FQXi essay contest, 2013 -- It from Bit or Bit from It? --- **B. N. Sreenath**.

Voyage from Discovery to Invention; Information & Reality in Physics, Biology & Mathematics.

Abstract: Exploration of the relationship between Bit & It (i.e. Information & Reality) in the fields of Physics, Biology & Mathematics (Humanities excluded), takes us on a voyage from discovery of Reality to its invention. Eventually we find that this journey is full of surprises and joy, and is endless. Consequently this provides us with limitless wisdom.

Introduction:

In this essay the study of the relationship between Information and Reality is limited to only Physics, Biology and Mathematics (Humanities excluded). The concept of Information and Reality has recently acquired immense importance in physics. This trend is set as a result of the way we conceive Information and Reality according to the implications of the Quantum–Mechanics (QM). For those who are accustomed to the classical physics' view of Reality, the portrait of Reality conveyed by QM becomes unpalatable. For a classical physicist, the Reality is 'out there to be discovered', whereas for a quantum physicist, the Reality is 'out there to be Invented' because the quantum Reality simply depends on the measurement outcomes and hence there is no *The Reality* but only circumstantial Reality. Many differences exist between classical information (CI) and quantum information (QI), mainly that CI can be copied and QI, by definition, cannot. CI is understood as a collection of bits whereas QI, by contrast, is a continuum.

It is very essential to discuss the relationship between Information and Reality in *Biology* with regard to the evolution of Life, if we are to know the *vastness* of our grasping power of Reality. The concept of Reality in *mathematics* becomes much more complicated and so is its relation to Information.

The concept of Information in Classical Physics:

In classical physics, an observer *views* the external world *mainly* through his *sense of sight* and to a lesser extent through his *sense of sound*. The set of *data* he receives of the external world or of objects in fact represents the Information he is having about them. The Information comes mainly in the form of electro-magnetic radiation (photons). Hence photons represent Classical Information as continuous collection of bits.

The concept of Reality in Classical Physics:

In Pre-Newtonian system, the Reality of the external world and of objects is taken for granted, i.e., it is independent of the physical as well as mental state of the observer. So whatever Information he receives from them simply represents their Reality by *instinct*. This is also the sort of *naïve realism* which usually people hold in their daily life. This picture is completely altered in the Newtonian system (NS) as observations of objects, whether classical or microscopic, are made with both Space and Time as *absolute* back ground entities. In NS, as was never done before, the Reality of the external world and of objects is expressed *mathematically* on the basis of physical concepts like Mass, Space, Time, Force, Velocity, Acceleration and the like. Information plays anchor role; while the mind that receives it tries to deduce the concept of Reality by *synthesizing* Information with the above physical concepts. So, mind plays central role in visualizing the concept of Reality by framing *Postulates* (or *Hypotheses*) and *Laws* to explain the facts of the external world and this process gives rise to the formulation of a scientific *Theory*. Although the existence of the external world and of objects is beyond doubt, the conception of their Reality is not so as it depends on the extent of knowledge the mind possesses when it tries to visualize it. Thus Reality is mind dependent, at least in the initial stages of framing hypotheses and Theories. In the NS, both Space and Time are absolute and static entities and hence play no direct *dynamic* role in finding the Reality. Where as in the Einsteinian system (ES), represented by the theories of Relativity (Special Relativity, SR and General Relativity, GR), both Space and Time are *relative* and *dynamic* entities and both *vary* as the speed of the reference frame varies and become significant near the speed of light; Space and Time together form four dimensional Space-Time as back ground entity. So length and Time (duration) decrease as the velocity becomes relativistic; simultaneously, the mass and energy of particles and objects go on increasing in turn. Hence observers in different reference frames view the same object differently although their measurement results are consistent with regard to their reference frames. This is explained on the relativistic concept of *Simultaneity*. Thus in this regard the ES is in direct contrast with the NS. Hence the Reality of the external world is *relative* in the ES and depends on the *physical state* of the observer and thus the conception of Reality differs from that in the NS. In ES, for example, the gravitation is explained *geometrically* as Space-Time curvature; where as in the NS, it is explained on the basis of *Euclidian flat geometry* using 'Universal Law of Gravitation' and Newton's Laws of Motion. Thus both systems view the same Reality from entirely different angles. In science, it is ultimately that theory which explains facts of the physical world more precisely stands out. In this regard, it is ES which holds water and hence accepted. Here it is to be noted that ES is based on entirely new physical concepts and hypotheses than NS and hence visualization of Reality is naturally entirely different from that in NS. As more and more Information and facts are acquired about the external world, newer theories are formulated to account for them by replacing older ones if they fail to account for all the known facts and Information adequately. But the newer theories thus formulated must be able to predict new hitherto unknown facts and which must be experimentally verifiable in near future. In this regard, the new theories formulated to explain the theory of QG by combining GR with QM, such as String Theory, Loop QG and the like, miserably fail. This is because they lack new and *original* concepts and hypotheses. These theories are also right-against the true scientific spirit of 'experimental verification of scientific Theories' set by Galileo and Newton. In this regard, GR and QM are outstanding theories and have stood ground to all tests so far performed to test their veracity to any accuracy. From the recent success of the theory of GR, in explaining all the known facts connected to gravitation to the predicted accuracy, we can safely say that if any discrepancy is seen between the theory and observation, the observed fact is not related to

