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CAN RELIGION GIVE SCIENCE A HEART?

1. The Traditional View of Science

We live in an age that has witnessed many marvels in the field of science and technology. Almost every day new items are being added to the already impressive treasury of scientific discoveries.[1] They have transformed our way of life through and through. Intercontinental travel has become an everyday affair; many are already mooting of inter-planetary voyages. Less and less fall victims to fatal diseases, more and more live longer. Open-heart surgery and such hitherto unimaginable surgical operations are becoming almost standard treatment, letting patients new leases of life. Indeed, the transformation has been all-permeating.

These welcome changes have painted a triumphalistic picture of science for the average person on the street. For such a person, science seems to have become the almighty, the solution-for-all. Science and scientists have earned in the popular mind an unparalleled respect and credibility. It seems to have become the last and reliable authority on practically every thing. Although such a picture is being challenged in many corners, it seems to be quite strongly set in the popular mind even today.

A number of factors contributed towards the creation of this view in the past. The tremendous success of Newtonian or classical science was a crucial factor. It could successfully predict many startling phenomena. A case in point was the discovery of the planet Neptune. After the epoch-making discovery of the planet Uranus by William Herschel in 1781, attempts were on to compute its orbit correctly. They ran into a snag because the theoretical or calculated values could not agree with the observed ones. Careful studies of this problem on the basis of Newton's theory led John Adams in

1. One of the latest in this series is the E-Lamp, developed in California in 1992. It is like an ordinary light bulb, but can last for over 20 years.

England and Joseph Leverrier in France independently to postulate a new body near Uranus disturbing its motion. By 1846 they had specified its theoretical orbit and a search for it by Dr. Galle of Berlin soon afterwards spotted the new planet exactly at the position predicted by Adams and Leverrier. This discovery was lauded as an outstanding demonstration of the incredible power of a scientific theory over nature.

The mechanical philosophy of nature in the nineteenth century and logical positivism, its twentieth century successor, also played a pivotal role in creating a triumphalistic image of science. The mechanical philosophy of nature, which was the official philosophy of science from the seventeenth to the beginning of our century, asserted that the science of mechanics could explain all phenomena of our experience. It claimed that all such phenomena could be accounted for in terms of matter in motion and interaction among material bodies. In fact, all these could be explained by four fundamental concepts: space, time, mass, and interaction. Under its influence attempts were made to develop purely mechanical explanations not only of celestial and terrestrial motions but also of biological operations like digestion, respiration, reproduction, etc. Although developments in science, such as the discovery of electromagnetic theory by Clark Maxwell, the theory of relativity by Albert Einstein, and quantum mechanics dealt a death blow to this unrealistic claims of the mechanical philosophy of science, in some ways, it was reborn under the garb of logical positivism, which also made similar claims. However, in the case of mechanical philosophy the claims were confined to the science of mechanics only, whereas in the case of logical positivism they were applicable to science in general.

Logical positivists came from the ranks of philosophically-trained or, at least philosophically-minded, scientists, especially from the Vienna Circle. They believed that scientific knowledge was the most perfect form of knowledge, the paradigm of true knowledge, totally uncontaminated by non-scientific factors, absolutely accurate, fully certain, and perfectly objective. If in actual practice all these virtues were not obtained, it was only due to practical difficulties. Ideally all these characteristics must be present. A good scientist, according to them, was an objective investigator, unswayed by passions, prejudices, and any other personal or subjective considerations. The only authority whom he respected was objective observations. Obviously science and scientific knowledge stood above national and racial boundaries, psychological and personal preferences. Scientific knowledge was universally applicable, solidly founded, and totally reliable.

The continuous stream of scientific discoveries and inventions, especially in the second half of the nineteenth and in the twentieth centuries, was the third factor contributing to the triumphalistic picture of science. Because of this although logical positivism and such philosophies have been discredited and the hollowness of their claims has been exposed, the image they helped to create still lingers on in the popular mind.

