

Notes
Relating to
Intensive Study Program
On
THE EMERGING SCIENCE-
SPIRITUALITY CONFLUENCE:
With specific reference to the Quantum Enigma

Being held at
NAVADARSHANAM
From
Aug. 12th to 16th, 2009

"It is probably true quite generally that in the history of human thinking the most fruitful developments frequently take place at those points where two different lines of thought meet. These lines may have their roots in quite different parts of human culture, in different times or different cultural environments or different religious traditions; hence if they actually meet, that is, if they are at least so much related to each other that a real interaction can take place, then one may hope that new and interesting developments may follow."

- Werner Heisenberg, one of the founders of quantum mechanics

WELCOME

to this four-day intensive study program on the emerging science-spirituality confluence.

This program will focus on the possibility of the emergence of a new kind of science - a science that accepts the reality of the spiritual dimensions. In order to examine this possibility, we will look into the "Quantum Enigma" represented by the wave-particle duality that emerges from experiments conducted by physicists, and also into the implications of this enigma as explained by Rosenblum and Kuttner in their recent book on this subject. We will speculate on the predictions of the two most prominent quantum-scientists of the last half century, John Wheeler and John Bell, bearing fruition. *"Somewhere something incredible is waiting to happen"*, is how John Wheeler had put it. John Bell's words were: *"the new way of seeing things will involve an imaginative leap that will astonish us."*

Does that prediction have implications only for the cloistered world of the quantum physicists? Not really. As we will see, what happens in their field is likely to have enormous repercussions on the lives of ordinary human beings. It could, in fact, usher in a new civilization - of the kind Mahatma Gandhi had recommended in his seminal book *Hind Swaraj*. In other words, a way of living that would reverse the most prominent trends we witness today - over-urbanization, over-centralization, over-monetization, over-commercialization and over-militarization. It could end our concerns on issues like pollution and climate change by introducing different *kinds* of technologies that promote ecology, rather than the present kinds which invariably tend to destroy it. Most important, it could very well lead to the emergence of a New Man, who sees the purpose of life on earth not in terms of accumulation and consumption, but in terms of an opportunity to reach out to the Creator.

We often associate social change only with the activities of politically conscious personalities like Marx and Mao. But careful thought will reveal that the work of scientists has actually had a more profound impact on our lives as social beings. For instance, the Schroedinger Equations have led to the internet, PC, MRI, lasers etc. - and would it not be right to say that these devices have changed our lives more than what Marx or Mao did or

contributed? Actually, science has helped shape our lives in modern times in a very basic way. No political revolution or social movement can match its influence.

The "incredible" development that Wheeler and Bell have predicted is likely to have an even wider impact than Schroedinger's Equations did, for there is every possibility that it will change for ever the functioning of science itself. During the course of the last two-three hundred years, we human beings have accumulated a lot of knowledge about the world around us through what is called the scientific method. This method is based on experimentation and personal verification, and does not allow any superstitions or dogmas or blind faith or rites and rituals to enter its realms.

The amount of knowledge accumulated by us about the Creation using the scientific method is staggering, and has changed for ever the landscape of our view about the world and the way it functions. However, scientists have steered clear of using their method to find out anything about the Creator - often implying a denial of the existence of God. Thus, science and religion are usually viewed as mutually exclusive (often antagonistic) realms of knowledge. The typical scientist either denies the existence of God, or prefers not to think about it (treating it as a question to which no satisfactory answer can ever be found), or compartmentalizes his or her life into two - the scientific method for doing work in the office, and rites/rituals/dogmas for dealing with home and family. The last option is particularly common in countries like India, leading to a schizophrenic mentality whose existence we rarely recognize. A much worse form of this schizophrenic mentality is evident in the religious bigots who are fanning 'fundamentalism' and terrorism, for their activities and thoughts are in direct contradiction to the true fundamentals of the religion they champion.

A question that often bothers any thinking individual is - is there really a God? Even more important, is there any method by which one can really verify the existence of God, or is it a proposition that can only be accepted as blind faith? The only way by which we can avoid brushing this extremely important question under the carpet is to discover a way by which spiritual knowledge can be obtained through personal verification.

The purpose of this four-day intensive study program is to acquaint ourselves with ideas that point to such a possibility, and the enormous potential for individual as well as social change that this possibility promises.

Xxxx

"Science without religion is lame, religion without science is blind."

- Albert Einstein

"The physicist-philosopher of the twentieth century must look beyond physics to the borderland of the material and spiritual worlds. For religion has become possible for a man of science mainly because the philosophical trend of scientific thought has been startlingly redirected by the discoveries of men like Einstein, Heisenberg and Bohr in the field of relativity and quantum physics." - Sir Arthur Eddington

THE SCIENTIFIC METHOD: Its Inherent Limitations

"In a society where scientists are the high priests and science is the religion, we must remind ourselves of the limitations of science, however precious it is." - Patsy Hallen

Science is a word that commands much respect these days, with the result that even disciplines which originally were not seen as having anything to do with science are bending over backwards to be seen as 'scientific' - resulting in new terminologies such as social science, library science etc.

But what exactly *is* science? When my wife Jyoti and I used to teach some courses in IITDelhi, we often used to ask IIT students (who are supposed to be the cream of India's budding scientific community) whether they had ever given this question any thought. Surprisingly, the answer was always in the negative.

The meaning of science as given in the Oxford dictionary is "the state or fact of knowing, knowledge. of something". In actual practice, it is seen as something less general - knowledge of the material world obtained through rational and objective ways. If we delve deeper, we come across a variety of definitions, with a lot of disagreement on what exactly constitutes science..

But there *is* a generally accepted definition of the "scientific method". In fact, many scientists *define* science as "all knowledge accumulated by the scientific method". This is a rather strange way of defining anything, for the word that is being defined itself appears in the definition! In effect, this definition of science elevates the scientific *method* to a sacred position, towering above science itself. Without saying so in so many words, this definition severely limits the scope of science itself.

Yet, in practice, it is this rather strange and inverted definition that has become the accepted norm in science. Anything that violates the scientific *method* is seen as a violation of science itself.

In this course, our focus will be to challenge the sacredness of the scientific method as accepted today, for that will reveal to us the nature of the Quantum Enigma and also lead us to true insights about Relativity more than any other intellectual exercise. To do so, let us first take a close look at what constitutes the Scientific Method.

The diagram below captures the essence of the Scientific Method.

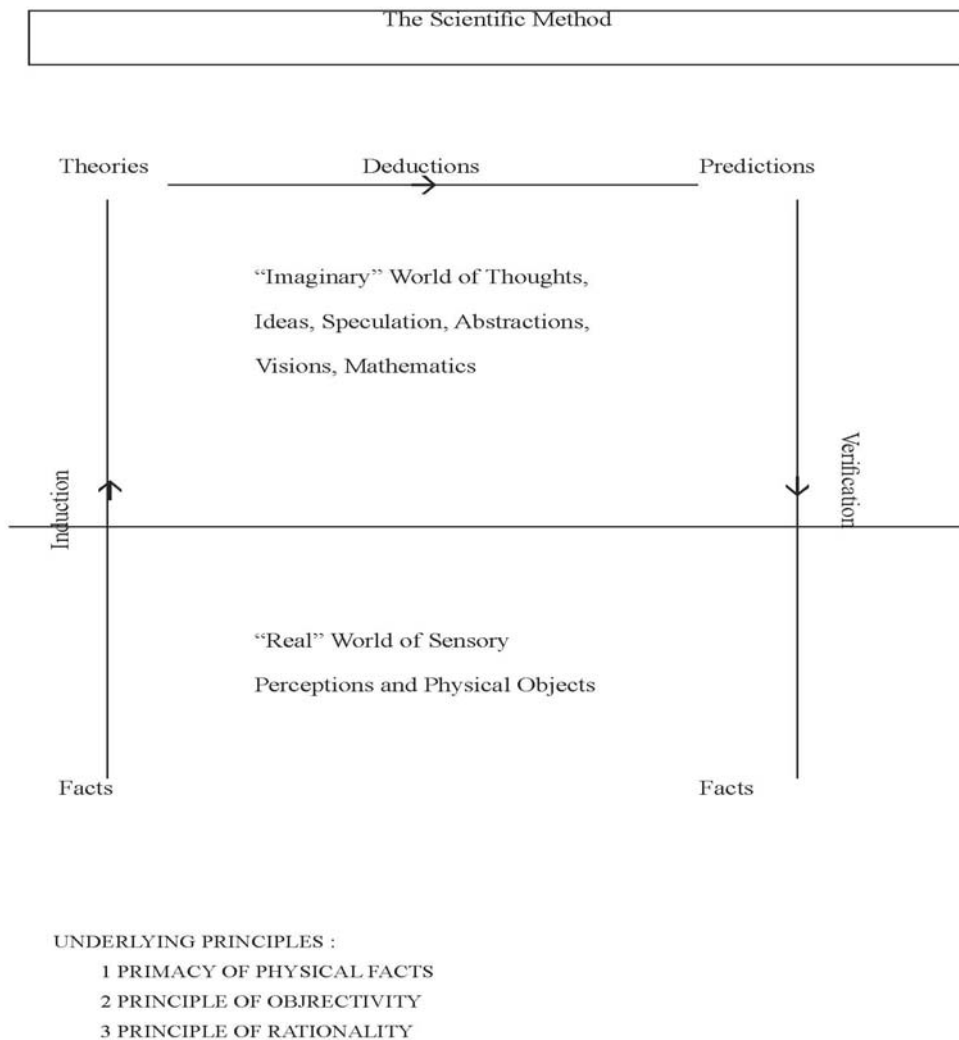


Figure 1

As shown in the diagram, the first step in the scientific method is the accumulation of "facts". This is often done through elaborate experiments in laboratories, though this is not a must - any observation of any kind constitutes a scientific 'fact', provided that the observation is objective, i.e., independent of the observer. A legend attributes science's most important equations to Newton having observed the fact that apples fall to the ground when they ripen. Whether or not this legend is true, let us make this our starting point to understand how the scientific method works.

If the observation of a fact makes us 'think', it leads us to the second step in the scientific method - and on to the upper portion of the diagram. If this thinking is rational, it leads to an analysis of the situation that we have observed. The Principles of Rationality (thinking logically) and Objectivity (observing without the observer's prejudices) are thus the two pillars on which the Scientific Method stands. If we apply them, we are in a position to speculate on a Law which made the fact happen. Here are some possible conclusions that such speculations may lead to with regard to the observation of the falling apple:

Hypothesis I : "The earth is the centre of the universe, and hence attracts everything".

Hypothesis II : "All fruits, when they ripen, are attracted towards human beings for they are God's gift to us".

Hypothesis III: "There exists a force of attraction between any two material objects".

Notice that the above are called Hypotheses, not Laws. There is a lot of leeway given in science to how a hypothesis may be arrived at (Kekule, for instance, hypothesized his famous Benzene ring based upon a dream). The step of arriving at a hypothesis in the scientific method is often referred to as "Induction". To qualify as a Law, each such Hypothesis must be subjected to the next two steps of the Scientific Method. The first of these calls upon us to figure out facts which must be true if the Hypothesis is valid - preferably facts far removed from the original set of facts that led to the hypothesis. This step therefore involves making predictions. The final step involves verification - often, in the world of science, this means the setting

up of elaborate, carefully controlled scientific experiments in sophisticated laboratories. to check out if the facts so predicted by the theory under test are correct (as for example the experiment that Eddington performed to verify Einstein's Theory of Relativity). If it turns out that the facts predicted are indeed true, then the Hypothesis is accepted in the world of Science as a Law - but again, only tentatively, for it can always be overruled if and when any new facts are discovered that contradict the hypothesis. Thus, the Scientific Method is quite harsh on all Hypotheses - it demands full compliance in situations far removed from that wherein it was originally formulated, and even when that is demonstrated, the Hypothesis is given the status of a Law only temporarily, ever in danger of being overruled by fresh facts that may be discovered. So, in the Scientific Method, *facts reign supreme*. The Method, scientists proudly proclaim, *'begins as well as ends in facts'*. In the diagram, therefore, the lower compartment has been called the 'real' world (of facts), and the upper portion 'imaginary' and 'abstract', implying it exists only in our imagination and is not real.

Imagination and 'abstract thinking' are, however, very important ingredients of the scientific method, and all great scientists are characterized by a superb ability in these two fields of human endeavour. The importance of imagination and abstract thinking becomes evident when we try to sort out the valid Hypothesis from the invalid ones. Coming back to our Hypotheses I, II and III - Hypothesis I seems quite valid in so many cases that we experience, but if it is really valid, it must apply to the sun and stars too. Scientists have used their powers of abstract thinking to discover that the sun and stars are not falling towards the earth, which gives us enough grounds to dismiss Hypothesis I. Hypothesis II can be disproved if we perform an experiment of growing trees where no human beings live, and show that fruits fall to the ground when ripened even in such cases.

It is Hypothesis III that Newton espoused, but the language in which he presented his hypothesis is called mathematics - and it is while dealing with mathematics that the role of imagination as well as abstract thinking becomes paramount. As we know, *mathematics is at the heart of modern science*. But again, just like most of our IITians have paid little attention to the question 'what is science?', they have paid even less attention to the very important question 'what *is* mathematics?', even though all IITians are usually very brilliant at mathematics.

Mathematics is actually a language. In theory, there is no equation of mathematics that cannot be expressed in English, or any other human language. But in practice, it becomes very difficult to do so, for mathematics is a very concise and powerful language, being extremely precise and always quantitative. It is thus able to express in one equation what English may take millions of sentences to do.

Moreover, mathematics *multiplies truth*. In other words, if a mathematical statement is made about one situation, it can apply equally to another situation which is far, far removed from the first one. It is this quality of mathematics that makes it such a powerful tool, enabling us to complete Steps III and IV of the scientific method in a comprehensive manner.

To take a simple example and see its far-reaching consequences, let us take the well-known mathematical proposition that the three angles of a triangle when added together always add up to 180° . Now, mathematically it can be shown that if this is true, then the universe in which we live is infinite. Corollary: if anyone can prove that the universe in which we live is finite (like a sphere), then the three angles of a triangle do *not* add up to 180° - for the two are mathematically inconsistent with each other.

Therefore, when Newton presented his version of Hypothesis III through the equations

$$F = MA \text{ and } F = G \frac{m^1 m^2}{d^2}$$

he was saying something that applied not only to the apple and earth, but to all bodies that make up this universe. Thus, it is possible to verify (or falsify) his equations by checking it against *any* two bodies that constitute this creation. *Because* his equations made thousands of predictions which were subsequently shown to be thoroughly accurate - for instance, the timing of all eclipses - they have been enthroned in science as the Universal Laws of Motion.

What Newton's equations represent, therefore, is a model of the *entire* universe, and the process of arriving at it is a method by which the "inner

world" of the scientist matches the "outer world" that we experience through our sense perceptions. Thus, the Scientific Method involves a 'match-making' of the inner and the outer. The inner capabilities of scientists - their intuition, imagination, thoughts, speculations, visions etc - are extremely important ingredients in this process, but are however relegated to the level of the 'imaginary'; the real world being seen as only that which can be viewed through our physical senses.

It is this fundamental assumption which are we are going to question in this course.

To arrive at our conclusions, let us first take a brief look at one of the limitations of that extremely powerful tool, mathematics, as presently practiced. What makes mathematics so powerful is its ability to replicate the real world through seemingly abstract equations, which can lead to wonderful, verifiable conclusions about the real world if step-by-step procedures are followed as per the rules of the game. So, let us start with a simple equation

$a = b$ (in the physical or 'real' world, this amounts to any two objects which are absolutely similar, a condition so easy to create)

If we multiply both sides by a , we have

$$a^2 = ab$$

We now add $(a^2 - 2ab)$ to both sides:

$$a^2 + (a^2 - 2ab) = ab + (a^2 - 2ab)$$

This reduces to

$$2(a^2 - ab) = a^2 - ab$$

If we divide both sides by $a^2 - ab$, we come to the conclusion:

$$2 = 1.$$

Obviously, this is an absurd conclusion, and if mathematics leads us to it, it fails in its claims to be a powerful tool to study reality.