gravitation (i.e. non-gravitational) and if it is purely gravitational then it *must* comply with the value predicted by GR.

From above considerations it is clear that in classical physics (CP) the notion of Reality is independent of the observer and it is out there to be found out; it is observer's *image* of Reality which must correspond with the Reality of the external world or of physical interactions in all aspects and from all angles and when this happens only then will we be able to have complete picture of the Reality and our theories will be able to explain all known facts and observations made (Information possessed) concerning the Reality of the physical interactions. We can call this process *discovery* of classical Reality in physics. This is how mind connects Information to Reality by framing hypotheses and formulating laws and Theories.

The concept of Information in Quantum Physics:

Since the quantum entities like atoms, molecules, protons, electrons, etc., are too small to be visible to our senses, we cannot have clear picture of their size, shape, etc., the way we can have of classical objects and such questions have no meaning in the quantum world. So the sort of Information that we have of them is quite different from that we have of objects in the classical world. In the classical world, the Information is directly accessible to our senses; whereas it is not so in the quantum world. The Information of *invisible* quantum entities and of quantum processes is obtained *only* through instruments by measuring their energy, mass, velocity, momentum, position, charge, potential, etc. Thus the Information obtained is indirect in this sense and can be interpreted in many ways. That is why many *consistent* versions of QM exist. In orthodox QM also, both Space and Time are treated as absolute back ground entities as in the NS. This is non–relativistic QM of Schrodinger and according to it the evolution of the psi (ψ) - function in time is continuous, like the evolution of classical system in time. But once the ψ - function is measured, the results obtained from it give only probability (an array of) values; that is why Information obtained in the quantum world is a continuum in nature. It is here that both classical and quantum physics differ. Because in classical physics, once Information about the initial state is known, Information of the subsequent states can be predicted theoretically before measurements are made and the predictions are always found to be true; this reflects the true nature of Reality in classical world. But in quantum physics, Information of initial state predicts only probability values for subsequent states. This is because of the very nature of quantum Reality and our knowledge of it has changed to a great extent with the formulation of Relativistic QM by Dirac, which predicted the existence of *anti-matter*.

The concept of Reality in Quantum Physics:

The CP also differs from the quantum physics in treating the concepts of Space and Time differently. In the former case, both Space and Time are continuous in nature; i.e., the evolution of the classical system takes place continuously describing a path and hence both Space and Time vary smoothly. Although in both Newtonian and Einstein theories, the concepts of Space and Time are different they agree on the continuity of Space and Time, and so there are no *gaps* in Spatial and Temporal intervals. That is, points in Space are connected to each other, and future points are connected to the past points and hence can be predicted from the theory of CP; i.e., in the classical world, points in Space are *causally* connected and so is the case with points in Time. This is how the *Law of Causality* comes in to picture in classical world and Reality is directly related to the Law of Causality. Whereas in quantum physics, both Space and Time are *discrete* entities and hence there are *gaps* in both Spatial and Temporal intervals; i.e., Space and Time are *quantized*. As a result of this, when an electron moves from one orbit to another one in an atom it does