II. THE CONTEMPORARY VIEW OF SCIENCE

The popular view depicted above is very much one-sided, mainly due to lack of adequate information and critical spirit. In more recent times, thanks to better and wider information, better education and critical approach, the old view has given way to a more modest and balanced one. Many eminent scientists and thinkers have begun to realize that despite all its success, science has many limitations. The contributions of science have been a mixed bag. We will now discuss briefly the positive and negative sides from various perspectives.

A. Science and Humans

There is no doubt that developments in science and technology have profoundly transformed the quality of life. The level of comforts and the amenities available have made tremendous progress. Thanks to science, today our life has become almost weather-proof, in the sense that one can live practically under any weather conditions. Humans are no more total slaves to the vicissitudes of rain, snow, heat, cold, and wind, as in olden days. With the advent of super-computers, weather forecasting is moving away from a guess-game to a scientific information and warning system. The supercomputers available today are so incredibly fast that they can perform more than a billion operations per second. Still faster ones are in the making. For instance, the Japanese are working on a computer project called the Fifth Generation Project, which is supposed to be capable of storing information containing as large as 1,000,000 000,000,000 characters and performing up to 1,000 billion computer instructions each second.[2] Breakthroughs in telecommunications have reduced our vast world into a global village, wherein what happens in one corner is almost instantaneously transmitted to all the other parts. Televisions and videos have brought the outside world into the privacy of our homes.[3] Supersonics jets have made inter-continental travel fast, comfortable, and pleasurable. Advancements in agriculture like the green revolutions have increased the food production considerably. In the field of medicine and medical technology also the developments have been amazing. Both preventive and remedial medicines have made tremendous progress in our times. Surgical operations of incredible accuracy and reliability are becoming routine service. These are just a partial spectrum of some of the well-known positive contributions of science to our society.

Thanks to science, today we know more about the origin not only of our human race but also of the universe. New discoveries in genetics are throwing fresh light on the evolutionary theory of the descent of humans. Giant telescopes with incredible power has been able to extend their gaze almost to the first stages of creation. The largest radiotelescope in the world, Arecibo, in Puerto Rico, is capable of making a portrait of a quasar[4] ten billion light years[5] away. It is so powerful that it can "see" the flame of a candle on the surface of the moon.

On the other hand, critics point to the other darker side also. Is it true, they question, that the quality of life has improved because of science and technology? This will obviously depend on the criteria

2. See Henry Mishkoff, *Understanding Artificial Intelligence* (Indianapolis: Howard W. Sams & Co, 1985), p. 233.

3. Television is no more the luxury of a select few. The most recent study by MRAS/Burke group reveals that even in a relatively poor country like India practically all with a monthly income of Rs. 2000/– or more have a television set. It has also found that about two thirds of all with a monthly income between Rs. 501 and 1000 also own television sets. (See *The Week*, June 7, 1992, p. 64).

4. Quasars are quasi-stellar bodies. They appear like stars, sending out radio frequency radiation. They are constantly moving away from us at an incredible speed.

5. A light year is a measure of astronomical distance. It is the distance a ray of light will travel in one year, moving at the incredible speed of 186,000 miles per second.

of such a quality. It is impossible to formulate a culture-neutral set of criteria. Whatever such a set be, there seems to be general agreement that one of the main criteria, if not the main one, has to be the level of happiness achieved by the developments under consideration. They should help to create more happiness, stronger unity, deeper understanding, and greater fulfillment. Can one say that the beneficiaries of the latest discoveries are more happy than their ancestors? Undoubtedly there has been a quantitative growth: there are more and varied means of enjoyment available today. It will be a grave fallacy to assume that the sheer strength of number or quantity will automatically lead to a qualitative growth. The aspect of happiness cannot be easily overlooked, since if no such growth takes place, one could question the meaning and relevance of these developments for us humans. We will now consider a number of considerations that cast shadows on the bright picture of modern science.

Many complain that modern science has helped to create a mechanical world, a world in which humans are reduced to mere machines. It has created a "heart-less world," one very much bereft of feeling for the other. This should not be surprising since human feeling and concern for each other are often engendered and nurtured by mutual dependence. For instance, one of the principal bonds of mother-child relationship is the mutual dependence between the two. Technology often helps persons to become more self-sufficient and hence less dependent on others. Today one can enjoy a tennis match on the television set in the isolation of his/her private room. The "car-society", which is becoming the mark of economically-developed countries, is very much noted for its tendency to isolationism and anonymity.