The mistake we have committed in the above steps is to divide by a^2-ab . Though not obvious at first sight, this actually amounts to division by zero, which is not allowed in mathematics. Why not? Because dividing anything by zero leads to infinity, and *modern mathematics, as well as modern science, cannot deal with infinity.*

Infinity represents "that which is beyond our intellect". Our intellect is confined to that which can be known through comparison (the word rationality is derived from the word ratio, meaning comparing one thing with another). It cannot know anything which is absolute. Thus, modern mathematics in its present form cannot tell us the *absolute* truth about this universe (The silver lining is the Arithmetic of Infinity initiated by Georg Cantor, which we will deal with later). As the Creator represents First Cause, is absolute and beyond the intellect, science and mathematics have steered clear of addressing questions about it.

The other Principle - that of Objectivity - on which the modern scientific method stands has a similar flaw, in fact a deeper one. This principle states that for an observation to be considered objective, it has to be independent of the observer. A very laudable objective indeed. But there are two limitations of the present process of making observations that are usually totally ignored. One is that we make our observations only through our sense perceptions, and these perceptions are very, very limited. For instance, Figure 2 (on the next page) shows the total electromagnetic spectrum as known to science. It ranges from radio waves which have frequencies in the region of 10^{-4} to cosmic waves whose frequencies are in the 10^{28} region. Out of this vast spectrum already known to science, only a tiny fraction (the 'vibgyor' range) is within our sense perceptions. Cats, dogs, elephants etc. can see much more than us. So then, how did science accumulate so much knowledge about things which cannot be 'objectively' observed? Through indirect perception: e.g., the cosmic rays falling on our cathode ray tubes create certain patterns which are visible to our senses, and after observing these patterns and using our intellect we make up some theories and draw certain conclusions about the existence and properties of things which we cannot see.

The Electromagnetic Spectrum

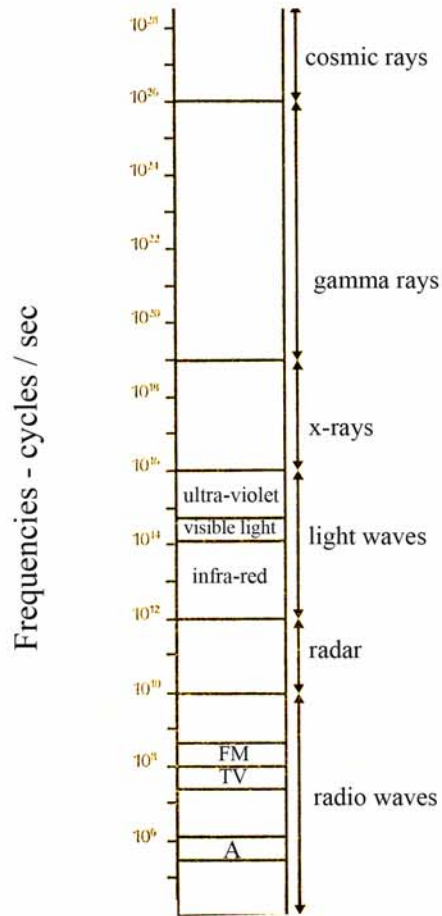


Figure : 2

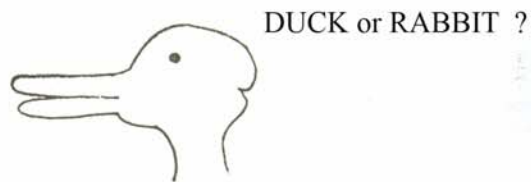


Figure : 3

Unlike in the case of direct perception, whenever our knowledge is gathered through the process of indirect perception, our level of certainty is never high - theories keep changing, and with it our perception of what is 'true'. This is one limitation of Objectivity as practiced at present. But there is a deeper and potentially more damaging limitation which applies to direct perception. To understand that, let us take a look at Figure 3.

Is it that of a duck or a rabbit? It depends on *how* we look at it! Our preconceived notions always affect our so-called objective observations, and these notions in turn are the result of our association with a *perspective*. For instance, when Indians and Pakistanis watch the *same* live telecast of, say, an lbw appeal against an Indian batsman, the Indians invariably see the ball as going away from the stumps, whereas the Pakistanis see it as being dot on the stumps. The same image, same sensory inputs, so how come the 'data' is recorded differently by Indians and Pakistanis? It is because of their perspective which results from their identity- each is identifying with a different team.

Scientists may like to believe that they are above such narrow identities, but that is self-deception. As Thomas Kuhn has shown in his *The Structure of Scientific Revolutions*, science has not progressed by the logical, rational process by which many of us think it has, but by 'paradigm shifts' that occur when one generation of scientists abandons the *perspective* of the earlier generation. Max Planck, the famous contributor to one such revolution, who lived before Kuhn's book was published, put it quite bluntly:

"A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it Science progresses funeral by funeral."

So then, does it mean that Objectivity as a goal is never achievable? Actually, real objectivity is the true goal of all good *spiritual* processes, for they teach us to rise above the narrow self, the 'I'-ness, that normally dominates our perspective ('I am an Indian, not a Pakistani', or 'I am a Musalman, not a Hindu', or 'I am the Managing Director, not an ordinary employee'). It is not easy - actually, it is an almost impossible task - to rise above this sense of 'I'-ness, but if achieved it results in an *enhancement in*

our ability at direct perception, eventually leading to an ability to see even the mind and the life force itself. Without such an enhancement, true objectivity and therefore really scientific knowledge of the perfect kind is not possible. The Buddha put the relationship between true objectivity and real knowledge succinctly:

"There is Truth and there is self. Where Truth is, self is not. When self appears, Truth is not."

As we human beings struggle to unravel the mysteries indicated by Quantum and Relativity theories, it may help to bear in mind what the Buddha was indicating - that real Objectivity is possible only when we detach ourselves completely from the world, with no thought of any rewards, recognition, or even result for our endeavours. As a matter of fact, Albert Einstein's *definition* of a real scientist is an echo of what Buddha had said:

" Where the world ceases to be the stage for personal hopes and desires, where we, as free human beings, behold it in wonder, to question and to contemplate, there we enter the realm of art and science. If we trace out what we behold and experience through the language of logic, we are doing science; if we show it in forms whose interrelationships are not accessible to our conscious thought but are intuitively recognized as meaningful, we are doing art. Common to both is the devotion to something beyond the person, removed from the arbitrary."

In the above quote, Einstein is (i) linking real Objectivity to 'something beyond the person', attainable only when we abandon 'personal hopes and desires' (ii) declaring that access to true reality is only through this route, and is available to all human beings, scientists and non- scientists alike - anyone who is bold enough to rise above 'I'-ness and thereby increase one's ability for *direct* perception (iii) if the experience of this direct perception is expressed using mathematics or other forms of logic, then it amounts to science, if it is done intuitively, it amounts to art. As he stressed on another occasion, not only scientists but *all* human beings should strive to rise above the narrow 'self':

"The true value of a human being is determined primarily by the measure and the sense in which he has attained liberation from the self."

Einstein's world-view as expressed above is actually fundamentally different from what is generally recognized as the 'scientific' world-view, and is in fact in consonance with what mystics tell us about reality. One of the great ironies of modern times is that Einstein, Schroedinger, etc. are recognized as very great scientists, but their world-view is totally ignored, especially by the scientific community. Let us now examine how such a sad state of affairs came about.

THE SCIENTIFIC WORLD-VIEW: From Newton to Einstein

"The violent reaction on the recent development of modern physics can only be understood when one realizes that here the foundations of physics have started moving; and that this motion has caused the feeling that the ground would be cut from science." - Werner Heisenberg

The modern, mechanistic view of our world that we usually subscribe to these days is generally referred to as the Newtonian world-view. As Newton spent a lot of his time and energy pursuing alchemy and mysticism, it is unlikely that he himself subscribed to this world-view, but the mathematical contribution he made to the laws of physics have entitled him to be given full credit for this world-view.

Essentially, Newton's laws give us mathematical equations to predict with astonishing accuracy the future position and velocity (speed + direction) of each body in any system if the 'initial conditions' of the system - meaning, the position and velocity of each body, and also all the forces operating within the system - are known. The universe is therefore seen as a giant machine, no more mysterious than a clock whose gears are not seen.

Even though Newton himself never denied the existence of God, it is easy to see how his model of the universe led to such denials. This is how the physicists Rosenblum and Kuttner have described the evolution of this world-view:

" To an 'all-seeing eye' that knew the position and velocity of each atom in the universe at a given moment, the entire future of the universe would be apparent. The future of such a Newtonian universe is, in principle, *determined* - whether or not anyone *knows* the future. The deterministic Newtonian universe is the *Great Machine*. The meshing gears of its clockworks move it on a predetermined course. God then becomes the *Master Clocksmith*, the *Great Engineer*. Some went further. After making

the completely deterministic machine, God had no role - he was a *retired* engineer. And moving from retirement to nonexistence was a small step."

The great French mathematician Laplace used Newton's equations to build a mathematical model of the solar system that dispensed with all empirical equations and astronomical tables that had been in common use till then. His huge, five-volume work was highly acclaimed, and the story goes that when he presented it to Emperor Napoleon, the latter remarked, "Monsieur Laplace, they tell me you have written this large book on the system of the universe, and have never even mentioned its Creator", to which Laplace replied, "Sir, I had no need for that hypothesis".

Newton's laws first tasted their grand success in mechanics and astronomy, and then were extended to the motion of fluids, then to elastic bodies, and finally to heat and gaseous substances. In each case, they worked with great perfection, prompting Alexander Pope to coin a new version of the Biblical version of creation:

"Nature and Nature's laws lay hid in night;
God said, Let Newton be! And all was light."

The fantastic success of Newtonian physics led other disciplines to emulate the same path. The first to do so was chemistry. Soon, biology and other branches of science were doing so, and even psychology tried to re-fashion itself "to represent psychical processes as quantitatively determined states of specific material particles", as Sigmund Freud put it. The disease then spread to what till then was known as 'the humanities', which became rechristened as 'social science'. Karl Marx, in fact, used Newtonian concepts as the basis for his famous theories. He claimed to "lay bare the economic law of motion of modern society". His 'dialectic materialism' is based on a model similar to Newton's, in which the 'initial conditions' that signify a feudalistic state of social order will *inevitably* give rise to capitalism, and capitalism will in turn *inevitably* give way to communism - a perfectly deterministic view of history. It may come as a shock and disappointment to the millions who have been attracted to Marxism on account of their moral or socially sensitive conscience, but the fact remains that Marx's theory had as its foundation not morality or conscience but social determinism.

So great was the all-round impact of Newton's equations that the physicist Lord Kelvin, who had himself made a great impact in the field of thermodynamics, declared in 1894:

"There is nothing new to be discovered in physics now. All that remains is more and more precise measurements."

A few years prior to that, when Max Planck had wanted to join the Physics department of his University, the Chairman of the department dissuaded him, saying, "All the important discoveries have already been made." As Kelvin had pointed out, all that was needed was to make more and more precise measurements, as the theory side was already seen as complete.

But two of the measurements thus made led to the apple cart being upset. Taking note of these developments, Kelvin modified his earlier remark, and in 1990 said:

"Physics is essentially complete. There are just two dark clouds on the horizon."

These two 'dark clouds' were (i) the Michelson-Morley experiments that attempted to measure the velocity of the earth while supposedly passing through the 'ether' medium, and (ii) the data thrown up while examining the spectrum of colours emanating from hot bodies. The first led to the Theory of Relativity, and the second to Quantum Mechanics. Individually as well as collectively, these two developments demolished the Newtonian world-view - a most unexpected and sudden development of great significance not just to physicists but to humanity at large. *Even though the world of science has refused to acknowledge it*, the fact remains that these developments portend a confluence of science with spirituality. Once understood in its full essence, this confluence can enable those scientists who are now trapped in the schizophrenic 'science at work, religion at home' dilemma to integrate their theories about the nature of this world with their natural inclination to worship the Creator.

Relativity Theory, whose sole significant contributor has been Einstein, is actually a firmer pointer to the science-spirituality confluence than even Quantum Mechanics, for it deals with the illusory (Maya!!) nature of Space

and Time as we experience it. Unfortunately, it is not possible to do justice to a study of the science-spirituality confluence from the angle of both Relativity and Quantum Mechanics in this short four-day program. So, rather reluctantly, I have confined it to an examination of just one of them - Quantum Mechanics.

THE ORIGINS OF QUANTUM MECHANICS

"Anyone not shocked by quantum mechanics has not understood it" - Niels Bohr, one of the key founders of quantum mechanics

The origin of Quantum Mechanics can be traced to Max Planck's decision to go ahead with a career in physics despite the warning given by the Chairman of the Department that "all the important discoveries have already been made". He chose to work in the field of thermodynamics - and set himself the task of explaining thermal radiation, i.e., the spectrum of colours given off by bodies when heated. The fact that all material bodies 'glow' when heated is common knowledge even to the layman. Actually, some radiation is generated even at ordinary temperatures - if we bring our palm near the face, we can sense a little heat, which is the result of 'infrared' radiation. This infrared radiation has very low frequency, and so cannot be seen by the naked eye, whose perceptions are confined to the 'vibgyor' range. As any body is heated, however, it gives out radiation at higher frequencies, which becomes visible - first as red, then yellow, then blue. When continuously heated, a metal finally becomes 'white hot' - because the frequencies of radiation emanated cover the entire visible spectrum from red to violet. If and when frequency of radiation exceeds that of violet, the light emanated again goes outside of our visible range, but we experience a 'blueish' colour, as for instance the colour of the stars which are very, very hot objects.

Figure 4 (on the next page) shows the light that emanates from the sun at 6000 degree centigrade. The intensity (amount) of the light first increases as the frequency of radiation increases from red to yellow, but then tapers off as the frequency continues to increase into the ultraviolet region. This diagram is typical of all thermal radiation - an observed fact confirmed through numerous experiments

It is the job of physicists to explain such phenomena using their mathematical models which match their 'inner' world of imagination with the 'outer' world of facts. So, physicists set out in earnest to explain thermal radiation using the same mathematical model that had proved so very useful in everything else - Newton's Laws.

Figure : 4

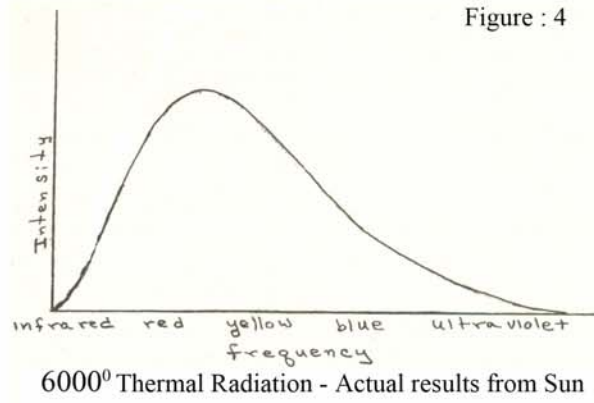


Figure - 5

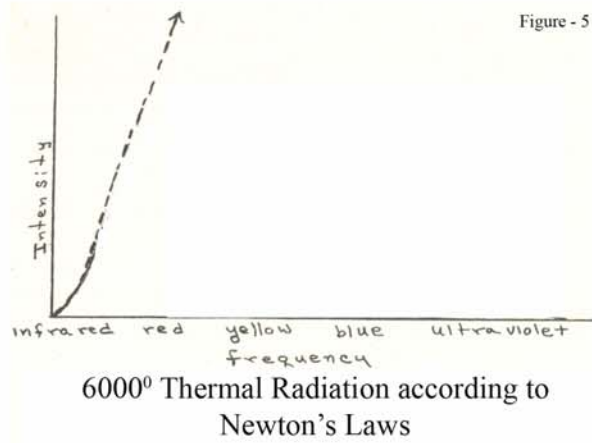


Figure : 6

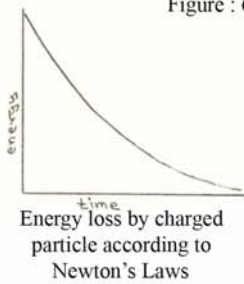
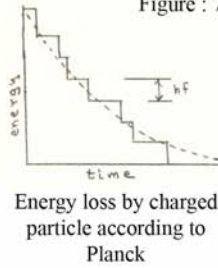
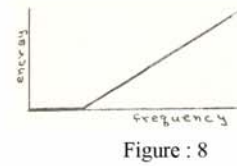


Figure : 7



Energy Of Ejected Electrons vs Light Frequency



To do so, they imagined the thermal bodies as made up of particles, each following these Laws precisely. The application of heat to any body made the particles 'jiggle', and radiation was seen as the energy by which these jiggling particles (electrons, as they came to be called) gave out energy to the outside world.