so by jumping *discretely* between them without covering the distance continuously as is to be expected from classical physics. In other words, there is *no path* between the orbits. So the points in both Space and Time are not causally connected; i.e., the connections are *acausal*. That is the future points in Space and Time need not necessarily follow from the past points; hence future cannot be predicted from the past with any accuracy and consequently Reality in quantum world is only *probabilistic* in nature as there is *no* The Reality in it. These are results that follow from the very nature of QM too. In QM, Schrodinger's ψ-function is the *whole* and *soul* of a quantum particle (Heisenberg's principle of indeterminacy is at the *core* of the ψ-function). It provides all information regarding the quantum particle and in it all the observable properties of the quantum particle such as energy, position, momentum, spin, etc. are in *superimposed* states. According to the *Principle of Superposition* (it plays central role in QM), all the properties of a quantum particle are in superimposed states. That is, the particle will not be in a definite state and it will have only probability value in any of its states. So, repeated measurements of the same state will not give the same result but only its probability value. This means that Reality in quantum world, as reflected by ψ-function, *depends* on the measurement outcome. Consequently there is no *absolute* Reality in the quantum world, but it is only contextual. So exploration of Reality is an *invention* as the concept of Reality changes from experiment to experiment and from measurement to measurement. Accordingly, the relationship between Information and Reality is also probabilistic as the same Information need not necessarily give rise to the same kind of Reality and vice-versa is equally true. We can *create* the logical picture of *unseen* Reality out of the Information given to us, if it is allowed by the quantum laws; this is also called the *Virtual-Reality*. We cannot do this in the classical world because the classical Reality is *out there* to be *determined* by the classical laws and we have got to conceive it the way it exists. This is the major difference between the conception of quantum Reality and that of classical Reality. The very picture of Reality portrayed by QM, drastically changes our attitude towards the world in which we are born with the instinct of viewing Reality in the classical way. Few examples of this are quantum-tunneling, quantum-entanglement, quantum-computers, etc. These phenomena are the consequences of the application of QM to the issues raised by it. These phenomena also give rise to hitherto unimagined (and deep) knowledge on the nature of Reality in quantum world; one of the consequences of this is that, maximum Information can be stored in smaller and smaller volumes by compressing computer files to less than atomic scales; this is tantamount to saying that we can store more and more data in the form of *Input* in smaller areas and we can recover it in the form of *Output* whenever we require it. This idea of compressing more and more Information to *Nano-scale* radically changes our very conception of Information and we can achieve that *artificially* by advances in the knowledge of our quantum-computer technology. The idea that the Information of the whole universe can be stored in an area smaller than the size of an atom shows us what power the quantum computer technology has got. Metaphorically, this is just like seeing the reflection of the whole universe in a small pot filled with water. According to quantum-entanglement, even if two entangled particles are separated by huge distances, the measurement of, say, spin state of one particle can give accurate Information of that of the other particle *instantaneously* without measuring it; this is possible as a result of *quantum-correlation* and thereby proving that quantum-correlations are far more stronger than corresponding *classical-correlations*. The realization of this fact shows that Information is *non-physical* in nature, although it may be having its origin in the external world. In this sense, even our *Knowledge* is non-physical in nature although it tries to *explain* the physics of the external world. But the *magnitude* of knowledge acquired is the product of the *Intellect* of the mind which it acquires through the Information of the external world available to it. In this sense Information acts as *stimulus* to *comprehend* Reality of external world by the mind through its

intellectual power. It is the *thinking* capacity of the mind which constitutes its intellect. The thinking capacity, in turn, consists in *creativity, reasoning, intuition* and *molding of facts or Information*, by the mind. All these factors play basic role in acquiring knowledge and in comprehending Reality by the mind and also *bind* Information with Reality. These factors are also responsible for framing axioms, hypotheses, laws and theories by the mind and hence in visualizing Reality, be it in science or humanities.