The growing urbanization also contributes to this anonymity and the loss or at least decline of human touch. Urbanization is a natural consequence of technological development because cities and towns tend to spring up around production centers. In many developed countries villages and rural life are a fast vanishing phenomenon; even in India the number of villages has begun to shrink in favor of towns.

These socio-psychological consequences cannot but leave their indelible marks on contemporary humans. Today humans are often tormented by the feeling of alienation from nature, isolation from fellow-humans, and alienation from oneself because of apparent meaninglessness of life. Perhaps the rate of suicide can be taken as an index of this state of affairs. It is significant to note that highly advanced countries like Japan, Sweden, etc., are among those topping the list of suicides every year. Already in the beginning of our century Teilhard de Chardin had perceived this painful predicament of modern humans. Paraphrasing his thought Gareth Jones writes:

> For many people this world is meaningless and absurd. Being unable to find any purpose in life, they are filled with despair. Realizing that human activity has been robbed of all hope and nobility, their anguish is complete. The world in which they live is vast and impersonal, remote and pointless, while man himself is an irrelevant bauble stumbling along pathetically and tragically into an irrelevant future . . . . Modern man is dominated by an existential fear of himself, of his own powers and of the world around him. Lacking any absolutes and certainties in life, he has abandoned himself to despair and has relinquished his responsibility to fulfil himself.[6]

Technological developments have taken a heavy toll on our environment. Our earth is no more "the sparkling blue and white jewel ..., laced with slowly swirling veils of white . . . Like a small pearl in a thick balk of mystery,"[7] as Edgar Mitchell described it while observing it from his spacecraft Apollo 14 in 1971. Ours is an irreversibly polluted and constantly polluting earth. The pollution level, mainly arising from the chemical waste products spewed by the ever increasing chemical plants all around the world, has already reached alarming levels, so much so the nations of the world are becoming nervous to find a solution to this suicidal situation.[8] It is said that until 1860, i.e., until the time the Industrial Revolution took deep roots, the carbon dioxide content of the air remained more or less the same. In other words, nature took care of the balancing of the different components in the atmosphere with meticulous care. How-

6. *Teilhard de Chardin : An Analysis and Assessment* (London: The Tyndale Press, 1969), p. 11.
7. Raj Chengappa, "The Wounded Earth," *India Today*, June 15, 1992, p. 69.
8. The Earth Summit in Rio de Jeneiro, in June of 1992, is the latest among these international attempts.

ever, between 1860 and 1960 the carbon dioxide content increased by 14% due to combustible fuels.[9] Today more than three decades later the increase must be much higher. Combustible fuels are only a small actor in this tragedy; the radioactive rays emerging from nuclear explosions and other devices, the fallout from nuclear weapon tests, etc., pollute the atmosphere even more mercilessly. In this connection a few items like acid rain, the ozone hole, CFCC (chloroflurocarbons), etc., have become significant.

Acid rain is a much-talked about phenomenon in North America (U.S.A. and Canada). It is actually the rain of acids, but not produced by mother nature, rather by intense industrialization. The formation of this dangerous rain can be explained simply as follows: the industrial factories and power plants pollute the atmosphere with two poisonous gases, viz., sulphur dioxide and nitrogen dioxide. When natural rain and snow fall, they interact with these gases floating in the atmosphere and produce harmful products. Thus the rain and snow falling will be a dangerous mixture of sulphuric acid, nitric acid, and water. This unnatural mixture is called acid rain.

Ozone is the triatomic allotrope of oxygen. The ozone layer, produced by the action of ultraviolet solar radiation, is found at about 25 to 30 kms above the earth. This rather rare component of the atmospheric air is part of nature's mechanism for protecting life on earth. By absorbing the highly harmful ultraviolet rays, it serves as a protective shield in the upper regions of the atmosphere.