To take an analogy which constitutes our everyday experience, let us imagine a situation where we put our child on a swing, and give the swing a push. We all know what happens - the swing goes back and forth (equivalent to the jiggling of particles in a heated body), but gradually slows down as it gives off its energy to the resistance of the air. Using Newton's Laws it is possible to calculate with astonishing accuracy the exact timings and amplitude of each swing, and the total time in which the swing will eventually come to a complete halt. To put it diagrammatically, the curve that shows the decline of the swing of the pendulum will look like Figure 6.

Physicists used exactly the same notions to calculate how the jiggling of the particles inside any heated body will give out energy. They expected their calculations to lead to the actual result, as shown in Fig 4. But instead, the results led to the dotted line shown in Figure 5. Though not obvious at first sight, this is actually a ridiculous result - for it shows that the intensity (amount) of high frequency ('ultraviolet') radiation will be continuously increasing, resulting in a burst of energy which will make all heated objects cool down instantaneously! Physicists have referred to this result predicted using Newton's Laws as the "ultraviolet catastrophe", to indicate how ridiculous the prediction is.

Strictly speaking, Newton's Laws should have been abandoned when this discovery was made, for the Scientific Method is, as we have seen earlier, very strict on all Laws - one falsification, and it is to be thrown out. But no one dared to do that with Newton's Laws, it was regarded as just too sacred. Instead, physicists searched and searched for plausible explanations within the Newtonian world-view of what nature was demonstrating through the Radiation Intensity curves.

Max Planck joined this search, and found it very frustrating. Finally, driven to the wall, he did what he has termed an "act of desperation". He 'fudged' the result!

Those of us who have tried to derive a mathematical theorem through the exacting steps involved in this exact science know what 'fudging' involves. We sit in the exam hall, furiously trying to derive the theorem we have been asked to prove. We struggle, and yet we are not able to arrive at the desired result through the given method. Meanwhile, the clock is ticking away, it gets close to the time to hand over our papers, so we become desperate and decide to 'fudge' - we *know* what the result is supposed to be, so we calculate backwards, insert an additional step into the mathematical process that is not supported by the logic of mathematical rigour, but thereby arrive at our 'correct' result. It is 'an act of desperation' that we have carried out, but we sometimes do it in the fond hope that the examiner will not notice that additional step through which we 'fudged' to the correct result.

Planck did exactly that, except that there was no element of cheating involved. He calculated backwards, and showed that if a 'fudge factor' (which he called h , and which is now famously known as Planck's constant) were to be inserted into the formulae, the results will correspond exactly with what appears in nature. So, wherever there was the factor 'f' (corresponding to the frequency of the electromagnetic wave) in the formula, Planck replaced it with a factor 'hf' and arrived at the desired results.

In effect, this meant that he was replacing the smooth curve for energy loss which is shown in Fig 6 by a set of lines of the kind shown in Fig 7. That means, electrons do not lose their energy gradually, but in spurts - through 'quantum jumps' . By doing so, Planck had laid the foundation for what eventually got to be known as Quantum Theory.

But of course, Planck was totally unaware of the revolutionary potential of what he had done, and was in fact quite apologetic about his formula. The reason for his diffidence is that what he was suggesting is equivalent to saying the swing on which our child sits slows down 'in spurts' - something totally repulsive to our commonsense. True, what Planck was saying applied only to small particles, but all big things are made of small particles, right?

The credit for boldly accepting Planck's proposition as an integral part of reality goes to Albert Einstein. He did so through his 'photon hypothesis' in 1905. This hypothesis stated that all energy is absorbed or radiated through 'quanta' of light, which comes in the form of 'photons'. Figure 8 shows the graph that displays this relationship. The slope of the straight line on this graph that was derived from Einstein's formula corresponded exactly with the 'fudge factor' suggested by Planck. Therefore, he concluded that the ' h factor', as it was then called, is not just an imaginary number coined in Max Planck's brain, but an important ingredient of nature.

Einstein's suggestion was initially met "with disbelief bordering on derision". Even the physicist Robert Milikan - whose own experiments confirmed that Einstein's formula in every case produced "exactly the observed results" - termed Einstein's hypothesis "wholly untenable" and "reckless"

As Rosenblum and Kuttner point out, physicists were not being pig-headed in refusing to accept Einstein's photon hypothesis despite experimental results confirming his predictions. They had good enough reason to do so - light had been *proven* to be a "wave", for it displayed "interference patterns", so it could not be accepted as a 'particle', as demanded of the 'photon hypothesis'.

Let us spend a little time discussing what these terms - wave and interference pattern - mean.

Sound and light are common terms that all of us are familiar with, for both are easily accessible to our physical senses. In the modern scientific world-view, they are *not* physical entities, but *disturbances* caused to a physical entity. For instance, sound is a disturbance caused to air - it propagates as a 'wave' in the air medium. Therefore, if we create a vacuum, i.e., remove the air, we hear no sound. Similarly, sea waves are disturbances in the water medium.

All waves display a property called interference. That is, when two waves meet, the 'crest' of a wave can cancel the 'trough' of another wave, or the crests of two waves may reinforce each other, depending on how (in which time frame) they are traveling and where they meet. Therefore, if light is allowed to pass through two slits, as shown in Fig.9 (on next page), and we 'collect' it on a screen ahead, we see an 'interference pattern' on the screen

Double Slit Experiment To Show Interference Of Light

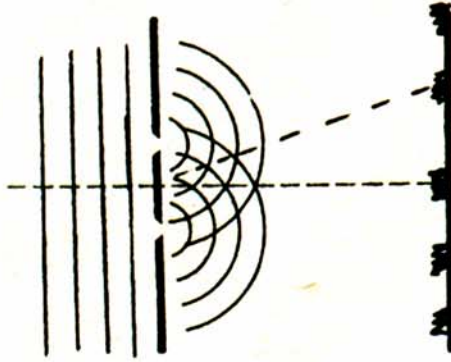


Figure : 9

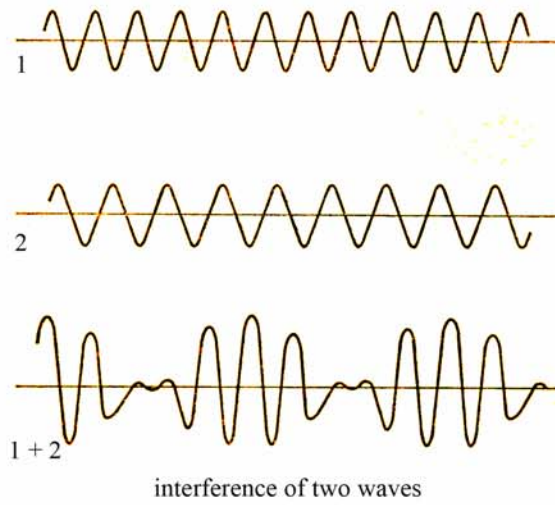


Figure : 10

- a few bright spots in between dark patches. Figure 10 gives a graphic picture of how these spots are formed. The spacing of these spots depends on the spacing between the slits - the more the slits are apart, the less will be the spacing between the bright spots. The exact pattern and intensity of these interference patterns can be predicted by physicists to an amazing degree of accuracy by using equations that describe a 'wave'.

Nearly two hundred years back, Thomas Young performed the first 'interference experiment' to show that light is a wave. Though initially derided by the physics community, this notion found its final acceptance after Maxwell formulated his famous equations which explained all electromagnetic phenomena in a comprehensive way through equations that had 'wave' characteristics.

Since then, the notion of light as a wave had got so entrenched in the physicist's mind that it was not easy for them to adjust to what Einstein was suggesting - the notion of light as a particle was just not possible to include in their world-view, the 'paradigm' through which they viewed reality.

We know that sea waves are a disturbance of the water medium, and sound waves are a disturbance of the air medium. But what is the medium that gets disturbed by the propagation of light waves? For a long time, physicists assumed that there is a very subtle form of matter that pervades all of space through which this propagation takes place, and because of its ethereal nature, it was called 'ether'. The Michelson-Morley experiments were performed to measure the speed of earth in the 'ether' medium, and because this speed was found to be nil, physicists eventually discarded the idea of ether and instead accepted the Theory of Relativity as propounded by Einstein.

But acceptance of what Einstein was suggesting did not come easily, even to physicists supposedly open-minded to new and revolutionary ideas. As Einstein's biographer puts it, "From 1905 to 1923, [Einstein] was a man apart in being the only one, or almost the only one, to take the light-quantum seriously." Light, claimed all the other physicists, displayed the interference pattern, so it *had* to be a wave. Einstein never disputed this fact, but insisted that a mystery existed in nature which enabled light to behave *both* as a wave *and* as a particle. This mystery has actually deepened with the

passage of time and performance of more and new experiments, and forms the core of the 'quantum enigma'.

In the years 1923-25, 'quantum theory' as we know it today finally got accepted in the world of physics, because de Broglie's experiments showed that *even particles can display an interference pattern*, and Schroedinger developed a set of equations that explained these results *and* enabled accurate predictions of results for all sub-atomic experiments and phenomena. These equations have been verified countless times through elaborate experiments, and all attempts to falsify them have so far failed miserably. Therefore, they have *replaced* Newton's Laws as the correct mathematical model of reality, with Planck's original 'fudge factor' now given the most honorific status of a 'fundamental constant of nature', on par with Newton's famous 'gravitational constant'..

So, does this mean Newton's equations are no longer seen as a correct description of nature? Well, they are 'good enough approximations' when we are dealing with large objects. Schroedinger's Equations, which are much more complex than Newton's, approximate Newton's when the mass of the objects we are studying is large, and as Newton's equations are much easier to deal with, they are the ones still used when large objects are being studied. It is like a crorepati calculating his assets - he can ignore the paise in his calculation, he can even round off to the nearest thousand. The figure he will arrive at is, strictly speaking, not the correct amount of his assets (in a balance sheet, for instance, this could result in irresolvable complications), but 'for all practical purposes' the figure he has arrived at is good enough. It is in this spirit that physicists continue to use Newton's Laws these days. But just as a beggar cannot afford to ignore paises while calculating *his* assets, so also physicists cannot ignore Schroedinger's Equations when dealing with small particles. These equations are the new Universal Laws of motion, and have actually replaced the earlier Newton's Laws.

And the fact is that what they are telling us about the nature of the universe we reside in is not only very different from the earlier Newtonian world-view, it is very different from all our 'common sense' ideas and experiences of the world. As J.B.S.Haldane put it, this world-view is not only queerer than we suppose, but queerer than we *can* suppose. To see how 'crazy' these ideas are, let us take a careful look at two chapters from

Rosenblum & Kuttner's book "Quantum Enigma". The first one, titled "The Visit to Neg Ahne Poc", is an imaginary journey to a land where human beings obey the same laws that electrons do; the other, titled "Our skeleton in the closet" is a description of actual experiments performed by physicists in the laboratories. Let us now try to understand the world-view conveyed in Quantum Mechanics by spending some time reading these two chapters very, very carefully.

I stress "very, very carefully", because when we come across something which is at variance with what we take for granted, the tendency is to either dismiss it as 'stupid' or to gloss over it, saying 'of course I understand what you are saying, it is not all that great'.

But the fact is that we have NOT understood the world-view of Quantum Mechanics unless and until, as Niels Bohr has emphasized, we are "shocked" by its conclusions. So, please keep reading these two chapters again and again and again until you are sufficiently shocked.

What kind of a shock? Suppose, while I am talking here at the blackboard, you were to slip out quietly and go to the kitchen building. And suppose you find me there. You would be taken aback, wouldn't you be? Just to check, if you came back here and still found me talking at the blackboard, how would you feel? Just to be sure of what you are seeing, if you ran back and forth between the kitchen and this home, at a pace you know I cannot very well match because of my age, and you *still* found me in both places, would you not be truly and fully shocked?

That is the kind of shock the pioneers of quantum physics experienced as a result of their experiments. You, I or anybody can repeat those experiments, and we will get the same result - it has been done millions of times by a variety of people, and the results have always been the same.

So then, why aren't all the physicists and electronic engineers who do these experiments day in and day out perpetually in a state of shock? Unfortunately, mathematics can also be used for *shielding* us from such shocks. If we immerse ourselves in mathematics without bothering about what our equations mean in reality, we insulate ourselves from picturing what is happening, and thereby avoid feeling the shocks - that is what most

quantum physicists tend to do. Rosenblum and Kuttner are among those brave physicists who decided not to fall a prey to this intellectual slumber. During the earlier part of their career, when they were fully immersed in applying quantum mechanics in their work as researchers, they asked their seniors what their equations *meant*, and have summarized the replies they got as "Shut up and calculate!" They opted not to shut up, but to go deeper into the subject, and have now designed a course for physicists *as well as non-physicists* which digs deep into the world-view that emanates from quantum mechanics. They have now written a book titled "Quantum Enigma: Physics Encounters Consciousness" based on the contents of this course, The opening lines of this book state:

"This is a controversial book. But nothing we say about quantum mechanics is controversial. The experimental results we report and our explanation of them with quantum theory are completely undisputed. It is the mystery these results imply *beyond* physics that is hotly disputed. For many physicists, this mystery, the quantum enigma, is best not talked about. It displays physics' encounter with consciousness. It is the skeleton in our closet."

What is remarkable about this book is that the essence of quantum mechanics is presented without any resort to mathematics or complicated intellectualizations. Reason - the book is addressed not just to physicists but to non-physicists too, for the authors believe the best insights to resolve the quantum enigma may well come from someone who is not already entrenched in the established paradigms of modern science. As they put it:

"The quantum enigma has challenged physicists for eight decades. Is it possible that critical clues lie outside the expertise of physicists? Remarkably, the enigma can be presented essentially full-blown without much physics background. Might someone unencumbered by years of training in the *use* of quantum theory have a new insight? After all, it was a child who pointed out that the emperor wore no clothes."

Not surprisingly, other physicists are alarmed at revealing their 'skeleton in the cupboard' to those outside their discipline. One of their colleagues objected to their book in the following words:

"Though what you are saying is correct, presenting this material to nonscientists is the intellectual equivalent of allowing children to play with loaded guns."

The intention of this four-day program is to enable you to discover that, indeed, the emperor has no clothes - and, then, to play around with loaded guns in a childlike way. But the fundamental prerequisite for developing this ability is that you *MUST feel* the shock of what the world-view of quantum mechanics is revealing. There is no point in proceeding further until all of you have really internalized that feeling of shock. Therefore, we will now spend as much time as is necessary to delve deep into those two chapters of Rosenblum and Kuttner's book, and keep discussing its implications until the shock is really and truly felt.

xxxxx

"As a man who has devoted his whole life to the most clear-headed science, to the study of matter, I can tell you as the result of my research about the atoms, this much:

"There is no matter as such.

"All matter originates and exists only by virtue of a force which brings the particles of an atom to vibration and holds this most minute solar system of the atom together...We must assume behind this force the existence of a conscious and intelligent Mind. This Mind is the matrix of all matter."

