CONNECTIONS: SCIENCE AND RELIGION*

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III
THE GLOBAL VIEW

In the last chapter we described the primary mathematical models by which scientists analyzed nature. Our purpose was to develop some appreciation for the power of the scientific method as well as to gain background for a later discussion of the limitations to man's ability to acquire knowledge.[†] We noted that these models are applied to many localized models, but at this juncture we would like to shift the viewpoint to encompass a much broader picture. This broader picture develops through the synthesis of the many studies of localized phenomenon. For example, a general picture of scientific cosmology is the result of multitudinous experiments in high energy physics and observations in astronomy, as well as much theoretical work in general relativity and quantum mechanics.

Our intention is to paint with a broad brush a picture of nature as the physical scientist perceives it. However, we will freely add historical and philosophic ideas where they seem appropriate.

A description of the 'big picture' is not possible as a linear progression since there are many interconnected parts and structures. This requires that the subject be developed in several ways and our choice for presentation is according to the following set of categories:

1. Levels in nature
2. Matter and Force Fields
3. Cosmology
4. Time and Space.

The background developed in these brief treatments will allow us to make connections with Swedenborgian ideas.

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[†]The introductory sentences relate to chapter II of this series, the title of which is "The Mathematization of Nature." The material in that chapter has largely been published elsewhere in *The New Philosophy* under the title "Probability: A View of Nature" (1984, 87:2:306-316), and the reader is referred to that article for the essential points.

Levels in Nature

Even a rudimentary study of what is known about nature quickly shows that matter is arranged in a multi-level structure.

We observe bulk matter in three states, solid, liquid, and gas. While these states are vastly different in their physical properties they are composed of a common material. For example, water comes in the forms of steam, liquid, and ice, each with their respective properties. Yet the common building block at the next deeper level is the H_20 molecule. In ice the molecules are locked together in a lattice structure; in the liquid the molecules move somewhat freely relative to each other, sometimes alone or in small groupings; in the gaseous state the molecules are far apart and only collide with each other occasionally. Yet the commonality of the H_20 molecule gives all these structures the chemical property of being water.

Now go down a level further than the molecular. The molecule is composed of two hydrogen atoms and one oxygen atom. Separately the atoms have nothing to do with the water property and can be used as building blocks for many compounds. This atomic level is then more basic and universal than the molecular level and, furthermore, the energies required to probe the dynamics on the atomic scale are typically higher (in the ultra violet region of the electromagnetic spectrum) than those used to study the molecule (infrared region).[1] The various types of chemical bonds which hold the atoms together as molecules—covalent, ionic, and so forth—have differing strengths, but none are as strong as the connections between the parts of the atom.

Inside the atom the constituents, at this level, are the electrons and the nucleus. The fundamental interaction is electromagnetic and fairly strong—usually of the order of several electron volts (visible and ultraviolet radiation). When atoms are pulled apart the electrons are peeled away from the atom and the process is called ionization. The identity of the atom is still maintained by a characteristic of the nucleus, namely, the number of protons in the nucleus. This essential identity is not disturbed by the ionization process.

The levels of the molecule and the atom are responsible for the

[1] There is a general proportionality between the frequency of radiation and the energy involved. The electromagnetic radiation spectrum extends from fairly low frequency radio waves up through microwaves, infrared, visible, ultraviolet, x-rays and gamma rays, and this range involves changes of many orders of magnitude in both frequency and energy.

great majority of happenings in the our world. Chemical, electrical, biological phenomena all have their origins at this level of nature. Furthermore the operative force or interaction is the electromagnetic interaction, whose exchange particle is the photon or 'particle' of electromagnetic radiation. (This type of 'force particle' will be further discussed in the next section.) The quantum mechanical theory which governs these processes is called quantum electrodynamics or QED.

If a deeper probe is to be made it must be into the nucleus of the atom. The nucleus is made up of protons and neutrons, the proton carrying an electric charge equal but opposite to that of the electron, while the neutron is electrically neutral (although it does have a magnetic moment). Hence the nucleus has a positive charge, which interacts via the electric force with the negative electron charge to keep the atom together.