The concept of Information in Biology:

All organisms have an inbuilt capacity to receive Information from their environment because without it they cannot carry out their daily living activities. In case of animals, birds, etc., Information is received through their five *senses*. But plants, bacteria, unicellular organisms, etc. have different designs. The five senses are classified in to five separate categories to receive Information; Information received by all five senses is called *sensual perception*. So Information may be defined as *"the data that our five senses perceive from the environment by communicating or interacting with it"*. The capacity the organisms have acquired to receive Information from the environment through their sense organs is as a result of the *evolutionary process* the living beings have under gone for billions of years after the existence of life on earth in the form of bacteria and unicellular organisms. But the evolutionary process of acquiring Information, without sense organs, had begun on earth for about a billion years, even prior to the existence of simplest form of life, in the form of *biological- network*, i.e., *biosphere*. Without the conception of biosphere as a *prerequisite*, it would be impossible for us to *think* of the existence and evolution of Life. Given its enormous complexity of existence (even in its simplest form), no sort of probabilistic explanation based on mathematical physics including QM can account for it and has defied all rational explanations based on physics. So biology, compared to physics, is altogether a much different field to deal with and needs to be explained on mathematics based on *biological laws* rather than on physical laws. The concept of Information in biology has undergone a profound change since pre-biological times to its current status and is still undergoing further changes as the evolutionary process continues. During preliminary stages of the existence and evolution of Life (here the word 'Life' with capital letter 'L' means all living beings from amoeba to man representing one big tree of Life including plants, bacteria, etc.), the function of sense organs were carried out by DNA and RNA in the cells; and later were performed by a complex *neural- network*, in the form of *neurons*, for receiving Information from the environment. The neurons formed a much complex network later and developed in to the most complex organ called *brain*. The brain besides receiving Information also controlled many other activities of living beings. Processing the Information and thereby *constructing* Reality of the external world out of it became the most important function of brain. This function of brain became more sophisticated later, especially in case of human beings, and distinguished itself in to what is now called *mind* with its characteristic traits such as *consciousness*, *thinking*, *reflex-action*, etc. Thus the words 'brain' and 'mind' are sometimes synonymously used with both having influence on each other. This is how the process of *conceiving* Reality also became *mental*. In the preliminary stages of the existence of Life, the utility of Information for living beings was just limited to locomotion and to acquire food from the environment by having a *vague picture* of it. But as the evolution progressed, the role of Information became more important and more complicated and it even had its hand in not only *regulating* the environment but also in *transforming* its very composition by the biosphere, and in case of man it has become the basic *stimulus* for acquiring all of his *wisdom* of the world. The expansion of the biosphere was possible as a result of acquiring more and more Information from the environment and this resulted in the evolution of Life.

The concept of Reality in Biology:

It is very important for us to study the concept of Reality in biology, because we (human beings) are ourselves the product of biological evolution and man is said to be at its pinnacle. So this study helps us to know how far and in what way we are constrained by our biological limitations to envision Reality and acquire knowledge of not only the world we are living in (knowledge pertaining to humanities) but also that of the universe. We get Information of an event from our sense organs and our brain processes it to have a vision of the Reality of the event; but now what about the living beings which have no sense organs and brain, like plants, bacteria, etc. and yet they respond to the same event in their own way? It is obvious that they also must have their own way of receiving Information from the event and will have their *own* vision of its Reality and then respond to the situation. Such organisms do so through their specialized *genes* and genes in them display the functions of senses and brain. So the capacity to receive Information and conceive the Reality by organisms has changed with the evolution of Life and requires as a prerequisite *consciousness* and *intelligence* as *inherent* traits. In primitive organisms, it is the genes which have acquired these traits from the biosphere. The evolution of the biosphere in Time means the expansion of its Information content and this result in increasing its conscious and intelligent activities, and later *leading* to the evolution of Life (*Darwinism*). With the evolution of Life also improves grasping power of visualizing the Reality of the situation in organisms. In the life of an organism, *experience* plays an important role in improving its grasping power of Reality of the situation by assessing the Information content available to it. Thus in organisms the grasping powers of Reality are restricted by their biological limitations and also depend on both the complexity of their neural network and of their brain as well. In higher organisms, the vision of Reality differs from species to species depending on their *adaptive* power. So the concept of Reality in biology depends up on a number of factors related to environment and so is the relationship between Information and Reality. Environment is the source of Information for biosphere.