---- Max Planck

THE SHOCKING REVELATIONS

"Nothing is more important about the quantum principle than this, that it destroys the concept of the world as 'sitting out there' "-
Wheeler

"We have reversed the usual classical notion that the independent 'elementary parts' of the world are the fundamental reality" - Robert Oppenheimer

What makes Rosenblum and Kuttner's book "Quantum Enigma" so special is that it deals with the enigma without going into the equations or intrinsic details of quantum theory. Instead, they focus on the **experimental revelations** which, we must never forget, remain valid *even if Schroedinger's Equations or the whole of quantum theory is dethroned in science*. In other words, what we are dealing with are the brute facts revealed by nature, which have nothing to do with any theory or even with science itself.

The first and most important brute fact that comes out is: *our observation creates reality*. This is *not* the same as the psychological or social meaning with which this phrase is sometimes associated. It refers to physical reality, the so-called 'solid' world - this chair, that table, this blackboard etc - with which we deal everyday and take for granted as an objective, real thing. Isn't it shocking to be told through these experiments that the chair, table and blackboard exist *only* because we observe them?

Their chapter titled "Visit to Neg Ahne Poc" (Copenhagen spelt backwards) is a description of this 'reality creation' involving human beings. This is an imaginary conjecture, for no quantum effects have ever been tested with respect to human beings or any other 'macro' objects. Of course, we must never forget that all macro objects are made up of micro particles, and so if these effects are valid at the micro level, would they not also be valid at the macro level? In any case, illustrating the point with an example involving human beings does help to convey the shocking nature of what is being revealed.

The other chapter titled "Our skeleton in the closet" deals with experimental results *actually* witnessed in our laboratories. Here, the essence of the quantum enigma is conveyed through proven facts which any of us can test out for ourselves if we so desire. Such testing has been done at the level of subatomic particles not once but millions of times, and gradually the size of the particles for which it is being tested has been on the increase - budget and technology being the only constraints that prevent it from being shown as valid for bigger and bigger objects.

Essentially, what these experiments reveal is - if you were to drop an object in one of two boxes, randomly, and then look into them at any point of time, you will find the object in one of the two, the other being empty. Anyone else looking will also find it in the same box. Up to this point, the experimental revelations correspond with our 'common sense'. However, if this dropping can be done *without us or anyone else observing it*, it is present *simultaneously in both boxes*. Further, if one of us were to choose to open one of the boxes to see if it is present or not, we will see it either as present or absent in that box and the reverse in the other, and *once* we have done that (but not before), all others who will look will see the same as we did - it will no longer be present simultaneously in both boxes. Even more weird - depending upon *how* we choose to look at it, the objects arrange themselves to be present in one box or both!

Quantum mechanics enters the picture only to explain these seemingly weird experimental observations mathematically, and by doing so gives us means by which to predict the behaviour of these 'small objects' (sub-atomic particles). This is done through the powerful language of mathematics. Using these mathematical equations, first formulated by Schroedinger, one can make as accurate a forecast about the behaviour of these small objects as one could do earlier about the behaviour of large objects using Newton's equations. Physicists and electronic engineers have done so by the millions, and we owe our PCs, telecommunication networks, internet, lasers, MRI etc. to these predictive calculations. Like Newton's Laws in the earlier days, the success of Schroedinger's Equations is nothing short of astounding, and has contributed enormously to the lives of human beings.

But while doing these intricate calculations, it is easy to gloss over the *meaning* of the mathematical equations. It is a bit like the Sanskrit *mantras*

that the *sadhu* utters when a villager goes to him for curing a snakebite - nobody asks him to explain the meaning of the words or how it is effective in saving the patient, they are just happy that the snake venom has been neutralized. Most *sadhus* also never bother about taking the trouble to learn the meaning, but if they were to do so from a truly realized *mahatma*, their ability to help others would increase a million-fold. Similarly, if what Rosenblum and Kuttner are suggesting is taken seriously, the ability of Quantum Mechanics to help humanity will increase by leaps and bounds, though the form this may take may involve spiritual and altruistic, rather than material, pursuits.

Central to the quantum enigma is the role of Probability Theory, which occupies an important part in the mathematics of quantum mechanics. This is a branch of mathematics which deals with uncertainty. The Professor from whom I first learnt this subject introduced it in the following words:

"The only thing that is certain in this world is that nothing is certain, and even that is a little bit uncertain."

Every human being is aware of the role of uncertainty in this world, whether or not he has mastered the mathematics of Probability Theory. This Theory was developed by mathematicians long before Quantum Mechanics entered the picture. The physicists who were struggling to unravel the mysteries of sub-atomic particles have merely used what was already existing to great advantage. But it is important to bear in mind that the meaning of the words 'uncertainty' and 'probability' when used in quantum mechanics are very, very different from what we normally imagine them to be.

Let me illustrate that with an example. But first, a joke - to make the atmosphere less serious!

There is this man who is about to go in for a major surgery. He is, understandably, very nervous. So, the doctor comes to him and reassures him, saying:

"You have nothing to worry about. Here, read this research paper - it tells you that eminent statisticians have done elaborate research work on the success rate of this particular operation. Using the sophisticated

mathematics of Probability Theory, they have arrived at the firm conclusion that the chances of fatality in this operation is only 0.0001%. This means that out of every million patients who go through this surgery, only one dies. In your case, therefore, you have absolutely nothing to worry about, because I have done this operation only once, and that patient died, so the next 9,99,999 can come under my knife without anything to fear ..."

The above humorous piece illustrates a very important point about 'probability' the way it is ordinarily understood - the occurrence of an event does not alter the probability of the event recurring. To put it in a simple way, even if ten tosses of my coin were to all end up as heads, the probability of heads coming up after that is still 50%.

In Quantum Mechanics, however, the meaning of the word 'probability' takes on an entirely different connotation. It says - the event *does not occur at all* until someone 'observes' it, at which point there is a fixed probability of a particular result, and that result will in turn *determine the past!* Thus, probability as used in quantum mechanics is not "stochastic" as in its ordinary usage, but in a sense "deterministic" - which is a contradiction in terms, and so makes an understanding of it mind-boggling, to say the least.

Let us say the doctor performs the operation on the patient, and does it in such a way that no observation of any kind takes place (not possible in any practical situation, but for the sake of understanding QM let us make that assumption any way). As no one has observed if the patient is dead or alive, the ordinary interpretation of probability theory tells us there is one in a million chance that he is dead. What Quantum Theory tells us is - no, he is in a 'state of superposition', *both dead and alive* (in the form of a 'wavefunction', which is the only reality), until someone were to observe him, at which point of time there is a one in million chance that he will be found dead. And once anyone has found him either dead or alive, all others will find him in that very state (for, the Theory explains, the 'wavefunction collapses once an observation is performed'). Even more weird, if the observation were to take place, say, a week after the operation was performed, and the patient were to be found dead (for which there is a 0.0001% probability), an autopsy would reveal that he was dead for 7 days, whereas if he were found alive (for which there is a 99.999% probability), all his body functions would have operated for that one week exactly the way a live man's should - in other

words, the history of the man is also *created* by that act of observation, i.e., time is made to work *backwards*.

It may be worth noting at this point that the possibility of time going backwards also appears in Einstein's Relativity Theory, as conveyed by that famous limerick:

There was a young lady named Bright,
Who could travel faster than light;
She went out one day,
In a sort of relative way.
And came back the previous night.

The above is not just a joke but a very *serious* prediction of Einstein's theories. Its physical verification, of course, has to await a lady who can travel faster than light! One big difference between the weird predictions of Relativity and Quantum Mechanics is that those of the latter are much more easily verifiable, as they relate to the here and now, to the world immediately around us, with which we deal with on a day to day basis, and around which experiments can be performed much more easily, principally because all waves display interference patterns, and these can be used to collect data about things that have not yet been subject to observation. Unfortunately for Relativity Theory, which deals with the seemingly abstract concepts of space and time, its predictions are not so easily verifiable at the 'here and now' level.

When physicists first dismissed Einstein's 'photon hypothesis', they pointed to the interference properties of light as proof that light was a wave, not a particle. Einstein did not dispute this, but pointed out that a mystery exists in nature. This mystery has now been extended beyond mere light to all material phenomena, which can behave either as a particle or as a wave. It is this seeming contradiction that gives rise to the quantum enigma. The cause for this contradiction was a mystery then, and continues to be a mystery even now. Rosenblum and Kuttner convey this in the following words:

"Though the quantum enigma has confronted physics for eight decades, it remains unresolved. It may well be that the particular expertise and talents of physicists do not uniquely qualify us for its comprehension. We physicists

might therefore approach the problem with modesty - though we find that hard."

It is not just physicists who find it hard to be modest these days. Humility is seen in the modern world as the certain road to ruin - we become a door mat for others to walk over us. So, we are taught from a young age to be assertive, if not aggressive, and to defend anything that is 'ours' - be it ego, family, religion, nation, tradition - irrespective of the rights or wrongs of the case. However much we might pretend to be objective, however powerful the arguments we cook up to defend 'our' case, real objectivity is not possible without real humility.

But there exists, and have always existed, a class of human beings who have made real humility their goal in life. Real humility is actually an extraordinarily difficult goal to strive for. Anyone who feels that he or she is humble, is not!! Therefore, real humility has to be sought not at the level of thought or mind, but at a deeper level. It involves a process by which we learn to 'still' the mind, and eventually rise above it. This process is called 'dying while living'. It should not be mistaken for a drop in our level of activity or interest, but, on the contrary, results in an extraordinary level of energy, enthusiasm and attention. Freeing ourselves from "personal hopes and desires", to use Einstein's words from the earlier quote, releases tremendous energy which till then had been caught up in worrying, scheming and planning. It also puts us in touch with an extraordinary truth - that the mind, by itself, is totally incapable of doing anything - it can create desires, but it does not have the power to fulfill them. It is somewhat like the sobering truth we momentarily realize when a near and dear one suddenly collapses and dies - we are seeing the same body we saw a few minutes back, but at that time the body was capable of walking, running, eating, laughing, etc. - and we realize that there was something *within but beyond* the body which made it do all those things. A similar realization about the mind comes about when we learn to 'die while living' - that the mind, by itself, is totally incapable of anything. It is, in fact, as inert as matter. That is real 'self-realization', and produces true humility. Once this narrow self steps out of the way of our perception, we see the Truth, as Buddha's earlier quote conveyed.

In their book, Rosenblum and Kuttner have often referred to Quantum Mechanics's conclusions as "sounding like mysticism". I do not know what they had in mind when they used word 'mysticism'. But in the spiritual traditions of the world, there have been many eminent personalities who have made overcoming the 'self' as the goal of their lives, and are generally known as 'mystics'. Buddha, Lao Tzu and Christ are examples of mystics of the distant past. More recently, there have been Kabir, Nanak, Tukaram and Namdev in India, and Moulana Rumi and Shamz-Tabriz in the Islamic tradition, Sarmad in the Jewish tradition, and Michael Naimy in the Christian tradition. India in particular has a rich culture of mysticism, and several really advanced and realized souls may be found even today. All these mystics represent a class of people who have gone beyond the narrow confines of the 'self'. Let us now take a look at how their world-view can help explain the quantum enigma.

Xxxxxx

"Make no mistake.
Love is not just a feeling
Or euphoric state.
These may follow,
Allowing love
To be a most pleasurable experience.
But for the most part,
Love is a minute to minute decision
To put self,
With all its interests,
Second.
To those of the one
We have committed to love.
Like the weather which fluctuates,
The experience is not always
Pleasant, sunny and warm.
Oftentimes
It's hard to walk in the rain."

- Moira Johnson

WORLD-VIEW OF THE SPIRITUAL SEERS

"Scientists are inclined to take their own outlook for the natural way of looking at things, while the outlook of others, inasmuch as they differ from theirs, are adulterated by preconceived and unwarranted philosophical tenets, which unprejudiced science must avoid." - Erwin Schroedinger

"The most beautiful experience we can have is the mystical. It is the fundamental emotion which stands at the cradle of true art and true science." - Albert Einstein

At the outset, we noted a limitation of the Scientific Method as practiced at present - that the Principle of Objectivity, though a laudable goal, is never achieved, because the narrow 'self' always clouds our view. Mystics (who, by definition, are totally selfless by dint of their having got rid of slavery to the sense of 'I'-ness, and have therefore replaced the narrow self by the real, eternal Self and thereby merged into God) are the only human beings who are therefore able to view this world in a totally objective manner. However, that does not mean that others cannot do so. This option is available to *any* human being, provided that he or she is willing to perform the same experiments in the inner realms that the mystics have done. *Like in science, their experiments are always reproducible, and anyone who does so will arrive at the one and only answer.*

Erwin Schroedinger has made a reference to this in the following words:

"The only possible inference from [my efforts to integrate biology with my quantum physics] is, I think, that I - I in the widest meaning of the word, that is to say, every conscious mind that has ever said or felt "I" - am the person, if any, who controls the "motions of the atoms" according to the Laws of Nature.

"Within a cultural milieu ('Kultukreis') where certain conceptions (which once had or still have a wider meaning amongst other peoples) have been limited

and specialized, it is daring to give to this conclusion the simple wording that it requires. In Christian terminology to say 'Hence I am God Almighty' sounds both blasphemous and lunatic. But please disregard these connotations for the moment and consider whether the above inference is not the closest a biologist can get to proving God and immortality at one stroke.

" In itself, the insight is not new. The earliest records, to my knowledge, date back some 2500 years or more. From the early great Upanishads the recognition ATMAN=BRAHMAN (the personal self equals the omnipresent, all-comprehending eternal self) was in Indian thought considered, far from being blasphemous, to represent the quintessence of deepest insight into the happenings of the world. The striving of all the scholars of Vedanta was, after having learnt to pronounce with their lips, really to assimilate in their minds this grandest of all thoughts.

"Again, the mystics of many centuries, independently, yet in perfect harmony with each other (somewhat like the particles in an ideal gas) have described, each of them, the unique experience of his or her life in terms that can be condensed in the phrase: DEUS FACTUS SUM (I have become God).

"Allow me a few further comments. Consciousness is never experienced in the plural, only in the singular... Consciousness is a singular of which the plural is unknown...there is only one thing and that, what seems to be plurality, is merely a series of different aspects of this one thing, produced by a deception (the Indian MAYA). The same illusion is produced in a gallery of mirrors, and in the same way Gaurishanker and Mt Everest turned out to be the same peak, seen from different valleys."

Yes, this is the *same* Schroedinger speaking whose Equations are accepted today as the Universal Laws of motion, whose name is well-known even to non-scientists. Yet, how many have heard of or read about or contemplated on what Schroedinger had to say in the above paragraphs? How many know that Schroedinger was an ardent student of Vedanta?

Rosenblum and Kuttner describe the occasion when Schroedinger had his 'brainwave' that resulted in the new Universal Laws of Motion thus: "The breakthrough came during a mountain vacation...To aid his concentration, Schroedinger brought with him two pearls to keep noise out of his ears.

Exactly what noise he wished to avoid is not clear." Could it be that Schroedinger was trying out something similar to the mystical process for accessing the inner realities, a process described by Lao Tzu thus:

Close thou the gates and doors [of your body]
Soften the brilliant lights
Turn noise into Silence
And behold the wonder of One-ness.

Could it be that Schroedinger's insight linking quantum mechanics with the experience of the mystics arose from an inner insight which formed the basis of his famous Equations in the first place? His reference to the Indian concept of *Maya* gives credence to such an assumption. *Maya* is often translated as 'illusion', but that can give rise to misunderstanding - that this world is totally unreal. In a sense, yes, mystics do look upon this world as unreal, but they also emphasize that while going through the experience of this world it is no use pretending that it is unreal. While dreaming, the dream *is* the reality - it is only when we wake up that it ceases to be reality.