The question now arises as to what force overcomes the electrical repulsion between the positively charged protons thereby keeping the nucleus held together. This force is called the strong nuclear force and it obviously must be stronger than the electromagnetic force. One can get a rough idea of the relative magnitude of these two forces by considering a comparison of the liberation of energy when parts of an atom are rearranged compared to parts of the nucleus being rearranged. A perfect example is the comparison of a dynamite explosion with a nuclear explosion. The dynamite explosion involves the breaking of chemical (electromagnetic) bonds whereas the nuclear explosion involves a rearrangement of the nuclear 'chemistry'. The significant difference between these two effects illustrates how powerful the strong nuclear force is compared to the electromagnetic.[2]

The nature of the powerful nuclear force is related to the inner structure of the neutrons and protons for these are not in themselves really fundamental particles. In fact they are composed of things called quarks which make up not only that class of particle called baryons (which includes protons and neutrons) but also some-

[2] The force between protons and neutrons is analogous to the chemical force between atoms. That is, chemical forces are a mixture of electromagnetism and quantum mechanics, and in a similar way the force holding the nucleus together is a combination of the strong nuclear force and quantum mechanics. See *The Nature of the Physical Universe,* 1976 Nobel Conference, Wiley Interscience, New York, 1979, edited by Douglass Huff & Omen Prewitt, p. 16.

what lighter particles called mesons. These quarks, of which there are several kinds, interact with each other using an exchange particle called a 'gluon' to be associated with the strong nuclear force. The mechanics which governs these interactions is called quantum chromodynamics (QED).

The strong nuclear force is, as noted above, very much stronger than the electromagnetic force. Somewhat closer to the strength of the electromagnetic force is the so-called weak nuclear force which is responsible, for example, for the transmutation of the proton into a neutron by the emission of a fast electron. (This particular process is known as beta decay.) This interaction also has its own set of exchange particles called W particles.

Finally we go back to the grossest level of nature where the action of gravity becomes apparent. Gravity is extremely weak compared even to electro-magnetism and therefore while its effects are continuously observed by us it does not play a significant observable role in the deeper levels of nature. (The one exception to this statement is in the case where matter is sucked into a black hole and loses much of its identity in the process; all but mass, charge, and angular momentum.) As a conclusion to this very brief discussion we present the following table which summarizes the levels and describes some of their properties.

Summary of Levels of Nature

Level	*Entity*	*Operative Force*	*Size*
gross	bulk matter	gravity	$>10^{-6}$cm
molecular	molecules	electromagnetic	10^{-7}cm
atomic	atomic parts	electromagnetic	10^{-8} cm
nucleus	beta decay	weak nuclear	10^{-13} cm
	quarks, gluons	strong nuclear	$<10^{-13}$cm

In the next section we will take a closer look at the nature of the forces themselves.

Matter and Its Force Fields

All connections between material objects of the natural world take place via forces. The nature of these forces has been a matter of human curiosity for much of recorded history. The idea of force depends on the idea of matter or whatever the force acts upon. We begin the discussion by looking at two opposing ideas of material reality. Isaac Newton, who claimed to frame no hypotheses, treated forces as acting between material point particles which are separated by some distance. He did not presume to suggest how the force made itself known over the distance between the particles but only that he could describe its effects mathematically. Newton's followers hardened this position by stating that there was no medium through which the forces acted. Hence there was only the vacuum and a kind of instantaneous communication between the particles (action-at-a-distance).

René Descartes took a radically different position. He hypothesized the existence of several types of particles which were all in a contiguous relation with each other. These particles fill all space, and forces between them would then travel via the connecting interaction or contiguity of the neighboring particles.

Swedenborg carried Descartes' position to a more sophisticated level. In his *Principia* he suggests also a variety of different particles, each of which is built up from the compounding of simpler particles through complicated motions (circular, spiral, helical, and so on). Taken as a group the sets of particles become the atmospheres or auras through which the various forces of nature act on matter. Hence there is an aura associated with gravity and another with light, etc. It is as if the particles, when taken individually are seen as particulate matter whereas when taken collectively they become a set of continuums which mediate the forces of nature.