The important question that is to be asked is, *'Is the human mind capable of comprehending the physical Reality of the external world as it is or is it restricted by its neuron structure or by the very structure of the brain itself, which is the evolutionary product of the Life?'*

The fact that human mind is endowed with the power of consciousness and intelligence (knowledge gathering capacity out of the Information available) as inherent traits which includes characteristics such as, creativity, reasoning, intuition and Information processing (creativity, in turn, is composed of curiosity, imagination, introspection and thinking; reasoning is compose of formal and deductive logic and mathematics), is enough to say that it has the *potential* to undergo evolution in its knowledge. Now we are in a position to frame the basic hypothesis in biology as follows; **"The evolution of Life is *analogous* to the evolution of the knowledge of mind"**. With this hypothesis behind us, we can solve not only the mystery behind the existence and evolution of Life but also that behind comprehending the physical Reality of the external world as it is by the human mind as a result of the evolution of its knowledge. Presently we are interested in only dealing with the latter half of the hypothesis, i.e., with *'the evolution of the knowledge of mind'*. Primitive man, probably millions of years ago, gifted with mind (brain) didn't obviously have all the knowledge that we have now, but his mind had that *potential* to acquire it through its evolutionary process and acquired it accordingly through its above mentioned qualities. In other words, his creativity, reasoning, Information processing, imagination and other qualities have increased *over time* and reached now the level they have reached in us. If in the past two or three centuries the increase in the level of the knowledge is exponential compared to the previous millions of

years, it is because of the way the evolutionary process works. Now if we ask, 'what would be the level of knowledge attained by us after a million years hence forth?' the answer to this can be given if we know the precise biological law operating behind this evolutionary process of the knowledge of mind.

Now the answer to the above question is, *'there is no limit to the comprehension power of the human mind just as there is no limit to the horizon of his imagination'*. It can answer, *over time*, any question for which it seeks answer. Consequently there is no limit to his understanding of the physical Reality of the external world and it is *unfettered* by the structure of his brain. During the course of evolutionary process, accumulation of more and more Information content in the biosphere over time can sometimes give rise to a sudden *burst* in to various life forms from the previous ones; otherwise it would be a gradual process. Similarly, accumulation of more and more Information content in mind over time can give rise to new hypotheses and theories to explain the facts of the external world and to comprehend the Realities behind them, either gradually or in a spurt. This spurt in knowledge could be either in theory or in technology or in both, as it is happening now.

The concept of Information & Reality in Mathematics:

Mathematics is broadly split in to *pure* (or *abstract*) and *applied* math. But, according to me, mathematics in any form starts as abstract math, for it is an *innate* quality of the mind (and of the Nature too) to comprehend the various *relationships* existing between different *quantities* and *symbols*, and only when it is capable of explaining the facts and phenomena of Nature, (or corresponds with the math of Nature) it becomes applied math. Well known examples of this among others are, the calculus invented by Newton (and Leibnitz) to explain gravitation and other phenomena, and Riemannian geometry of curved surfaces used by Einstein after a few decades of its formulation to explain the same gravitation. In pure math, Information is contained in the *axioms* and it is not supplied from outside. Similarly the Reality derived from the axioms, through successive mathematical steps (which are intuitively certain), follows as logical conclusion from the axioms and it too is abstract. So Reality *as* conclusion is *covertly* contained in the axioms. In this sense, mathematics just like logic is a *tool* used by mind to realize Reality and the *veracity* of the Reality thus derived from the axioms, depends on the veracity of the axioms but not on the kind of mathematics (or logic) used. In applied math, Information supplied from outside is contained in the axioms and the Reality derived from the axioms helps in explaining the facts and phenomena of Nature and coincides with that of Nature whether it (Reality) is deterministic or probabilistic in nature. So if a mathematical theory devised to explain the Reality of Nature, succeeds in comprehending it from all aspects then it becomes *the* successful scientific theory. Like an *artist* who is having a blurred vision of Reality when he starts drawing his sketches and envisions it fully when he completes his drawings, a mathematician too will have a blurred vision of Reality and frames axioms to deduce mathematically from them the Reality which he is after and realizes it completely when his mission is accomplished. When a mathematician carves the Reality out of his preconceived axioms he resembles a sculptor who carves a preconceived figure on a plain blank stone. So mathematics is a *creative* activity of the mind and needs a mathematician not only to *know* what mathematical Reality is but also to *feel* the *joy* of its discovery/ invention. All mathematical equations (ME) are *ideal* and *elegant* in nature and each equation presupposes *symmetry* behind it and when they are applied to explain Natural phenomena, divergences from them are to be expected since Nature is not *always* ideal. Elegance always contains an element of *beauty*, and all ideal and elegant equations are *time symmetric* in nature. So when a mathematician *meditates* over framing an axiom, his mind *sees* that all the above points such as Information, Reality,

symmetry, etc., are implicitly contained in his axiom. Hence in mathematics, Information and Reality *supplement* each other. The Reality (and veracity) of ME is independent of; Nature and her phenomena; Space and Time, and its Creator too. That is, they are *absolutely* real for Reality is *inscribed* in them. All ME need not be scientific equations but all scientific equations are necessarily ME.