To help understand this and relate it to the 'wave-particle duality' concept so central to Quantum Mechanics, it may help to divide reality into two parts - the visible and the invisible. So long as our consciousness is confined to the physical body, our vision (direct perception) is confined to material bodies - the particle aspect of reality. We *know* (through indirect perception) that there do exist phenomena outside of the visible range - cosmic rays, radio waves etc - but we also assume that these can never be observed through direct perception. In the Newtonian world-view, the attempt is to explain the invisible through the visible - and this extends not just to physical reality but even to mind and life. As Feynman has said at the start of his famous "Lectures in Physics":

"Everything is made of atoms. That is the key hypothesis. The most important hypothesis in all of biology, for example, is that everything that animals do, atoms do. In other words, there is nothing that living things do that cannot be understood from the point of view that they are made of atoms acting according to the laws of physics."

Francis Crick, the Nobel Prize winner regarded as the father of modern biology and co-author of the Double Helix theory, has also echoed this percept:

"The aim of the modern movement in biology is in fact to explain *all* biology in terms of physics and chemistry."

This way of perceiving the world has led to a 'nothing but' attitude among the scientific community - thus, sound (including music) is 'nothing but' a disturbance in air (provoking Einstein to deridingly refer to it as 'reproducing Beethoven's Ninth Symphony in the form of an air pressure curve'), and the most important thing we have, life, is 'nothing but' a collection of RNA and DNA molecules. Everything that is invisible is sought to be explained (and, often, explained away) by the visible. It is because of this attitude that quantum experiments result in a seemingly unsolvable enigma.

Mystics have developed the ability to *see* the invisible, and therefore are sometimes referred to as 'seers'. Based upon this direct perception of the life force that keeps us alive, they assert that the opposite of what is assumed in the Newtonian world-view is true - that *it is the invisible that gives rise to the visible*, not the other way round.

At the sub-atomic level, it would translate into: wave is primary, particle is not. The quantum enigma arises because we think of particle as primary, and wonder how it can be present simultaneously in two places, or how it can effect the behaviour of another particle far away instantaneously. These thought patterns arise in us, in turn, because we see ourselves as physical bodies, and ignore the invisible or wave aspect of our existence.

To the mystical way of thinking, the quantum experimental results do not present an enigma because of the recognition that our real self is not the body, not even the mind, but a life force. Moreover, when seen from the angle of this life force, *all living beings are one*, connected together as members of one single body. Schroedinger has made a reference to this fundamental truth in the earlier quote wherein he says: "Consciousness is never experienced in the plural, only in the singular... Consciousness is a singular of which the plural is unknown...there is only one thing and that,

what seems to be plurality, is merely a series of different aspects of this one thing, produced by a deception (the Indian MAYA)"

Another scientist of great repute, James Jeans, has conveyed the same thing in simpler language:

"As it is with light and electricity, so it may be with life; the phenomena may be individuals carrying on separate existences in space and time, while in the deeper reality beyond space and time we may all be members of one body."

Mystics emphasize that the above reality has to be *experienced*, each one for himself or herself. There is no use merely talking about it. As Lao Tzu put it:

"The Tao that can be told is not the eternal Tao;
If it could be told, everybody would have told his brother.
He who knows, telleth not.
He who tells, knoweth not."

Thiruvalluvar, the well-known saint of South India has said the same thing using almost exactly the same words, but expressed in the classical Tamil language:

कण्डिवर विण्डीलर
विण्डिवर कण्डीलर

So did Kabir, as conveyed by his famous lines:

पोथी पढि पढि जग मुआ, पन्डित भया न कोय
ढाई अक्खर प्रेम का, पदे सो पन्डित होय

How to experience it? As Kabir has pointed out above, it is through love - when our love becomes really pure and unselfish, when we think only of the other and never of ourselves, that is when the 'I' ness leaves us, and we achieve real objectivity. Along with it, comes the enhancement of direct perception. In fact, as Kabir has explained, the level of consciousness that

we attain when we really develop perfect love by the process of fully and completely stilling ourselves is impossible to even imagine at this level of consciousness:

तन स्थिर, मन स्थिर, बचन स्थिर, सुरत निरत स्थिर होय

कह कबीर इस पलक को, कलप न पावे कोय

Christ conveyed the same thing when he said: "Be still and know that you are God", which he also, like Kabir, equated with Love.

The God that mystics speak of is not someone sitting 'out there' in the heavens. It is a Power that is *within* each of us, manifesting itself as our life. Therefore, it is 'immanent' - within every particle. It is also 'transcendent' - beyond the senses and the intellect. Mystics have learnt to rise above the senses and intellect through the development of unalloyed love, and are ever willing to teach others to do so too. This education in pure, unselfish love leads to the best use of our life on earth. As Michael Niemy has explained in the *Book of Mirdad*:

"Love is the Law of God. You live that you may learn to love. You love that you may learn to live. No other lesson is required of Man. And what is it to love but for the lover to absorb forever the beloved so that the twain be one?"

We are sent into this world of illusion so that we may learn to love. But then how come so few of us attempt to do so? Why is there so much violence, hatred, jealousy etc. in this world?

Mystics explain that the Creator being all love, he never forces anything on anybody. So, if our inclination is towards violence, hatred, jealousy etc., he creates a world (or, rather, our own propensities create a world) where we can dwell in impurities these to our hearts' content. This physical world has been created just for this purpose. But it is not reality, it is deception wherein we see ourselves as 'bound' to a body, and mistake the particle existence as real existence. If and when we learn to love, we 'wake up' to the true reality, which is beyond Time and Space, beyond all constraints. Thus, the lesson of true Love is taught to us by creating a world that seems real to us, but is actually unreal. To illustrate with an example: when our child insists

on putting his finger into the fire of a candle, we forcibly prevent him from doing so. We have saved him from harm, but at the same time we have not really eliminated his desire to put his finger into the fire. If we really want to eliminate that desire, the best course would be to allow him to play with the fire. As this would result in a terrible harm to him, we have no choice but to intervene and forcibly take him away. But *suppose* we had a way of giving the child an artificial body which *he thinks* is his only one, but which we know is a temporary and unreal one. Then, we can safely allow him to burn his finger, learn the lesson well, and yet not be harmed in any way, for at the end of the experience through which he has learnt his lesson we can restore his real body to him. That is precisely what, the mystics tell us, the Creator is doing to us.

This gives an insight to the 'don't we have free will' question which often takes on a perplexing role in the quantum enigma, as pointed out on pages 21 and 94 of Rosenblum and Kuttner's book. To understand how mystics look at this issue, let us imagine a Coach who is trying to train a young man in how to face fast bowlers. As part of the training, the Coach first bowls two really fast balls at him, both well-pitched and aiming for the off stump. The young man sees the ball well, and blocks both. Then, the Coach cleverly bowls the next one in a similar way, but makes it seam to the offside. The young man again tries to block the ball, gets an outer edge, and is nicely caught at the slips. He curses himself for doing such a stupid thing, for he assumes he had the free will to have lifted his bat away from the ball. The Coach, however, smiles and continues with his coaching - for he knows the young man had no free will, he was ensnared into the trap. He also knows that as the young man matures he will eventually develop the skill to distinguish between the different deliveries bowled at him, at which point of time he will have real free will to decide whether to block the ball aimed at the off stump or to keep his bat raised. What he now has is apparent free will, but actually it is no free will at all.

Mystics tell us that the relation between us and the Creator is analogous to that of the young trainee batsman and the Coach. At this stage in our evolution, we *think* we have free will, and it is necessary for us to think so for the great game of Life to proceed. But actually we have no real free will, only an apparent free will. Using it, we play the game of this creation, which involves a false body which we take as real. It is only when we eventually

take our consciousness to levels beyond the finite, 'particle' notion of the body to the infinite, 'wave' notion of reality, that we develop real free will. There are different *levels* to which we can develop, each characterized by a level of Love, and each corresponding to a level of Infinity.

Therefore, when the GROPE member on p. 94 of Rosenblum and Kuttner's book insists ' We're conscious human beings, we have free will, we could have made the other choice', what he is saying is true - but only at the 'particle' level of consciousness. From the perspective of the higher ('wave') level of consciousness, it does not hold true. The mistake we are making is to confuse levels - trying to understand what is happening at the wave level without rising to that level, but instead confining our consciousness to the particle level.

This is not the place to dwell too much into the details of the mystical world-view, for our focus is the quantum enigma. We are examining the mystical world-view only because it gives a hint as to how the enigma may eventually be overcome.

Of course, as the enigma belongs to the world of physics, it will eventually have to be resolved in the language of physics - i.e., mathematics. Physicists are never comfortable with poetry, parables and such other means that have been traditionally used by mystics. Physicists, as a community, are unlikely to settle for anything other than mathematics, especially because of its predictive powers. Therefore, let us now give some thought to how the mystical world-view may eventually get expressed in terms of mathematics.

Xxxxxxxxxx

"For a convinced physicist, the distinction between past, present and future is an illusion, though a stubborn one." - Albert Einstein

MATHEMATICS AND INFINITY

"To see a world in a grain of sand,
And a heaven in a wild flower,
Hold infinity in the palm of your hand,
And eternity in an hour." - William Blake

"Poets," declared Richard Feynman, the eminent physicist, in his famous Lectures in Physics, "do not write to be understood". What he was referring to was the seeming lack of logic in poetry - how can the entire world, whose dimensions are so huge, be contained in a grain of sand, whose diameter is less than a millimeter? How can infinity, which is 'endless', be held in anyone's palm, which is so very limited in size? How can eternity, which represents an infinite number of hours, be contained in just one single hour?

Referring to the scientific standing of the same Feynman, Rosenblum and Kuttner say:

" According to Richard Feynman, who understood quantum mechanics as well as anyone ever did: 'Nobody understands quantum mechanics'."

Could it be that physicists are not able to understand the deeper message of quantum mechanics *precisely* because they cannot understand poets?

Poets of the highest order, like Blake, are sometimes in communion with infinity - just the way mystics *always* are. Mathematics, on the other hand, keeps infinity out of its bounds. Could, then, the quantum enigma find its ultimate resolution in a new Mathematics of Infinity?

The first step in this direction has already been taken by the Hungarian mathematician Georg Cantor. He has worked out three 'levels' of infinity, as follows:

1. The total number of numbers in *any* arithmetic series.
2. The number of points in *any* line.
3. The number of all geometrical curves.

The first refers to *all* arithmetic and geometric 'progressions'. This means, for instance, that the number of numbers in the infinite series of odd numbers (1,3,5,7, and so on to infinity) is the *same* as the number of numbers in the infinite series of total numbers (1,2,3,4, and so on). This seems to conflict with our 'common sense' perceptions, which tells us that the first must be less than the second, for the first series excludes half the numbers contained in the second. Well, infinity *is* a concept beyond the powers of the ordinary intellect.

But more interesting and 'stranger' things follow. The number of points in the line shown below

Is the *same* as the number of points in the line shown below

In other words, the number of points in any line, *irrespective* of its length, is the same. Even more bizarre, this number (of points in any line) is *infinitely higher* than the infinity that represents the total number of all integers (i.e., arithmetic progressions like 1,3,5,7 and so on). In other words, these represent two different *levels* of infinity. There is a third level too, that Georg Cantor identified - the number of all geometric curves. What he has put forward represent the first three steps - the equivalent of '1,2,3' in ordinary arithmetic - of what will eventually emerge as the Mathematics of Infinity, which has not even reached the nascent stage as yet.

Georg Cantor presented rigorous mathematical proofs of his contentions. This is not the place to go into the details of these proofs, but it is worth noting that:

1. These concepts of infinity baffle the ordinary imagination, just the way quantum mechanics does.
2. They correspond to the notion of reality spelt out in the yogic scriptures.

The yogic scriptures refer to reality as 'microcosms that contain the macrocosm'. In other words, the universe we see around is not so much 'out there' as 'in here' - each one of us contains the entire universe!! What seems 'out there' is Maya - a reflection of a reality that is actually *inside* of us. *Anyone* can verify this provided he or she goes *inside* - by stilling the mind, which opens the gates to the 'mansions' within, as referred to by Christ and other mystics. There are *levels* of mansions revealed inside, depending on the level of stillness of the mind acquired. Each level corresponds to a yogic *charka* - energy centres that create and sustain the outward (physical) universe. These energy centres (waves) are primary, the physical world (particles) are secondary, arising out of the 'invisible' realms. The first four energy centres are the source of the solid, liquid, plasmic and gaseous aspects of physical reality. They are referred to in Sanskrit as Muladhar charka, Indri or Svadasthan charka, Manipurak charka, and Hriday charka, respectively, and the deities like Ganesh, Indira etc many Indians worship are actually a reference to these powers *within* each of us.

This is not the place to go into details of the mystic cosmology, but those interested can look into the chapter "The Microcosm and the Macrocosm - the Subtle Constitution of Man" in John Davidson's book "Subtle Energy". What is of importance from the point of view of our speculations regarding the possible emergence of a Mathematics of Infinity is that *each charka or energy center is on the one hand the fountainhead of a form of matter (solid, liquid, plasmic, gaseous) and on the other hand it also in turn corresponds to a particular level of infinity.*

Thus, a Mathematics of Infinity is not just a reference to something abstruse, but would lead to an explanation of *physical* phenomena (things that are finite, measurable). It is also worth noting at this point that the Upanishadic chant 'Purna madaha' so popular among us Indians is a way of explaining worldly reality in terms of the Whole which constitutes our real Self, and whose properties correspond to that of Infinity, as evident from Vinoba's excellent rendering of this chant into Hindi:

पुर्ण है यह, पुर्ण है वह, पुर्ण से निष्पन्न होता पुर्ण है
पुर्ण मे से पुर्ण को यदि ले निकाल, शेष तब भी पुर्ण ही रहता सदा

Basically, all infinite series can be divided into two categories - convergent and divergent. When they converge, they refer to reality at the lower levels, and thus become useful in dealing with day-to-day problems of this world. When they diverge, they refer to reality at the higher levels, and so become pointers to the higher spiritual truth which constitutes our real Self. Thus, all convergent infinite series can prove very useful in practical problems of day-to-day living. To some extent, this has already happened in the world of science. - Calculus (which deals with 'infinitesimals') and Bernoulli numbers (which deal with a particular form of infinite series) being two examples of application of the concept of infinity to arrive at fantastically accurate predictions about how the finite, physical world behaves..

There is another example that is worth going into in some detail - the contributions made by S. Ramanujam, the Indian prodigy who has been referred to as "The Man Who Knew Infinity" by his biographer Robert Kanigel. Unlike Newton and Leibniz who invented Calculus, or Bernoulli whose work helped extend calculus in a special way, Ramanujam's essence was not a quest after science but an interest in *pure* mathematics that originated in his spiritual or mystic leanings. In fact, he attributed all his mathematical insights to his communion with the goddess of Namagiri, who would 'write the equations on his tongue' or 'bestow insights in his dreams'. And he looked at his equations and mathematics as an artistic expression of divinity. As Kanigel records:

"One idea Ramanujam bruted about dealt with the quantity 2^n-1 . That, a friend remembered him explaining, stood for ' the primordial God and several divinities. When n is zero, the expression denotes zero, there is nothing; when n is 1, the expression denotes unity, the Infinite God. When n is 2, the expression denotes trinity; when n is 3, the expression denotes 7, the Saptha Rishis, and so on'..."

Ramanujam's life history is fascinating. He was born, and lived most of his short life, in dire poverty. He flunked in college not once but four times, and never did get a degree. One subject he failed in was physiology, in which he scored less than 10 out of 100. Kanigel describes his interaction with physiology thus:

"The text was a small book, *Physiology for beginners*..... 'Procure a rabbit which has been recently killed, but not skinned', chapter 3 of the text began. 'Fasten the rabbit on the back by its four limbs to a board, and then, with a small sharp and pointed knife and a pair of scissors...' Ramanujam reacted to all this with a skittish - and uncharacteristic - sarcasm. The professor would dissect a big, anesthetized frog, earnestly pointing out physiological similarities to humans, only to have Ramanujam pipe up with - And where is the serpent in this frog?, apparently a reference to the *nade*, or serpent power, that Hindu tradition ascribes to human nature."