The auras of Descartes, Swedenborg, Newton, Hooke and Huygens were the antecendents of the mathematically sophisticated lumeniferous ether (the medium of light travel) of the 19th century. And the dual tradition of a) action-at-a-distance, and b) the ether medium of interaction, gave rise to two competing, but not entirely satisfactory, pictures of material reality: forces acting 'at a distance,' instantaneously, between two particles with no force 'carrier,' and light acting as, for example, a water wave being carried along by an unknown, but subtle, medium at a finite velocity.

The twentieth century brought with it some radical changes in both these views and yet there are bits and pieces of the previous thought patterns which remain. (Of course, there are many realms of science where the naive Newtonian picture is sufficient. Astronauts travel to the moon on the basis of Newton's laws of motion.)

In a major departure from the traditional view Einstein's 1905 theory of special relativity suggested that the speed of light represented the upper limit by which causative information could travel from one place to another. Forces could not act over a distance instantaneously. Einstein showed that Maxwell's equations, which were the basic theoretical description of electro-magnetism, were consistent with this same property, and earlier experimental work had shown that light was an electromagnetic interaction. Einstein also showed that a medium for light travel (such as water for water waves) was unnecessary.

In 1916 Einstein published his general theory of relativity in which he suggested that the paths by which interactions (for example, a light ray) travelled became curved in the presence of gravitational fields. Since the interaction behavior was the fundamental physical event this led to the conclusion that space (and also time) were curved. The very geometric fabric of space-time depended on matter, and at the same time the interaction between bits of matter depended upon the existence of accompanying fields whose properties propagate through space at the speed of light. For example an electron carries an electromagnetic field with it as it moves through space. Changes in the electrons' motion are propogated outward, again at the speed of light. The field becomes a property of the local space-time coordinates and therefore particles are acted upon by the amount of force or field which resides in their particular region of curved space. The field theory picture became a kind of intermediary between the previous particle-in-vacuo picture and the more fundamental ideas which followed.

Finally, in the latter part of the 1920 decade the quantum theory was developed by Schrodinger, Born, Heinsenberg and others. The picture of matter which was to develop involved the evolutionary notion that physical reality was a manifestation of excitations from a pervasive ground state 'sea' of energy. Therefore the quantum theory of electro-magnetism, initiated in 1929 and brought to maturity in 1948, suggested that visible light would be merely a higher state of some vast energy sea and that the exact number of excitations at any instant was subject to statistical laws. Therefore the existence of a beam of light is not a strictly determined event.

From these revolutionary developments during the early part of this century a new picture of material reality emerges. Matter is no longer matter as commonly perceived except in its grosser manifestations; rather it becomes a sort of excitation above the sea of energy that exists as a reservoir for the material world, and that interactions between these excitations propagate along curved space-time at the speed of light, subject to a certain statistical limit called the

Heisenberg uncertainty principle. Furthermore, a new picture of these forces was developing in which the interaction between material particles was being carried by excitations called 'exchange particles' These came into existence to effect the interaction and then go out of existence very rapidly. But more information should be given on the individual force characteristics before further describing the 'exchange particles.'

Following the initial work in the new physics called quantum mechanics, experimental work on the so-called elementary particles of nature gave rise to the discovery of two more forces to add to gravity and electro-magnetism. These new forces were both in the nuclear domain, one being much stronger than the other. The weak nuclear force is responsible for beta decay, a form of radioactive decay, and the strong nuclear force is responsible for holding together the constituents of the nucleus.

In the late 1960's this picture was gradually extended to the world of so-called elementary particles. The weak nuclear interaction was incorporated into the theory of quantum electro-magnetism and successful efforts are being made to include the strong nuclear interaction. This work toward unification of forces, called GUTS (grand unified theories) is an effort to show that all forces have the same character and origin. In fact the present cosmological theories hold that in the earliest moments of the universe when the temperatures were very high, all forces were the same. Only when the universe cooled did the various forces 'freeze' out separately, or break the symmetry of the early unified force field.

