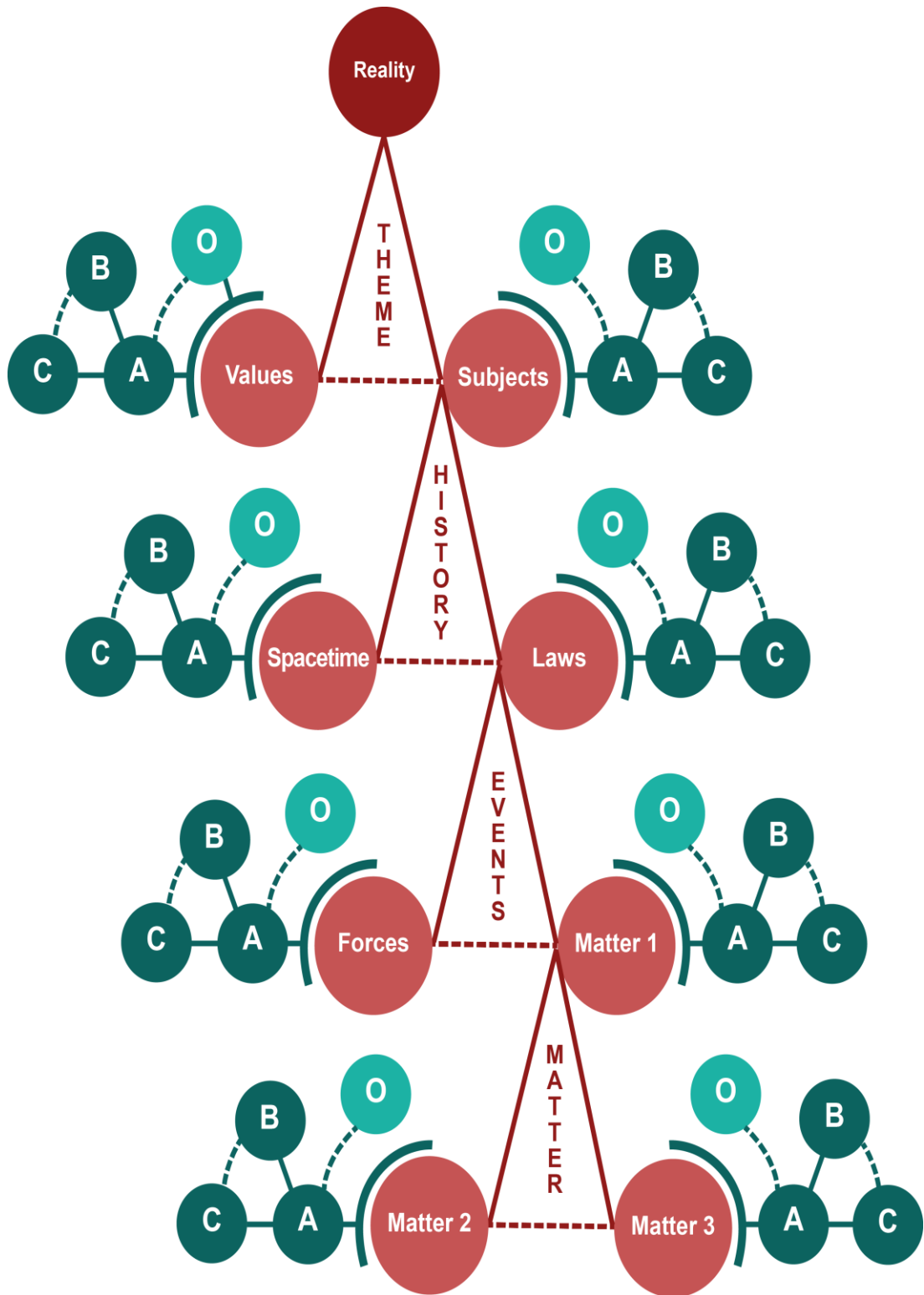


Figure 1. The Tree of Everything. Details are shown in Table 1.

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fred@wohlbier.swiss

Table 1. Details for Figure 1

Values:	O = Freedom; A = Goodness, B = Truth & C = Beauty
Subjects:	O = Inanimate; A = Unconscious Living, B = Conscious & C = Rational
Spacetime:	O = Time; A, B and C = Spatial Dimensions x, y and z
Laws:	O = Physical; A = Unconscious, B = Conscious & C = Rational Events
Forces:	O = Gravity; A = Strong, B = Weak & C = Electromagnetic Forces
Matter 1:	O = Electron-neutrino; A = Electron, B = Up Quark & C = Down Quark
Matter 2:	O = Muon-neutrino; A = Muon, B = Strange Quark & C = Charm Quark
Matter 3:	O = Tau-neutrino; A = Tau, B = Top Quark & C = Bottom Quark

O = Odd-one-out parameter.

A, B & C = Triad of parameters that belong together.

A & O are closely related to each other.

B & C are very closely related to each other, even closer than A & O are.

(I) The Primary Structure.

The primary parameters of the Tree of Everything come in four closely-related or complementary couples. From top to bottom:

(1) *Values & Subjects*: These are insofar complementary to each other as the actions of subjects are guided by values; and values become part of reality through these actions.

(2) *Spacetime & Laws*: These two parameters are closely related to each other insofar as both involve the concept of time: Laws describe what happens within the timespan of a given event, or a set of events. The description of a given event requires both knowledge of its spacetime location in relation to all other events, and its causal background which is given in terms of laws and lawlike entities.