The *nade* or 'serpent power' that Ramanujam was referring to is actually an integral part of the mystic understanding of the 'macrocosm in the microcosm' - the Kundalini power that exists in a latent form in all human beings (but not in frogs). Davidson's chapter referred to earlier gives a detailed explanation of this in terms of the yogic *charkas*.

To Ramanujam, the mystic world-view came naturally, and led to his great mathematical insights. Therefore, even without a degree or proper mathematical training, he was able to write his famous *Notebooks*, which are even today - a full century after they were written - being plumbed for new insights in the field of mathematics, and being applied in such diverse fields as polymer chemistry, computers and cancer research.

The fountainhead of his mathematics was his mystical bent of mind. As Kanigel records:

"When he was twenty-one, he showed up at the house of a teacher, got drawn into conversation, and soon was expatiating on the ties he saw between God, zero and infinity - keeping everyone spellbound till two in the morning. It was that way often for Ramanujam. Losing himself in philosophical and mystical monologues, he'd make bizarre, fanciful leaps of the imagination that his friends did not understand but found fascinating anyway. So absorbed would they become that later all they could recall was the penetrating set of his eyes. 'Immensely devout', R. Radhakrishna Iyer, a classmate of his, would later term him. 'A true mystic, intensely religious', recalled R.Srinivasan, a former professor of mathematics."

Central to Ramanujam's insights was a realization that the visible, finite reality we experience in this physical world is a reflection of a higher, invisible, infinite reality. He expressed it in three simple steps:

1. Zero represents Absolute Reality. (This corresponds to the mystic *pre-requisite* for enhancing direct perception to *see* the life-force which is the true reality in each of us, and at which level we are all 'members of one body', as James Jeans had explained. This pre-requisite is the development of a very unique degree of humility, wherein the narrow notion of 'self' which dictates our day-to-day functioning is abandoned. Mahatma Gandhi has used the term 'reducing oneself to a cipher' to describe this state.)
2. Infinity represents the Power that emanates from becoming 'a cipher', and thus realizing the Absolute Reality. (Our consciousness has got three attributes - Power, Wisdom and Love. Our real Self, or God, represents 100% Absolute Power + 100% Perfect Wisdom + 100% Pure, Selfless Love. But it can be realized only when we take to the path of Love, not Power or even Wisdom. Real Love comes when we 'reduce ourselves to a cipher',.)
3. Every individual entity in this creation is represented by $\infty \times 0$. This product leads not to one number, but to *all* numbers. (Thus, finite numbers and their mathematics, *if imbued with the beauty and truth of mystical understanding*, tell us about the finite world of physical beings and the reality behind the Maya. The path to the real Self, or God, is strictly through the enhancement of Love. Any distraction to this Love by either Power or even Wisdom leads to a downfall. It is this 'snakes and ladders' game combining love, power and wisdom that life on earth is all about.) The Lebanese mystic Michael Naimy's earlier quote about Love being the Law of Life, when viewed in the light of the above, makes eminent sense. Jalaluddin Rumi, the famous mystic of the Islamic tradition, echoes the same through a powerful analogy:

"The lamps are different, but the light is the same-
"it comes from beyond.

"If you keep looking at the lamp, thou are lost -
For thence arises number and plurality.

"Fix your gaze upon the light."

Rumi was putting across the notion of Life as infinity, the Whole beyond the parts but containing all the parts. It leads to "that knowledge the knowing of which all else is known", as the Upanishads put it. To those steeped in modern education, all this may sound strange, but that is because we have been brought up to think 'reductionistically' - that the sum of the parts tells us about the whole (e.g., the properties of DNA and RNA molecules is supposed to lead us to a complete understanding of the body). It is because of this reductionist mind-set that we are unable to fathom how homoeopathy and other 'alternative' medicines produce seemingly miraculous results. A grounding in Infinity will lead to a different perspective, and to a better understanding of subjects like homoeopathy.

The perspective implied by an understanding of infinity is also implicit in the way Einstein and Gandhi look at their tasks relating to *this* world: "Nobody is able to achieve this completely, but the striving for such achievement is, in itself, a part of the liberation and a foundation for inner security," Einstein said when explaining Love as the true goal of all human endeavours, in his definition of a human being as reproduced later in this chapter. In a similar vein, he told Pearl Buck: " Success or failure is not measured by how much you have achieved, but by how hard you have worked at it". This is an echo of Gandhi's words:

" The goal ever recedes. Satisfaction lies in the effort, not the achievement. Full effort is full victory."

Both Gandhi and Einstein are referring to an effort in which the *process* rather than the goal is primary. Infinity is the *setting* in which this effort takes place, but is not a goal that can be 'achieved'. Achievement orientation and humility cannot go together, and so the pursuit of Infinity demands we drop all achievement orientation, as conveyed beautifully by a poet:

"Utopia lies at the horizon.
When I draw nearer by two steps,
it retreats two steps.
If I proceed ten steps forward, it

swiftly slips ten steps ahead.
No matter how far I go, I can never reach it.
What, then, is the purpose of utopia?
It is to cause us to advance."
— Eduardo Galeano

In mystic and yogic literature, there is reference to the 'akashic tattwa' as the fifth element of matter, whose energy is derived from the fifth yogic center in our spinal cord (the seat of the 'macrocosm' within each of us). 'Akash' is a reference to the sky - which keeps moving away from us as we move towards it, a perfect case of the Infinite. The 'akashic tattwa' is *seen* (by dint of their mystic practices) by yogis as the spring from which the lower four states - solid, liquid, plasmic and gaseous - originate. Thus, the finite world of matter becomes a reflection of an Infinite state apparent at a subtler level. I suspect that in the new Mathematics of Infinity to emerge, all convergent series will point towards the four lower yogic centres as the origin of the physical universe, and all divergent series to the fifth and still higher charkas within the subtler forms of the human body. In addition, all 'constants' (such as Planck's constant, gravitational constant, speed of light etc) that appear in equations relating to physical laws of nature will be *derived* from these convergent infinite series. Moreover, these constants will no longer be treated as *permanent* constants, but as constants which *seem* to have permanence because of the finite nature of our vision. But in the yogic view in which one 'day' of Brahmam amounts to a staggering 4.32,00,000 years, these constants are also constantly changing, albeit very, very slowly from a human angle. So, they give us an *illusion* of permanence. But when a sufficient amount of time (measured in aeons) passes by, these constants will be changed sufficiently to cause dissolution of the physical universe. Computer simulations have already shown that a 0.0005% increase in Planck's constant will lead to the entire physical world evaporating, and a similar decrease to its total freezing. Thus, these constants will be seen as emanating from a level *beyond* the physical, to be understood at the level of Infinity, and will be seen as the foundation of a *very delicate balance* (as implied in the Chinese *yin-yang* concept) which enables the physical world to exist in its present form. Similarly, all body functions will be seen as extraordinarily delicate balances being maintained by forces such as *prana*, which are subtle (beyond the senses and intellect), and whose withdrawal

results in the disintegration of the body (but not of the mind and spirit, which are controlled by forces far more subtle than *prana*). But all phenomena at the level of the body and mind will be seen as temporary, subject to dissolution (*'pralaya'*) and grand dissolution (*maha pralaya*) over millions/billions of years. The only exception would be the Spirit that enlivens Life itself, which is beyond all this illusion, and can be seen as the Infinity of all Infinities. It would also be totally above all duality, representing the Great Grand Truth, the Ultimate Law, fully and completely satisfying that criteria of a 'great truth' as put forward by Niels Bohr:

"There are small truths and there are great truths. The opposite of a small truth is a falsehood. But the opposite of a great truth is another great truth."

The new Mathematics of Infinity would therefore have to *transcend* the normal realms of logic and rationality.

Such a Mathematics of Infinity may enable even a Richard Feynman to get an understanding of what poets and mystics like Blake, Rumi and Galeano speak of. It would lead to predictions about the physical world around us that would be experimentally verifiable. It would give us insights into the behaviour of sub-atomic particles that will go way beyond what Schroedinger's equations have done. It would, in a word, solve the quantum enigma in a manner and with a rigour acceptable to the most diehard of scientists..

It would also lead to revolutions in our social, educational, cultural and economic set-up. As the physicist Fritjof Capra has put it:

"At present our attitude is too *yang* - to use Chinese phraseology - too rational, male and aggressive. Scientists themselves are a typical example. Although their theories are leading to a world-view which is similar to that of the mystics, it is striking how little this has affected the attitudes of most scientists. In mysticism, knowledge cannot be separated from a certain way of life, which becomes its living manifestation. To acquire mystical knowledge means to undergo a transformation; one could even say that the knowledge *is* the transformation. Scientific knowledge, on the other hand, can often stay abstract and theoretical. Thus, most of today's physicists do

not seem to realize the philosophical, cultural and spiritual implications of their theories. Many of them actively support a society which is still based on the mechanistic, fragmented world-view, without seeing that science points beyond such a view, towards a oneness of the universe which includes not only our natural environment but also our fellow human beings. I believe that the world-view implied by modern physics is inconsistent with our present society, which does not reflect the harmonious interrelatedness which we observe in nature. To achieve such a state of dynamic balance, a radically different social and economic structure will be needed: a cultural revolution in the true sense of the word. The survival of our whole civilization may depend on whether we can bring about such a change. It will depend, ultimately, on our ability to adopt some of the *yin* attitudes of Eastern mysticism; to experience the wholeness of nature and the art of living with it in harmony."

Capra's well-known book "The Tao of Physics" has been dismissed by many in his profession as one not befitting a physicist. For those who feel contemptuous of Capra, here is the definition of a human being and the purpose of life on earth that Einstein propounded on the basis of his discovery of the nature of space and time:

" A human being is part of the whole, called by us 'Universe', a part limited in space and time. He experiences himself, his thoughts and feelings as something separated from the rest, **a kind of optical delusion of his consciousness**. This delusion is a kind of prison for us, restricting us to our personal desires and to affection for a few persons nearest to us. Our task must be to free ourselves from this prison by widening our circle of compassion to embrace all living creatures and the whole of nature in its beauty. Nobody is able to achieve this completely, but the striving for such achievement is, in itself, a part of the liberation and a foundation for inner security."

How come Einstein's definition of a human being based on his famous concepts of Space and Time is so similar to that of the spiritual sages (for instance, Buddha's summary of his meditative instructions - 'Practice the simple truth that the man there is thou')? Because, as he told his son-in-law Marianogg once, his Theory of Relativity was the result of a vision based on a 'cosmic religious experience':

"The cosmic religious experience is the strongest and noblest mainspring of scientific research...

"During that vision, in a clarified and unified view of the universe, I saw the pattern and integration of all things.

"And that is when peace came, and that is when conviction came, and with these things came an almighty calm that nothing could ever shake again..."

What did Einstein mean by the term *cosmic religious experience*? The term religion, in its original connotation, means *re+legio* - Latin for 'that which unites with the source'. So, Einstein was referring to that experience which united him with the entire cosmos!

How does one get united with the entire cosmos? Einstein has put forward the following two mental conditions as prerequisites for this experience:

1. The individual must feel the 'futility of human desires and aims'.
2. Existence bound by the narrow self must impress him as 'a sort of prison' from which he wants to get liberated.

But the above are only prerequisites, the starting point. A great struggle lies ahead for anyone who wants to actually experience this vision. In the words of his son-in-law Marionogg:

"He told me that one day he had gone to bed in a state of discouragement so profound that no argument could put it to an end. He said:

'When one reaches despair, nothing can help anymore, neither hours of work nor past success, nothing. All confidence disappears. It's over, I told myself, everything is useless. I haven't obtained any results.... And that's when the thing came about.'

"With infinite precision, the universe and its secret unity of measure, structure, distance, time and space, such a monumental puzzle, was slowly reconstructed in Einstein's mind. And suddenly, as if printed by a giant

printer, the immense map of the universe clearly unfolded itself in front of him in a dazzling vision. That is when he came to a sense of peace."

Two important points are worth noting from Marionogg's description of how Einstein arrived at his Theory of Relativity. One: We usually imagine that all great scientists arrive at their theories from an analysis of 'facts' revealed in experiments conducted in our physical laboratories. But Einstein did not do so - and this is true of other great scientists as well. His laboratory was *inside himself*. As he once said, "The kind of work I do can be done anywhere". Or, as he jokingly told his doctor friend, Paulette Brubacher, when she asked him where his laboratory was, "Here", pointing to his breast pocket that contained his pen.

The other point worth noting is that, as Einstein's desperation demonstrated, results of researches done within oneself are much, much harder to come by than those conducted in our physical laboratories. The reason - it demands a discarding of our sense of 'I-ness', of all achievement orientation. See how closely Einstein's description of what he went through resembles the description given by Thomas Merton, the well-known Catholic priest, of what he experienced during his journey with the Buddhist techniques of meditation:

"One cannot really attain enlightenment unless pressed to the limit... Forced to face and to reject his most cherished illusions, driven almost to despair, he abandons all false hopes and makes a breakthrough into a complete humility and detachment."

Humility and detachment are *the* stepping stones to any real mystical experience, which is what makes it so difficult to attain. Humility here should not be confused with self-humiliation, as Dag Hammarskjold, the former Secretary General of the United Nations (who also had very mystical leanings) has explained:

"Humility is just as much the opposite of self-abasement as it is of self-exaltation. To be humble is not to make comparisons. The self is nothing, yet at the same time one with everything."

So, in order to move towards becoming one with the entire cosmos, one first has to become nothing, 'reduce oneself to a cipher', as Mahatma Gandhi has explained in his autobiography. The result is 'en+light+enment', the ability to see the Universe in a different light, from a totally self-less perspective. The great historian Arnold Toynbee has explained the goal in the following words:

"to see the Universe as it is in the sight of God, instead of seeing it with the distorted vision of one of God's self-centred creatures".

It is in the above sense that we have to understand Einstein's famous statement:

"I want to know how God created this world. I am not interested in this or that phenomenon, in the spectrum of this or that element. I want to know His thoughts, the rest are details".

Xxxxxx

All Nature is but Art, unknown to thee

All Chance, Direction which thee cannot see

All discord, Harmony by thee not understood.

Alexander Pope



"As far as the propositions of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality." - Einstein

ECONOMICS AS IF HAPPINESS MATTERS

Let us now shift our gaze from the spiritual to the material, from mystics to ordinary men, from Infinity to the physical world of finite things, from the lofty planes of mathematics to the 'real' world of making a living.

Science and its sister, technology, have given us access to a variety of machines in a way that few could have dreamt of two centuries back. Every single technological breakthrough has been hailed as a harbinger of an easier, happier and more comfortable life for mankind. Technology is therefore seen as *the* solution to our problems, at least as far as physical comforts are concerned.

And yet, have our modern gadgets made us really happier? Have they given us abundance, as promised, or have they instead made the most essential things of life dearer? When I entered the USA as a student in 1965, the mathematician Tom Lehrer welcomed us foreigners with a song which began with:

"When you visit American city, you will find it very pretty;
Just of two things you must beware, don't drink the water and don't breathe
the air; Pollution, pollution...."

Soon, I realized that what Tom Lehrer was singing was not just funny, it was also true. Every place where development takes place, the environment goes for a six. If the environment in USA is cleaner today than it was way back in the '60s, the credit goes not to catalytic converters and other such devices, but to the fact that, unlike in those days when everything of value was being manufactured in that country, today practically everything of value has been outsourced to countries like China, where the environment problems have become truly staggering.

Thus, the irony of modern technology is this - that while we try to get an abundance of 'luxury' items for ourselves, the most basic things of life like air, water and healthy food are fast becoming scarce commodities.

Not only that, we actually end up experiencing the opposite of what we are trying to achieve. In New York and Tokyo, everybody has leisure-producing devices (i.e., labour-saving gadgets like washing machines and cars), but nobody has any leisure; whereas, here in the hamlet next to Navadarshanam, nobody has any of those devices, but what leisure they all enjoy! In Bangalore, where so many of you come from, a good number of people have air conditioners, but the weather has become so terrible as a result, and unbearable whenever there is a power cut; whereas here in this rural area so close to Bangalore we enjoy 'air conditioned' luxury without even an electric connection from the power grid.