What are the means by which the forces of nature are described? Each force may be characterized by a variety of properties. The most easily understood is the range over which the forces act. Both gravity and electro-magnetism act over an infinite range although it is clear that the strength of these interactions decreases with distance between the participants. On the other hand the nuclear forces act over very short distances and have no effect beyond a distance of the order of the size of the atomic nucleus. These distances correlate well with the distances listed in the earlier table on the levels in nature.

Another property the forces have is their relative strength. Gravity is the weakest by far yet the only requirement for gravitational interaction is the presence of mass. No fancy rules or even the requirement of electrical charge is required. Therefore gravity acts on everything however weakly. Electro-magnetism is a considerably stronger force but needs a net charge in order to act. For example, the earth's motion around the sun is entirely accounted for by gravity and therefore while the earth contains billions of electrical charges the number of positive charges exactly balances the number of negative charges. Next in strength is the weak nuclear force and finally, very strong, is the strong nuclear force. This force must be very strong if it is to counter the repulsive electrical effect between the positively charged protons in the atomin nucleus and thereby hold the nucleus together.

The modern theory of interactions includes the concept of exchange particles peculiar to each force and the respective masses of these 'particles'. (Other properties also distinguish these exchange particles but we will not deal with them in this brief discussion.) The exchange particle is an object which comes into being, a kind of bubbling out of the energy field, and travels between the objects as a way of communicating the presence of the force fields. (It should be made clear that this is only a model which the equations suggest and therefore a simple pictorial description will be a distortion to some extent.) The coming into existence of the exchange particle temporarily defies the law of conservation of energy but under the statistical rules of the quantum physics this momentary increment of energy is allowed for a short time. The general rule is that the larger the increment of energy the shorter is the allowed existence time of the particle.

Now, during the time interval of the particle's existence it may travel a certain distance subject to the limiting speed of light. Hence a particle with finite mass (and therefore energy) can travel only a finite distance in the alloted time. Hence the exchange particles of the strong interaction, called a gluons, and the particles associated with the weak nuclear interaction, called W bosons have mass (rest energy) and therefore the range of these forces is limited as suggested above. On the other hand the exchange particle of gravity, called the graviton, and the exchange particle of electro-magnetism, which is the photon, both have zero rest mass, and therefore their times of existence are unlimited and therefore the range of their respective forces is infinite.

The following table summarizes the simplified picture we have described.

Summary of Force Properties

Property	Gravity	Electromag	Weak Nucl	Strong Nucl
Range	infinite	infinite	10^{-13}cm	10^{-13}cm
Strength	1	100	10^{-13}	$10+^{38}$
Ex particle	Graviton	Photon	W bosons	Gluons
Rest energy	0	0	100 Gev	10^{+14}Gev

(1 Gev equals 1000 Mev. The rest mass [energy] of an electron is 0.5 Mev.)

From this discussion it becomes apparent that to speak of the natural world as a world of matter is somewhat of a misnomer except in describing the most outward and obvious levels. The most complete descriptions available for the last 60 years have been equations, rather than pictures which the eye can readily view. Even in one's imagination the model remains fuzzy. Perhaps one can suggest three general aspects or categories for the perception of material existence:

1. Bulk matter—the particle category. This also includes the molecular, atomic, and nuclear level when they act in particulate ways such as in chemical activity.
2. Fields—the level of macrosopic fields such as light which travels in curved space-time. These fields may be sensed by the eye or complicated man-made electronic devices such as television receivers.
3. Energy excitations—the fundamental entities (such as exchange particles) for which we have only inadequate images and which collectively give rise to the outer levels of the fields and eventually the particles. With these general properties of matter and forces in mind, we now look at their roles in the history of the cosmos.

Cosmology

Scientific cosmology is the study of the origins, scope, and future of the natural universe. Its tools are those of the telescope in all its varieties, the computer, and recently, the high energy accelerators of elementary particle physics.