Conclusion:

Although Information & Reality (Bit & It) have physical origin, without *mind* they are in themselves empty and blind. Bit comes from It, but mind can *know* of It *only* through Bit. Thus the relationship between them is *triangular* and so all three are equally essential for knowledge to coexist. For classical physicists, 'It' is *basic* and *more important* than Bit; but for quantum physicists, *Bit* is basic and more important than It. For biologists, both are equally important and for mathematicians, both are *engraved* in their axioms. Biological Reality (BR) *basically differs* from quantum Reality (QR); QR is a probability allowed by QM to show up at any time *in Time*; BR is the Reality *created* by the biosphere out of the Information content available to it from the environment *over Time*; so QR exists as *virtual* Reality in the *quantum sea before* it is found, but BR exists or *realized only after* it is created by the biosphere at its *will*. Mathematical 'It' would be in *semi-realized* state in the axioms and when conclusions are derived from them, it becomes *self-realized*. In math, Bit is *contained* in the axioms; but in biology, environment *feeds* Bit to the biosphere.

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End Note:

Classical Physics: In Classical Physics (CP) of Newton, Space and Time are treated as separate back ground entities to view the events taking place in the world around us. Space is having three dimensions and Time one. Newton was the first scientist ever to use *mathematics* (and introduce the concept of *mass*) in science (physics) and since then mathematics plays *dynamic* role in physics; we can now say conclusively that without it there is no physics. Physics is almost reduced to mathematics except that it is an empirical science. Before Newton, there was *chaos* in science (physics) and it was he who brought *order* in to physics by applying mathematics to the physical postulates he had framed. For this he had to invent *Calculus*, the mathematics of *infinitesimals*, to derive his theory from his postulates and this endeavor gave birth to *perfectly deterministic* system in physics and succeeded in explaining various phenomena in physics known at that time. Newton formulated his *three laws of motion* and applied calculus to derive equations which could explain the motion of objects around us with precision. The *paths* or *trajectories* described by objects could be predicted by his laws and calculus. To describe the paths, he based his entire system on *Euclidian geometry* which is used to describe the paths on *flat surfaces*. He, among other phenomena, also discovered gravitation and to derive the theory of gravitation, he made use of his *universal law of gravitation* along with the laws of motion and calculus. This brought remarkable order in accounting for *celestial mechanics* by explaining the motion of planets around sun accurately. Thus Newton's system became a deterministic system by implying the law of causality, and in which future state of objects, such as position, velocity, etc., could be predicted from their past states. So the *role of god* in the routine affairs of motion of celestial bodies was unnecessary, but god was retained as the *first cause* of motion in the universe. Comprehending Nature and her *permanent* Reality became *scientific* with Newton and the nature of Reality was absolute of human mind or of his physical state.

With Einstein dawned a new era in conceiving the *permanent* Reality of the physical world. He too followed Newton's deterministic and mathematical approach to describe the Reality of the physical world. According to him, both Space and Time are *relative* concepts and Time is to be viewed as the *fourth dimension* of Space; so Space and Time together form four dimensional *Space-Time manifolds* in which the events in the world take place. To cognize this Einstein had to formulate his theory of Special Relativity (SR), by postulating 1) the velocity of light, c, is the maximum speed to be attainable in the universe and is an absolute constant irrespective of the motion of reference frames and 2) the concept of the relativity of simultaneity. No particles or objects, having rest masses, would attain 'c' according to relativistic equations as their masses and energies would become *infinite*, and at the same time measuring rods on them shrink to zero and clocks come to a standstill. These are the astonishing conclusions an observer observes as he approaches 'c'. Thus the *nature* of the physical Reality depends upon the *physical state* of the observer. To account for gravitation, he made use of *Riemannian curved geometry* and postulated the *Equivalence Principle* (EP); according to it both *inertial* and *gravitational* masses are *one and the same*. This is General Relativity (GR) and in it he merged his SR. According to GR, gravitation is nothing but *Space-Time curvature*; EP and gravitation as Space-Time curvature have been verified to a remarkably high degree of accuracy in various experiments performed so far, thereby GR has become a highly trust worthy theory in physics. GR's cosmology succeeded in explaining the harmony and coherence existing among all celestial bodies in the universe, thereby reducing it to just one entity as there was *singularity* at the beginning and out of it the universe originated with a *bang*; along with it also originated both Space and Time and so the universe had a definite beginning in Time as there was no Time and Space before the bang. That is why CP needs Reality to be objective in order to be discovered.