What, then, has gone wrong? Our present state has been caused by the modern scientific world-view, which sees nothing sacred in anything. Therefore, the world 'out there' is viewed as one to be conquered ('conquest of space', 'conquest of rivers', 'conquest of Everest' are examples of the terms commonly used). This has in turn resulted in an *obsession* with owning property and accumulating goods, which not only destroys the earth's delicate fabric, but has also led to a societal set-up where unlimited production is given not just the highest priority but *exclusive* priority. As the economist John Kenneth Galbraith has noted:

"Nothing would be more discomfiting for the economic discipline than were men to establish goals for themselves and say 'I have got what I need. That is all for this week'. Not by accident is such behaviour thought irresponsible and feckless. It would mean that increased output would no longer have social urgency. Enough would be enough. The achievement of the society would then no longer be measured in the annual increase in GNP. And if increased production ceased to be of prime importance, the needs of the industrial system would no longer be accorded automatic priority. The required readjustment in social attitudes would be appalling."

To make sure that we all conform to the above requirement of ever-increasing output, modern society has *defined* success and development in purely material terms. An individual is hailed as successful if he becomes a millionaire, even if his character is flawed or his family life is in shambles. A society is hailed as developed if its GNP is galloping, even if its environment becomes like China's or its suicide rate like America's.

Often, this material quest is justified in the name of 'alleviating poverty'. The great economist John Maynard Keynes did so in the following words:

"For at least another one hundred years, we must all pretend to ourselves and to each other that foul is fair, and fair is foul, for foul is useful and fair is not. Avarice and usury and greed must continue to be our gods for a little longer still, for it is only these gods who can take us out of the tunnel of economic necessity into daylight."

Keynes had uttered those words way back in 1930. Nearly 80 years have passed since then, and we are nowhere near overcoming 'economic necessity'. If anything, the tunnel looks longer and darker.

As Keynes has admitted, there is also a moral consequence of this obsession with accumulating goods - we cannot *afford* to be nice to the other person, we instead have to pretend to ourselves and to each other that fair is foul and foul is fair. Several wise men and women of eminence have raised their voices against this, and have questioned our present way of life. Tolstoy, Thoreau and Emerson belong to this category. So of course does the Father of our Nation, Mahatma Gandhi.

We call Gandhi the father of our nation, and then blithely ignore every single thing that he advised. One reason for this is that we consider him 'impractical' and 'unscientific'. But if we look carefully at his ideas, we will discover that he was actually very practical, and also very scientific. In fact, anticipating a confluence of science with spirituality, he made the following predictive projection:

"Modern science is replete with illustrations of the seemingly impossible having become possible within living memory. But the victories of physical science would be nothing against the victory of the Science of Life, which is summed up in Love which is the Law of our Being."

Gandhi therefore did not reject science, but predicted the emergence of a new kind of science which would be much more powerful than the existing one. He clearly understood the limitations of the modern scientific method - its exclusion of data beyond the senses and the intellect. He therefore argued that it ignores the most important thing we have, Life, treating it

instead as a consequence of molecular chemistry. Once this defect is corrected and we understand that it is the invisible and not the visible that is primary, he averred, we would discover the Universal Law governing this creation as the Law of Love or Non-violence, with all physical laws like those applying to gravitation, electricity etc. being sub-sets of this one universal law.

In his seminal book *Hind Swaraj*, he has spelt out the contours of a new civilization which would be built up around this science-spirituality confluence - a civilization which would abandon our present overemphasis on urbanization, centralization, industrialization, monetization and militarization. This is not the place to go into details of these, but let us just take a brief look at Gandhi's views on economics.

Gandhi addressed professional economists just once - in 1916, at Allahabad. The audience consisted mostly of British professors and anglicized Indians, all of them experts in economics, and also well-versed in the Bible. He began in a most humorous way, telling how his friends had warned him he was a fool to appear before such an august body of experts when he had not read Adams or Marx, not even heard of Marshall, and declared that he is an 'incurable fool'.

He then becomes serious, declaring that for some things you need 'no proof from without' (a reference to the books on economics) but that an 'inner voice' guides him. He goes on to explain that continuously increasing production and GNP in the name of the 'starving poor' is a flawed concept, for it only results in the creation of an elite body who become rich by cornering scarce resources of this earth - and it is this cornering of scarce resources which is the basic cause of poverty. The earth, as such, has the capacity to feed and clothe and house all, and "for this very simple performance, we need no assistance from economists or their laws". Imagine the guts required to state that in front of the cream of the country's economists!!

He then goes on to explain the basic flaw with modern economics the way that it is practiced today - that the moral and spiritual dimension of life is totally ignored. Slowly and painstakingly building on this idea, he ends up deriving his essential message:

" Let us seek first the kingdom of God and His righteousness and the irrevocable promise is that all else will be added with us. *These are real economics.* May you and I treasure them and enforce them in our daily life."

What is the connection between 'seeking the kingdom of God' and economics? How can spiritual pursuit lead to *material* progress? The key to understanding this connection lies in distinguishing between productivity and creativity. Let us spend a little time looking at this distinction, for it has a direct relevance to our linking a possible Mathematics of Infinity with technology.

XXXXXX

"It is the same with all their machines. Their labour-saving devices multiply drudgery; their aphrodisiacs make them impotent; their amusements bore them; their rapid production of food leaves half of them starving; and their devices for saving time have banished leisure from their country." - C.S.Lewis

PRODUCTIVITY *Versus* CREATIVITY

"Never ask a writer what he is doing staring at the wall. That is when he gets his work done". - Henry Geiger

My first job was with Xerox Corporation in Rochester, NY, USA. Soon after I joined (in 1966), *The Wall Street Journal* carried a cartoon showing the boss giving a thick file to his junior, saying (with a clock at the back showing it was 5 pm on Friday), " No hurry on this, Wilbur. You can take all weekend if necessary". My boss gleefully pointed out this cartoon to me. He was a "workaholic" - a new word in English that I became acquainted with only after entering the corporate world.

In 1969, when I returned to India, my first job here was with IBM, where the word "Think" was displayed prominently in different languages at all vantage points, in every corner of the office. I was in charge of a little unit created for "Applications Research and Development" - meaning development of software packages for applications in industry. After a couple of boring assignments, I was given what I considered an interesting one - developing a package for inventory control. I was excited, drew up a 'systems flowchart' and took it to my boss. He shared my enthusiasm, appreciated my flowchart, until he realized my time framework - I had planned to complete it in three months. "But the client needs it in one week", he pointed out. I retaliated by pointing out the board that displayed "Think" above his desk. He smiled, and said, "*That* requires time, and time is money, and money is everything.... No time for all your fancy stuff. Just take another ready-made package available, make the necessary changes to please this particular client, and give it to them double-quick".

Not just in the corporate world, but just about everywhere, we are all engaged in a maddening 'rat race' these days. An Air Vice Marshal in the Indian Air Force had a cartoon above his desk, showing a rat standing proudly on the victory podium and addressing a multitude of fellow-rats thus: "Even if you win this race, you are still a rat". The Air Vice Marshal, having risen to the topmost rungs of his profession, was driving home the point that no matter how well we succeed in the modern world, there is no escaping the compromises we have to make from the moral and spiritual angles.

Why do we all subject ourselves to this rat race? Because we have defined success in its terms. And why has success been defined this way? Because, as Galbraith's earlier quote indicates, increased productivity demands it. But is productivity all that central to our achievements, even the ones on the material plane? Let us examine this question carefully.

Let me take the example of Xerox Corp. In the 1960s, it was a great success story, one that had stunned the corporate world. The company was originally called Haloid Corp., and was a small outfit in Rochester, NY, supplying inconsequential ancillaries to its Big Brother, the photographic giant Kodak. The young man who inherited the company from his father in the early '50s, Joe Wilson, was a far-sighted visionary, who looked around for an invention which would have far-reaching consequences for the world of education, in which he was deeply interested. After much searching, he located one such patent, assigned to Battelle Memorial Institute by one Chester Carlson, who had invented a 'dry copying' process which nobody else thought had any value. He had worked on it alone (with just one assistant) in his garage with full dedication for all of 35 years, even though everybody pooh-poohed his idea as a useless one. Once he had perfected his technique, he tried to interest entrepreneurs and big companies (including IBM) in it, but no one showed any interest. Finally, he assigned the patent rights to this research institute where it came to Wilson's attention. Wilson felt it did have enormous potential, and his hunch turned out to be correct. In 1960, when he introduced the industrial version of this invention into the market, it was an instant success. This machine, called Xerox 914 (the word Xerox comes from the Greek 'xerography', meaning 'dry copying') transformed the fate of Wilson's company, and he renamed it Xerox Corp.

The inventor of Xerography, Chester Carlson, was an unknown person for much of his life. He had a *creative* mind, but was least interested in converting that ability into money. He was a practicing *yogi*, and was Vice-President of the Ramakrishna Mutt at New York. He was deeply interested in the *Gita*, and derived inspiration for his work from it. Only in his last years did he become well-known because of the enormous success of Xerox Corp. He was then featured on the cover of *Newweek*, and during the interview he was asked what sustained him during the 35 years when he

worked alone in his garage, oblivious of the criticism from foe and friend alike that he was working on something 'useless'. His reply was "The Gita".

I am mentioning all this to illustrate that our obsession with "production" in companies like Xerox and IBM is a misplaced one. They owe their success not to productivity but to creativity - often of just of one individual.

The essential difference between productivity and creativity is one of 'efficiency'. Production systems, in order to increase efficiency, regard time as money, and so introduce concepts like assembly lines. Those who are creative need to be free of all constraints of time and expectations, *including that of results*. As the extremely perceptive writer Henry Geiger (editor of the weekly journal *Manas*) once put it, "Never ask a writer what he is doing staring at the wall. That is when he gets his work done".

Creativity cannot be "produced" in a mass way. The huge R&D centres we see these days are not the crucibles to nurture it. The really creative person is never after the glassed cubicles, or even the high salaries, offered in such centres. He would like, instead, "leisure" in the *original* sense of the term.

Kanigel has explained very beautifully in Ramanujam's biography the original meaning of the word leisure - not recreation or play, but freedom and opportunity. Not freedom *from* anything, but freedom *to* do something dear to one's heart. When Ramanujam flunked college, he used his time in the spirit of that freedom, and came up with his famous *Notebooks* which have made and are still making much important contributions in the fields of polymer chemistry, cancer research and computer science, apart of course from pure mathematics. That was when he was *just twenty years old*. Of course, he depended on his family for his basic needs - food, clothing, shelter.

How the family tried to 'solve' the problem of a genius in their midst is described beautifully by Kanigel, and is typical of how society tries to stifle real creativity:

"When he thought hard, his face scrunched up, his eyes narrowed into a squint. When he figured something out, he sometimes seemed to talk to himself, smile, shake his head with pleasure. When he made a mistake, too

impatient to lay down his pencil, he twisted his forearm toward his body in a single fluid motion and used his elbow, now aimed at the slate, as an eraser. Ramanujam was ...all energy, animation, force. He was also a young man who hung around the house, who had flunked out of two colleges, who had no job....For a long time his parents put up with him. But in the end they too reached their limits, grew irritated and impatient. Enough is enough, his mother decided. And sometime probably in 1908 she moved decisively to invoke what the Indian psychologist Ashis Nandy has called 'that time-tested Indian psychotherapy' - an arranged marriage."

Marriage is a very interesting institution. In the early 1970s, I was involved with an organization in Delhi dedicated to helping the poor and to social change. I was introduced to it by my friend Anil Malhotra, a gold medalist from IITKh. I was very impressed by his dedication to helping the poor. That institution had been founded by a girl named Ena Nader, a dynamic and energetic organizer. Eventually, Anil and Ena got married. Some years later, when I asked Anil why they were no longer doing their social service work, he replied, "Until the age of thirty, I was keen on saving the world. Now I am content to save half my salary."

The cares of this body - food, shelter, clothing - force us to 'make a living', and marriage reinforces it, as now we have to care not just for ourselves but for others too. This is what happened to Ramanujam - he now had to feed two mouths. To do that, he first tried his hand at tuitions, but his students deserted him. "He would talk only of infinity and infinitesimals. I felt this tuition might not be of real use to me in the examination, so I gave it up," recalls Govindaraja, one of his students, who later on rose to become Chairman of India's Public Service Commission,

Eventually, Ramanujam was rescued by Ramachandra Rao, the Collector of Nellore district, who was himself deeply interested in mathematics despite all his onerous administrative duties. He arranged to send a sum of rupees twenty five to him every month so that "simple food could be provided to him, without exertion on his part, and that he should be allowed to dream on". 'Dreaming on' did not mean self-indulgence, it meant the freedom to employ his gifts, which Ramanujam did with astounding results, until the English mathematician Hardy spotted it and called him over to Cambridge.

Hardy's story is another illustration of what real creativity involves, and how the 'system' tries to stifle it. Hardy was a brilliant mathematician, but who was least interested in its utility value or applications. For him, mathematics represented beauty and truth. "I have never done anything 'useful' ", he wrote of his illustrious career," No discovery of mine has made or is likely to make, directly or indirectly, for good or ill, the least difference to the amenity of the world".

In a word, Hardy's forte was pure mathematics, not its applied version. That does not mean it has no practical applications - it only means while the mathematician is working on his problem, he does not *think* of its practical applications, that is not his aim. His aim is truth and beauty, just like the poet's - but expressed in the language of mathematics. But others can very well make use of his work for 'utilitarian' purposes. An excellent example of how this can happen is the work of the pure mathematician Professor Hamilton, who originated a particular 'matrix operator' in 1830. It was a purely theoretical exercise, with no 'useful' application in mind. Yet, nearly a century later, the founders of quantum mechanics made use of it, and today all those working on semi-conductors, lasers etc. are using the Hamiltonian Operator, as it is called, to great benefit. Thus, while creative thinking has as its primary foundation the pursuit of beauty and truth, and has to be carried out for its own sake, it nevertheless does have a lot of material spin-offs. No wonder one of the founders of Quantum Mechanics, Paul Dirac, said: "It is more important for an equation to have beauty than to fit the facts". Dirac's statement stands the presently accepted scientific method on its head, and points out the need - if we wish to resolve the quantum enigma - to modify this method such that the 'inner' world (which includes concepts like beauty and truth) is given primacy over the outer.

Unlike Ramanujam, Hardy did not have to struggle with poverty to make ends meet. How did he manage that? By successfully passing the Tripos exam. But to do that, his friend Littlewood recalled, "even the rebel Hardy" had to swallow "the bitter pill" of learning rote subjects from 'tutors' who prepared students for this highly competitive examination. "When I look back upon those two years of intensive study," Hardy would recall later," it seems to me almost incredible that anyone not destitute of ability or enthusiasm should have found it possible to take so much trouble and to learn no more".

Hardy was making the important point that creativity and modern education *just do not go together*. In the modern education system, we are being prepared for a career - we learn in order that we may earn. Worse, as Hardy hints, we hardly learn anything, at least anything of real value - how many of us really make use of what we were taught during our college days? Those who 'succeed' in life today, therefore, are likely to be those who are *not* wanting to be creative, or, worse still, who have *stifled* any creative talents they might have had. As Kanigel bemoans:

"How many Ramanujams, his life begs us to ask, dwell in India today, unknown and recognized? And how many in America and Britain, locked away in economic or racial ghettos, scarcely aware of worlds outside their own?"

I would add that as creativity comes more naturally to the females in our species, shifting emphasis from production to creation in our education system will enable a great flowering of talent in our women, and bring them into the forefront of science. A Professor of Quantum Mechanics has dedicated his book on the subject to his wife, to whom, he said, all the intricate concepts he has described were "obvious". Perhaps he was making fun of her, but the fact is that the *yin* attitudes needed to intuitively grasp the quantum enigma does come more naturally to women.