The presently accepted theory of the origin of the universe is that there was a beginning which occurred in a spectacular hot big bang explosion of energy. The energy liberated caused an unfolding of space-time and a gradual degradation of that energy in the form of an expanding universe and a subsequent cooling of the energy through a variety of physical transformations. The extent of the universe is not known although present observations of Quasars suggest a distance factor of at least some 12.5 billion light years (a light year is the distance light can travel in one year) and a time history between 10 and 20 billion years. The future of the universe is uncertain. It may continue to expand forever or it may eventually collapse in a kind of giant reversed big bang event.

Before going into the details of this model let us summarize the physical evidence for it. The main pieces of evidence do not necessarily stand alone but often interlock like the pieces of a puzzle.

First there is the observed phenomenon of the Doppler red shift. The red shift is a perceived change in the frequency of a source of radiation (such as sound or light) when the source is receding from the observer. This effect is familiar to those who have listened to passing traffic or trains. When the source is receding the tone, or frequency, lowers, and in astronomy, it is observed that most sources outside our galaxy have a light spectrum which is shifted down in frequency, toward the red. The usual conclusion is that these extra-galactic sources are receding from us. (However, Andromeda, a large neighboring galaxy, is blue shifted and therefore travelling toward the Milky Way.) In general the universe appears to be expanding.

The very fact that the sky is dark at night is also suggestive. In 1833 Olbers formulated the idea that if the universe were static and infinite in extent then the night sky should not be dark, but rather, as bright as the sun in every direction. A variety of proposals have been made as to why the sky is indeed dark and one popular solution to the problem is that the universe is either expanding or is finite or both. While the paradox may be explained in terms of a static infinite universe in which stars are only luminous for a certain duration the dark sky is quite naturally explained by the big bang model.

Another quite dramatic piece of evidence supporting the big bang theory is that of the background microwave radiation. In 1965 two scientists at Bell labs discovered the presence of a very homogeneous and isotropic microwave radiation in all directions of observation. Subsequent measurements confirmed the presence of electromagnetic radiation corresponding to a very cold object, about 3 degrees above absolute zero. This very cold radiation is taken as a remnant of the flash of the big bang. This leftover radiation may also be theoretically predicted from the age of the universe and others factors as a kind of trail left behind by the bang and the observations agree well with the calculations.

Observations on the abundances of elements in the universe provide important data. Most elements are manufactured inside stars by a kind of nuclear alchemy called nucleosynthesis. However, these are in very small amounts (about 2%) compared to the two main elements of hydrogen and helium which were produced earlier during the initial expansion. Roughly speaking, the hydrogen to helium ratio is 3 to 1 by weight, which agrees very well with the predictions of the big bang theory.

There are other, more subtle forms of data extant, such as the age of globular clusters, a variety of experiments in high energy physics, and so on which generally support the big bang theory. Let us now present the scenario which is the presently accepted version of this primeaval explosion.[3]

Our universe originated in a vast space-filling explosion somewhere between 10 and 20 billion years ago. (Space itself was wrapped up around the explosion because of its high energy density.) The first moments of that explosion are packed with a richness of physical happenings which the elementary particle physicists would love to reproduce in the laboratory, but alas, cannot. Nevertheless, in the first instant prior to 10^{-43} seconds even the definition of time becomes murky. What must have happened would be subject to the laws of quantum gravity and there is no good theory for that subject. Stephen Hawking of Cambridge Univeristy claims that every point in space would have been a mini-black hole with an energy of formation of 10^{19} Gev. (1 Gev is a billion electron volts—about the energy produced per particle in a thermonuclear explosion,) The effective temperature would have been about 10^{33} degrees on the Absolute scale. An approximate picture would be a foam of forming and reforming black holes, an unimaginable turbulence!