(3) *Forces & Matter 1*: These parameters are complementary to each other: Matter 1 consists of normal elementary particles, whereas the forces are communicated by *virtual* messenger particles. On the one hand, virtual particles are emitted by normal particles and thus would not exist if there were no such particles. On the other hand, if there were no virtual messenger particles, no one would ever be able to perceive the presence of normal particles, which is the same as saying that they would not exist.

(4) *Matter 2 & Matter 3*: These particles represent high-mass versions of the Matter 1 particles, i.e. they are very closely related to each other.

It is important to note that the two parameters of a given couple become ever more similar to each other as we go downwards the tree from top to bottom. It is as if, upon reaching the level of Matter 2 and Matter 3 at the bottom, the two sets of particles are so closely related to each other that no further parameter settings are possible or feasible, and the actual story of the universe is ready to begin.

It is also noteworthy that the primary parameters come in two tetrads; each exhibiting the same relational characteristics as we have observed for all other parameter tetrads with which nature works.

(i) The upper tetrad refers to Values, Subjects, Spacetime and Laws. Values here can be seen as the odd-one-out parameter because they do not directly take part in events, whereas Subjects, Spacetime and Laws belong together insofar as all three are needed in order to describe the history of the universe; the sum of all events, that is.

(ii) The lower tetrad of primary parameters encompasses the material particles with which nature works. The odd-one-out parameter refers to Forces because these are due to *virtual* messenger particles that can be observed only indirectly. The three sets of normal particles (Matter 1, Matter 2 and Matter 3), in contrast, can be observed directly and are very similar to each other; differing only in their masses.

(II) The Substructure.

As indicated in Figure 1 and Table 1, each of the eight *primary parameters* refers to a set of four *individual parameters*; each tetrad featuring a triad of closely related parameters (dark green) and an odd-one-out parameter (light green).

In addition to this 3+1 structure, all substructure tetrads also show a 2+2 pattern consisting of two pairs of parameters (connected by broken lines) that are closely connected or complementary to each other. The first pair always refers to the odd-one-out (labeled O) and one of the other parameters (A). The remaining two parameters (B and C) are always more closely connected to each other than the parameters of the first couple are.

IV The Reality of Values

In the forthcoming book, *The Great Pattern of Nature*, it will be shown that the Tree of Everything is characterized by a well-established logical top-down order. It also leads to testable scientific predictions and can help us in understanding such issues as to why there are three families of matter (not more and not less) and why there is more matter than antimatter in the observable universe. Furthermore, the Tree allows us to discuss philosophical issues, such as the reality status of values.

Values are “real features of the universe.” This statement is part of Stuart Kauffman’s recently proposed “worldview beyond reductionism, in which we are

members of a universe of ceaseless creativity in which life, agency, meaning, value, consciousness, and the full richness of human action have emerged.”³

This is quite in line with the Tree of Everything and its logical top-down structure. The Tree begins with ‘*Reality*’ (the sum total of everything there is) and the initial splitting process leads to the first couple of primary parameters; *Values* and *Subjects*. These are complementary to each other. On the one hand, subjects act in line with values. On the other, such actions make values become part of reality.

As the Tree follows a logical top-down order, all other parameters *must* be in line with this doublet if the Tree is to be self-consistent and unambiguous.

For example, what is clearly required is a universe with at least three spatial dimensions (as is indeed the case in our universe) because only one or two dimensions would not be sufficient for the formation of the highly complex information-carrying molecules (proteins, DNA etc.) that are required for the emergence of life.

A second example is the requirement of freedom: If we are to have a universe in which free choices are possible (as the setting of the first parameter couple requires), we need to have some indeterminacy somewhere in the laws of nature. The observed quantum indeterminacy shows that this condition is indeed fulfilled in our universe.

The structure of the Tree of Everything is therefore also fully in line with the so-called ‘anthropic principle’ which refers to the unexpected finding that nature’s parameters and constants seem to be fine-tuned to the eventual emergence of life and consciousness. The top-down logic of the Tree – together with the fact that the first parameter doublet refers to *Values* and *Subjects* – shows that there is nothing to be surprised about here. The apparent fine-tuning turns out to be simply a *logical consequence of the initial conditions of the Tree of Everything*.

It remains true, however, that the universe began to function with elementary particles and the forces acting between them, and that life and consciousness emerged billions of years later. At present, we cannot explain *how exactly* this emergence has come about.

However, the Tree of Everything points to the direction in which further research is expected to yield answers. The Tree describes nature in terms of a set of fundamental parameters ranging from ‘values’ and ‘subjects’ to ‘material particles’ and their ‘forces’. The common denominator here is information. This suggests that further research must emphasize the *informational* aspects of nature.

Judging by the Tree of Everything, it is not only factual information (truth) that influences the events taking place in nature. Actions in the realm of life can also be influenced by the good effects to which they lead, or by the beauty that they help realize. As these values cannot be defined objectively, the information concept will

have to be expanded to cover also subjective and context-relevant types of information.

In the end, we may have to describe reality in terms of a universe that expands not only in the dimensions of space and time, but also in the dimensions of the fundamental values.

Summing up, it seems that we are all engaged in realizing a value-based universe; each of us contributing her, or his, lifetime events to the great work. This conjecture corroborates with recent statements by various philosophers and scientists:

“We ought... to accept some value-based, objective theory.”⁸ (Derek Parfit)

“Only then will we be able to talk sensibly about the value of truth..., if we are ready to accept the spiritual as primary element of the world... This is valid for the truth, and it is also valid for the good, and for the beautiful.”⁹ (Peter Strasser).

“We are co-creators of a universe, biosphere, and culture of endlessly novel creativity.” (Stuart Kauffman³)

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