It is also worth mentioning that a *plural* society where different religions, customs, languages and traditions are allowed to bloom is more conducive to the flowering of creativity. Unfortunately, the present trend towards globalization and productivity tends to suppress plurality. So does our present education system.

Gandhi's pleas on education are centred around the same concern. Unfortunately, he often used the term 'religious education' to describe what he had in mind, and in today's 'secular' age this term has come to be associated with sectarian divisions and blind beliefs. The word 'spiritual' or, even better, 'mystic', may have led to less misunderstanding. The economist E.F.Schumacher, author of *Small is Beautiful*, had written *A Guide for the Perplexed* shortly before his death in 1976, in which he has explained the same ideas as Gandhi's on education, but using different terminology. He has differentiated between modern education and what Gandhi had in mind by pointing out that the former stresses 'thinking', but ignores those wonderful

processes by which we can become masters, rather than slaves, of the thinking process. It is these wonderful processes that mystics teach, and it is this that Gandhi was referring to when he used the term 'religious education'. Schumacher explains in detail what is involved in such a form of education, and stresses that mystic methods are found as much in Christian tradition (as for example the *Philokalia*) as in Buddhist, Hindu or Islamic cultures:

"Inner work, or yoga in its many forms, is not the peculiarity of the East, but the taproot, as it were, of all authentic religions. It has been called the 'applied psychology of religion', and it must be said that religion without applied psychology is completely worthless. Simply to believe a religion to be true, and to give intellectual assent to its creed and dogmatic theology, and not to be know it to be true through having tested it by the scientific methods of yoga, results in the blind leading the blind."

The great psychologist Carl Rogers explained very beautifully during his Presidential address to the American Psychological Association in 1972 how this 'inner work' represents the greatest of challenges to a person truly desirous of studying the mind:

"Perhaps in the coming generation of younger psychologists, hopefully unencumbered by university prohibitions and resistances, there may be a few who will dare to investigate the possibility that there is a lawful reality which is not open to our five senses; a reality in which present, past and future are intermingled; in which space is not a barrier and time has disappeared; a reality which can be perceived and known only when we are passively receptive, rather than actively bent on knowing. It is one of the most exciting challenges posed to psychology."

How does one 'dare' to investigate this 'lawful reality'? That is precisely the process that mystics teach. Schumacher has used quotations from Prof. W.T.Stace to explain:

" Our normal everyday consciousness always has objects, or images, or even our own feelings or thoughts... suppose we were to obliterate [these] ... One would suppose *a priori* that consciousness would then entirely lapse and one would fall asleep or become unconscious. But the introvertive mystics -

thousands of them all over the world - unanimously assert that they have attained to this complete vacuum... what emerges is a state of *pure* consciousness..."

It is very interesting to note that the *original* meaning of the word University smacked of this mystic road to 'one-ness':

"The University was founded in the middle ages to find and to orchestrate all methods and systems of knowledge leading to union with the one God; as the UNIVERSUS - turned to one - reveals. The students appointed their professors, those who professed a way to attain this aim, according to their interests and motivations, and not in view to obtaining academic degrees." - Professor Arnold Keyserling

What Gandhi was suggesting was a revival of this form of education. Its highest form would be "seeking the Kingdom of God"- and what better way to engender creativity than to move towards the Creator? So, in a society where the pursuit of God is given primacy, creativity will flower, and where creativity flowers, material progress will come of its own. This was the essence of what Gandhi was trying to tell the economists way back in 1916.

Even amongst those few who have retained their interest in Gandhi, the spiritual aspect of his existence and message is generally ignored, only his social and political ideas are studied or accepted. This is unfortunate, for everything he did and stood for, including his political activity, was grounded in his spirituality - as he himself made abundantly clear in the Introduction to his famous Autobiography. A major reason why this aspect of Gandhi has been ignored, despite his repeatedly stressing it, is our feeling that it has nothing to do with social change. Let us now try to do away with this misunderstanding by examining the deeper forces that bring about social change in our midst.

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"The worst of all possible misunderstandings would occur if psychology should be influenced to model itself after a physics which is not there any more, which has been quite outdated." -

Opprheimer

THE HUNDREDTH MONKEY PHENOMENON

"Never doubt that a small group of thoughtful, committed people
can change the world.

Indeed, it is the only thing that ever has."

-- Margaret Mead

We normally associate social change with political events such as the French, Russian and Chinese revolutions. But have such revolutions really changed our lives? George Orwell's famous "Animal Farm" has beautifully captured the illusory nature of such social movements.

What, then, brings about *real* change in our lives?

To get a different perspective, let us take a look at an experiment that biologists carried out in Japan. They were studying the behaviour of a species of wild monkeys called *macaca fuscata*. In 1952, on the sea shores of a set of islands where these monkeys lived, they dropped sweet potatoes, which the wild monkeys had never seen till then. These sweet potatoes got coated with a lot of sand, dirt and muck from the sea shore, and so the monkeys refused to touch them. Then, one day, on the island of Koshima, one young monkey (whom the biologists later named Imo) had this bright idea - why not wash the potato in sea water? He did so, and found it a very tasty dish. But his parents and superiors disapproved of such an action, and continued to ignore the sweet potatoes. After some time, some of Imo's friends started doing what he had initiated, and gradually many others were lured to this new kind of food. This spread of the 'sweet potato culture' was actually a very slow process, and the number of monkeys taking to it increased very, very slowly between 1952 and 1958. But in 1958, when approximately a hundred monkeys staying on Koshima started eating the sweet potatoes, a sudden and unexpected thing happened - all the monkeys, including Imo's parents and others who had initially disapproved of his action, also took to the same method of washing and eating the potatoes.

Something else incredible happened, too. Monkeys everywhere, including in far-off islands and on the far-away mainland of Takasikiyama, also started doing the same. There was absolutely no way these other monkeys could have

seen or otherwise been in contact with their brethren in Koshima, and yet this happened! The biologists were very surprised at their discovery, and termed it the 'hundredth monkey phenomenon'.

The Cambridge biologist Rupert Sheldrake has written a book titled "A New Science of Life" based on the hundredth monkey phenomenon and similar experimental data available to biologists. He has questioned the earlier explanation of all biological activity as the consequence of the properties of DNA and RNA molecules of our bodies, and instead suggested a "hypothesis of formative causation". His thesis is that the form, development and behaviour of living organisms are shaped by 'morphogentic fields' similar to electrical fields - they exist across all of space and time. Just like the behaviour of each sub-atomic particle affects the electrical field, and the electric field in turn shapes the sub-atomic particles, similarly all members of a species affect a 'field' which connects all of us together, and in turn get affected by the field. In other words, whatever we do has an effect on all others, and is spread over all of space and time - just like the ripples caused by a stone thrown in water. In quantum physics, this effect is described by a powerful statement:

"When an electron vibrates, the entire universe shakes."

All electrically charged particles are therefore seen as connected together at a level beyond space and time. Sheldrake's theory is therefore an extension of quantum mechanics to biology. It gives credence, from the biological scientist's perspective, to James Jeans's statement:

"As it is with light and electricity, so it may be with life; the phenomena may be individuals carrying on separate existences in space and time, while in the deeper reality beyond space and time we may all be members of one body."

Albert Einstein put across the essence of this invisible connection from a more visible perspective thus:

"If the bee disappeared off the surface of the globe, then man would only have four years of life left. No more bees, no more pollination, no more plants, no more animals, no more man."

Looked at from the angle of this invisible connection analogous to that between all electrons, the hundredth monkey phenomenon would be explained thus: the 'idea' that originated in Imo's brain to wash the potatoes affected the 'morphogenetic field' in which all monkeys function (in fact, the then existing morphogenetic field also played a role in enabling Imo to come up with the idea in the first place). So, what Imo was doing changed the field for *all* monkeys, but as Imo's effort was initially a solitary one, the effect was not apparent. But, gradually, as the idea spread, so did the effect on the field, until, suddenly, the effect got multiplied manifold through what Sheldrake has called 'morphic resonance'.

Resonance is a term commonly used in many areas of science. It refers to the sudden increase in amplitude of a wave caused by an alternating force which coincides with the 'natural' frequency of that wave. Our radio sets, for example, get 'tuned' to waves of a certain frequency (meaning, the amplitude of the particular wave we desire is increased manifold) using this concept of resonance. Soldiers on the march are asked to stop marching when crossing a bridge precisely for that reason - the fear that the joint force of their coordinated steps might match the 'natural' frequency of the bridge calculated as a function of the span of the bridge. Bridges have been known to collapse when this rule has not been followed!

Sheldrake extended this concept of resonance to explain phenomena such as the hundredth monkey episode - that the morphogenetic field reached a 'resonance' level when a particular monkey's contribution 'tilted' the scales in favour of such a 'resonance' effect. Another analogy that can be given is the 'critical mass' needed to trigger a nuclear explosion - it happens so suddenly, but the foundation for it is being built slowly, steadily at an unseen layer.

Mahatma Gandhi looked at all history, all social change, through this perspective. As he put it:

" The seed is never seen. It works underneath the ground, is itself destroyed, and the tree which rises above the ground is alone seen...

" History, as we know it, is a record of the wars of the world... How kings played, how they became enemies of one another, how they murdered one another, is found accurately recorded in history, and if this were all that

happened in the world, it would have ended long ago... Hundreds of nations live in peace. History does not and cannot take note of this fact. History is really a record of every interruption in the even working of the force of love or of the soul. Two brothers quarrel; one of them repents and re-awakens the love that was lying dormant in him; the two again begin to live in peace; nobody takes note of this. But if the two brothers, through the intervention of solicitors or some other reason take up arms or go to law - which is another form of the exhibition of brute force - their doings would be immediately noticed in the Press, they would be the talk of the town and would probably go down in history... History, then, is a record of the interruption of the course of nature. Soul-force, being natural, is not noted in history."

Soul-force or Love is central to Gandhi's perception of history and social change. It is the deepest and most subtle, yet fundamental, force that determines the course of our fate - the truly universal law of existence. Above it, there are less subtle forces too - an almost infinite number of layers - each of which plays its role. Sheldrake's morphogenetic field would be one such force, perhaps the least subtle of the lot. When we do something at the gross or physical level, these forces do get affected, but not all that much. Activity at the mental level has a far deeper effect, especially if the level of concentration is high. But it is activity done at the level of the spirit that has the most profound and everlasting effect - even if this activity is not evident at all at the physical level. Thus, people like Ramana Maharishi may be seen by us as quiet introverts, disinterested in what is happening in this world, yet the impact of their inner vibrations is far more than that of political revolutionaries. Sir Aurobindo, who began life as a political revolutionary, realized this, and switched to becoming a 'seed' instead.

Activity at the mental level, too, does have far-reaching consequences, especially if a 'critical mass' is reached. In the 1950s and 60s, vegetarianism was regarded as a dying way of life, condemned by medical science as an unhealthy diet, looked down upon by economists as the cause of poverty in countries like India. But today, it has staged a dramatic revival, and seems to be the 'wave' of the future. What has caused this wave? At the rational level of analysis, nobody could have predicted such a revival 40 years back. But the rational level confines itself to the senses and the intellect, and

does not take into account the subtle forces operating within the morphogenic field, wherein the 'resonance' created by a small but dedicated set of vegetarians was enough to produce the 'hundredth monkey' effect. As Margaret Mead has conveyed eloquently:

"Never doubt that a small group of thoughtful, committed people can change the world. Indeed, it is the only thing that ever has."

The 'hundredth monkey' effect can be noticed even at the level of physical feats. For example, what heroic efforts were needed between 1920 and 1953 to try and conquer the Everest, and yet until Tensing and Hillary finally made it, all these efforts were in vain. After 1953, the success rate slowly started going up - one can plot it as an exponential curve - and now every Tom, Dick and Harry seems to manage what was once regarded as an almost impossible feat.

The same thing could happen to 'mystic' experiences. Right now, it is confined to a few - very few - human beings. But the number is increasing, and so we could very well witness a 'morphic resonance' in this field. But the important thing to bear in mind is that for the world-view of humanity to change, it is not necessary that the majority or even a large number actually experience anything mystical. Today, the Newtonian world-view is prevalent in us, but what percentage of human beings are really conversant with concepts like calculus and integration, or even Newton's Laws? Even amongst those who have studied science, how many know that as per the Newtonian world-view, the world in which we live is 'deterministic' (ie, its future is fixed)? The fact is that once a world-view becomes 'accepted' by those who act as the 'guides' of society, that world-view takes hold on the masses and determines their way of thinking, and hence their way of life. Only the high priests - whether in religion or science or any other field that is 'guiding' humanity - are familiar with the concepts and intricacies of the world-view, the vast majority of ordinary people just follow what they are told. This is not as undemocratic as it sounds - the fact of the matter is that the vast majority *want* to be guided, they do not have the time, energy, capacity, wherewithal and interest to work out things for themselves from scratch.

But once things are 'worked out' by the "powers that be" acceptable to humanity, the world-view thus worked out does act as a guide to how we live

in this world. A little story, perhaps a true life one, illustrates this point. It is about a Western anthropologist who was researching a tribe in Africa. As the tribe was located in a remote area, he used to fly there in his small plane. The entire tribe would gather at his landing point, watching him in fascination, during his take-offs and landings. One day, the Chief asked him, "Sir, when you go up there into the sky, do you see *God*?" Smiling inwardly at the naïveté of the native, the anthropologist answered, "Of course not". The Chief persisted, "Not even once?" "No" answered the anthropologist firmly. "But surely, you must be hoping to see him sometime", the Chief remarked. Again, the anthropologist answered with a firm "No". Knitting his eyebrows, the Chief then asked, "But then, why do you keep going up there again and again?"

How our world-view can effect everything we do is well illustrated by this story. To the anthropologist, flying was just a means of saving time, for 'time is money, and money is everything'. To the tribal mind, *God* is everything, so taking so much trouble without any hope of moving in that direction did not make any sense.

Thus, the advent of a science-spirituality confluence will not make the vast majority of humans into mystics, but it will change the way we look at this world, and our purpose of life. That will bring about a change in *everything* that we do, and thus profoundly impact our social, educational and economic structures.

Is there any hope of this actually happening? Only those who have insight into the subtler levels of functioning that change our 'morphogenetic fields' can say for sure. But there are indications that the world is getting ready for such a revolution.

One such indication is the reception that Sheldrake's book has received. The world of science has treated him with derision, if not contempt. Why so? Not because he is not qualified to write such a book - his credentials are impeccable, he is an established biologist of the highest order. Not because his work is of poor quality - it is a very well-researched effort, strictly adhering to all the tenets of science. Not because his work is in any way unscientific - in fact, he has used concepts of quantum mechanics, the newest ideas in physics, as the ground on which to build his biology.

So, then, why so much opposition to Sheldrake's ideas? Heisenberg had warned, as we noted in his earlier quotation, that once the implications of quantum mechanics get understood, the "ground would be cut off" from science - and the scientific establishment would like any such 'cutting off' to be nipped in the bud. Therefore, the Editor of *Nature*, the most prestigious magazine in the world of science, wrote a stinging editorial on Sheldrake's book, declaring that it was a book "fit for burning".

"Burning" is an interesting word. Remember when Giordano Bruno was burnt at the stake for seconding what Copernicus had said about the earth revolving around the sun, or when Galileo was given a tour of the torture chambers during the Inquisition for espousing 'independent thought' based on experimentation? Those burnings and tortures turned out to be the starting point of the Enlightenment.

So, maybe, the world is getting ready for another Enlightenment.

Xxxxx

The live fish swim against the stream, the dead drift with it. While we drift, we are the thing we cannot help ; but in willing and working in God's will we become men. - T.S.Eliot

**If you can dream - but not make dreams your master,
If you can think - but not make thoughts your aim,
If you can meet with Triumph and Disaster
And treat these two imposters just the same ...
Yours is the Earth and everything that's in it,
And - which is more - you'll be a Man, my son!**

- Rudyard Kipling