The next stage is in the time frame from 10^{-43} to 10^{-35} seconds during which all the forces of nature are unified according to the GUTS mechanisms and physicists also see this era as one of rapid expansion or "inflation" during which the very high energy density causes a stage of unbelievably fast expansion. At 10^{-35}seconds the temperature has dropped to 10^{28} degrees and the strong nuclear

[3] David N. Schramm, "The Early Universe and High-Energy Physics," *Physics Today,* April 1983, p. 27.

interaction decouples from the unified forces and develops its own identity. The symmetry of forces has started to break down leaving the electromagnetic and weak nuclear forces still the same. This pair breaks up at about 10^{-12} seconds when the temperature has dropped to about 100 Gev energy equivalence or 10^{16} degrees in temperature. At this point the particles of the strong interaction, quarks, and the light particles called leptons are freely roaming space. But very quickly as the time of creation drops to about one millionth of a second the quarks gather together to form nucleons, this process is called confinement (of the quarks). The neutrinos of the weak interaction now develop their own identity and interaction and are decoupled from the electromagnetic field. All of these events occurred very rapidly.

The remaining history is much less dramatic. When the universe is perhaps 100,000 years old, one can see through the photon field and then galaxies and stars begin to form. From that point to this the universe does not change dramatically as in earlier times. The photon field is the microwave field that Penzias and Wilson, the Bell labs scientists, observed. Scientists would also like to observe the neutrino field (of the weak nuclear interaction) which should be at a temperature of about 2 degrees absolute. However, this would be extraordinarily difficult since neutrinos barely react with anything tangible.

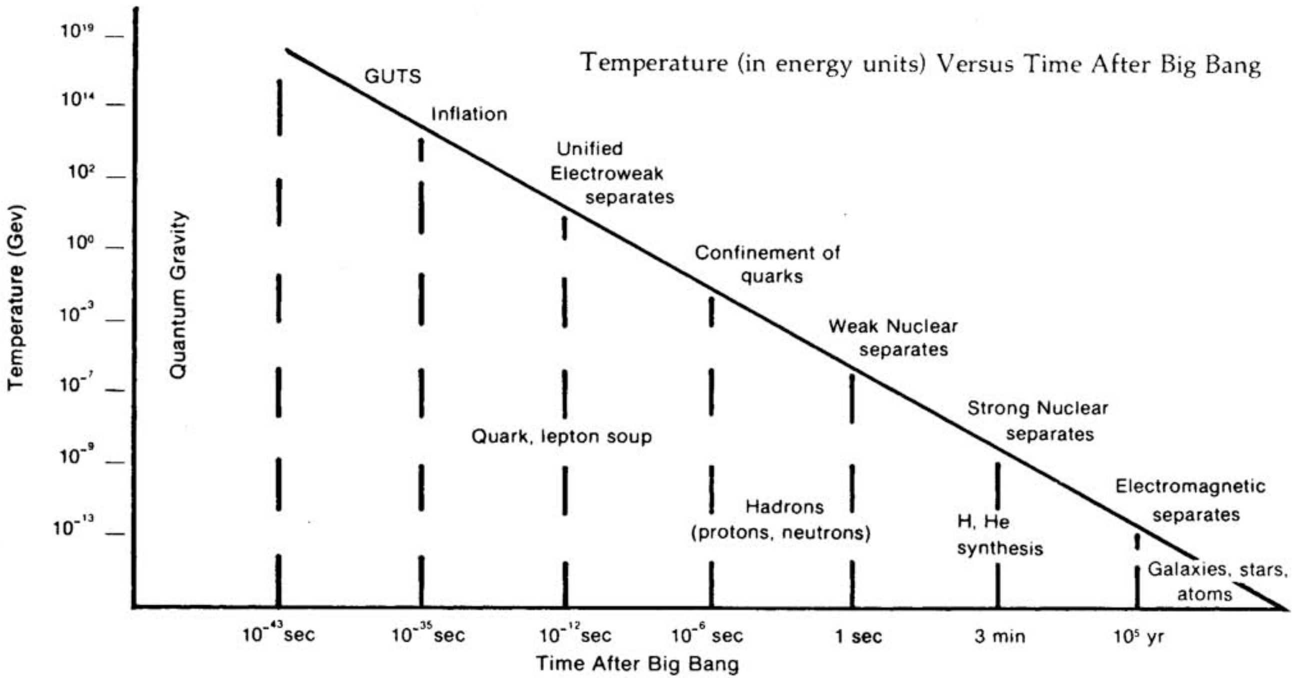
The diagram[4] on the opposite page summarizes the main processes. Now let us turn to a discussion of the arena in which the drama of nature is played out.