Quantum Physics: There are many interpretations of QM; few important ones are Copenhagen interpretation, many worlds' interpretation, pilot wave theory, hidden variable theory and von Newman's interpretation, etc. Among them Copenhagen interpretation is widely popular and Reality in the quantum world is conceived based on this. Heisenberg's principle of indeterminacy (HPI) is at the core of QM. The two equations of HPI are $\mathbf{\Delta p.\ \Delta x \geq \hbar/2}$ and $\mathbf{\Delta E.\ \Delta t \geq \hbar/2}$. HPI is often wrongly interpreted as giving not only indeterminacy values (IVs) but also *unreal* values (UVs). This is misinterpretation of not only HPI but also that of QM based on it. It is true that HPI gives IVs, but this doesn't mean that IVs are UVs because Reality is different from indeterminacy and IVs could very well be *real values* and this is what HPI is after. What HPI tells us is that Reality in the quantum world is probabilistic in nature and measurement of probability always does not give the same real value as it changes from measurement to measurement. That is Reality is uncertain in the quantum world due to the principle of superposition and consequently Δp, Δx, ΔE and Δt represent indeterminacy values. The same effect (Information) need not presuppose or follow from the same cause (Reality) and vice versa is equally true. So quantum Reality is having *momentary* existence or *contextual* in measurements; it could be virtual as in quantum-tunneling, information-processing; it could be *eternal* as it is depicted in the *basic equations* of QM.

Biology: I have already said that, biology can *never* be explained on physical laws and for this we have to formulate biological laws to account for the existence and evolution of Life. I have also said that before Life existed on earth there was *pre-evolution* (for at least billion years) in the form of acquiring Information from the environment, this resulting in the formation of *biosphere*. This pre-evolutionary period was as a result of the *tendency* exhibited by biological molecules (i.e. life constituting materials like DNA, RNA, amino acids, etc.) to start the *chain* of Life forming processes by acquiring Information from the environment and thereby building the *essential* biosphere. When the biosphere was filled up with enough Information and minimum conducive environmental conditions existed for Life to originate in its simplest possible forms, living materials started the chain of Life forming processes and thereby produced Life for the first time on earth in the form of bacteria. With the existence of Life also started its evolution over time and resulted in the production single celled organisms and later in complex organisms. So evolution of Life in to various kinds of organisms is to be viewed as *creation* of *biological* Reality out of the Information content available to the living materials. The existence and evolution of Life is an opportunity to be borne out by the *presence* of following factors; living matter, biosphere, favorable environmental conditions, enough Information content in the biosphere and ample Time. For this reason we are not able to produce Life in the lab in spite of strenuous efforts and reminding us of Pasteur's great insight that *life comes only from life*.

Mathematics: Mathematics in itself is *not* Reality but it is the *path* which leads to *realize* Reality involving logical steps which are intuitively certain or self-evident and hence beyond doubt. So it is the *process* of realizing Reality from the axiom, in which the Reality is covertly contained and is the path of certainty. The path and the process are determined by the *nature* of the axiom itself. That is, the kind of mathematics to be applied depends upon the nature of the axiom. In this sense, mathematics is a *tool* used to realize Reality and in itself it is neither *true* nor *false* but always leads to *right path* if it is *properly* applied to the axiom to which it suits. New kinds of mathematics appear as new ideas come to mind and new axioms are framed. So *horizon* within which mathematics is applicable cannot be fixed and this horizon is *limitless* like the horizon of the *knowledge* comprehension capacity of the mind. If we go through the development of mathematical ideas for the past few thousand years, too many branches and theories in mathematics are developed and this process is still continuing rapidly with *no* end in sight.