Time and Space

Time and Space are the frame of reference from which and within which man observes nature. 'There are two things proper to Nature-space and time. From these man in the natural world forms the ideas of his thought, and thereby his understanding" (DLW 69). Therefore we are in the interesting positon of trying to study space and time from a space-time vantage point. Nevertheless we persevere.

This subject can be viewed in many ways. In some contexts space and time are taken together, as when relativisitic aspects are discussed. In other situations time may be treated separately from space.

[4] Adapted from Schramm, *ibid.*



A diagram which represents schematically the decrease in energy density of the cosmos from the first instant of Creation. The scales used are non-uniform.

There are certain features which are common to both. As noted above, space and time provide the fixity and limitations which are associated with the natural world. While appearances of space and time exist in the spiritual world the correspondential relationships are states of affection and states of wisdom respectively. Therefore the spaces and times observed in the spiritual world can be quite variable depending on the spirits involved. But in this essay the primary concern is with space and time in the natural world and their many properties.

First we think of space as a kind of medium which contains the things of the universe. While space cannot be seen it seems to have a reality; it becomes a metaphysical thing. Similarly time seems to have a kind of permanence especially in regard to historical and cyclic events. We count on events that have happened and will recur as being real. We are born; the events in last week's newspaper really happened and affect us even now. This view of space-time is the metaphysical position that space and time have existence in their own right. Newton supported this view and held that space-time was a kind of stationary theater for the drama of nature.

Next consider the characteristic of space-time as a relative frame of reference for our activities. In this context we are not discussing the metaphysical or "being" property but rather the utilitarian aspect of space and time, the measurement property. This is the property which allows us to state relationships between events, time and position intervals, speeds and accelerations. Leibnitz spoke of this as the "relational" aspect of time. One extreme variation on this aspect of space-time is that space and time are simply properties of the way the mind works, and that space and time do not have an existence independent of the mind.

Somewhat connected to the relational view is the utilitarian philosophy or the "parameter" view of time whereby time and space are felt to be simply quantities which enter into the mathematical equations which apply to scientific phenomena. Scientists and mathematicians invent models of nature often in the form of differential equations whose solutions involve time and space coordinates as independent variables. Time and space therefore have existence only by virtue of their use as mathematical quantities or parameters.

The measurement property noted above raises many further issues. For example, are space and time discrete in character or do they have the continuum property? The continuum notion implies that space and time are infinitely divisible and yet philosophic argumerits have been raised against this position.[5] With the advent of the quantum theory there is a tendency to look for atomicity in physically meaningful quantities, and speculation arises that time is not infinitely divisible and would therefore be discrete in character.

The issue of measurement of space-time quantities leads naturally to relativity theory. The 1905 special relativity of Einstein is quite radical in its results while being quite economical in its basic assumptions. Einstein proposed that science was concerned with the problem of measurement, not the 'essence' of nature. This assumption coupled with the postulates that 1) the laws of physics were the same for a certain class of observers, and 2) the speed of light was a constant for these same observers, led to the revolutionary notion that space and time based observations would be different for different observers (all of whom belonged to the original class of inertial observers). Unbelievable as the predictions appeared to be they have since been well substantiated countless times in many laboratories. Of course the most public and spectacular result has been the demonstration of nuclear weaponry. Relativity theory has, in a sense, supported the relational aspect of space and time, and also placed a limitation on our notion of the fixity of natural things. It would seem that some of the variability of space and time in the spiritual world resides in the observations from our deeper study of the natural world.

In this chapter we have attempted to give some feeling for the way in which the knowledges of science provide a picture of the physical world. This picture is not always clear, nor is it a static view. But the general outline provides sufficient scope for developing some connections with religious concepts as described by Swedenborg. This discussion will be the task of the next chapter.

[5] G. J. Whitrow, *The Natural Philosophy of Time,* Oxford University Press, 1980, p.200.

(To be continued)