CFCs are made up of chlorine, fluorine, and carbon. They are used as propellants in aerosols, as refrigerants, and as coolants in airconditioners. The CFCs produced move up in the atmosphere where they are broken up by the ultraviolet rays, releasing chlorine, which combines with oxygen to produce chlorine monoxide. This compound of chlorine is mainly responsible for the destruction of the ozone layer. Obviously all these destructive pollutants are the price we have to pay for our "high standard" of living.

Being thrilled by the overwhelming success of the spaceshuttles, the Skylabs, the Salyuts, the Mir-stations, and the like; being astoni-

9. See *Manorama Yearbook 1992*, p. 111.

shed at the astounding precision of space satellites and the Tomahawk missiles, moderns often overlook the other side of the story. The unsuccessful mission of the Apollo 13, the Challenger disaster in 1983, the reported and unreported failures of the Soviet missions, the disasters in Three Mile Island in the US, the tragedy in Bhopal, India, in 1984, and Chernobyl in the former Soviet Union in 1986, are only a handful of reminders that this dark side can never be bypassed. One may point out that many of these disasters could have been averted with better caution and care. This is only partially true since these sophisticated devices and machines make use of physical laws which are probabilistic in nature. As such these laws cannot rule out failures. Quantum physicists often point out to a curious "unwritten law" in quantum mechanics: "If something is not forbidden, then it must happen!" There is no scientific law forbidding such disasters. In fact, according to the laws, they should occur occasionally. Hence one should not be surprised if on one fateful day one of the numerous nuclear monsters in the secret arsenals of the nuclear powers were to explode accidentally. The precautions taken by the governments can only reduce the risk, not remove it. In fact, in a very recent report the U.S. Department of Defense has admitted that many accidents involving nuclear weapons took place during the last 40 years.[10] This fact alone should be sufficient to force the world leaders to have a second look at nuclear weapons. This is also a good argument for countries like India which call for a global nuclear non-proliferation than a mere regional one.

The computer revolution also has opened up a bag of problems. The computer along with its natural partner artificial intelligence (AI) threatens to reduce the human mind or brain to a super-sophisticated computer. Since many of the functions traditionally attributed to the human mind can be carried out today by a computer, especially by a super-computer, many in AI believe that it is only a matter of time when *all* such functions will be done by a computer, more effectively and more reliably. This thesis, if it turns out to be correct, will have serious consequences. For if the human mind or brain is nothing but a super-sophisticated computer, then it is only a small step away from the creation of the machine-man. One may

10. See *Maharashtra Herald*, Pune, June 11, 1992. See also *The Indian Express*, Pune, June 12, 1992.

say that such problems are only theoretical issues. There are also practical consequences with computerization. For instance, it increases unemployment by transferring human work to machines. Many computer companies and related business communities have argued against it, pointing out that the computer revolution will generate new work opportunities through its supporting industries. This argument is self-destructive since if computerization, at least in the long run, does not reduce work load, then there is not much point in going for it. Besides, the facts have shown that the critics are right. After the initial boom, the computer industry all over the world seems to be in a slump. Even the glamorous Silicon Valley of California is no exception. This is very true of the computer market in India. There is no good reason to believe that this slump is only a temporary affair. It is clear that the computer revolution has thrown a lot of people out of job and has not generated enough jobs to make up for it.

In the medical field also the darker side cannot be ignored. Mystery still surrounds the cause and cure of many diseases. Often the glaring instances of AIDS, cancer, etc., are pointed out. One does not have to go to serious cases of this kind; even the common cold has not found a reliable cure. The same seems to be true of certain cases of hyper-acidity. More surprising is the precious retina of the human eye. The problem of deterioration of the retina still baffles medical science. It has no clear idea about the cause of this problem, no cure for it, not even any means to arrest further deterioration. Of course, there are excellent techniques to repair the punctures in the retina and the marvelous laser treatment to reattach a detached retina. But these are basically sophisticated "repair work." Medical science is still a long way off to master the mysterious ways of the human body.

Even the remedies already available are far from being satisfactory. Chemical drugs are notorious for their side-effects, which are at times worse than the sickness itself. Even surgery, despite all its sophistication and effectiveness, is a crude and cruel way to treat a human body because the basic principle of surgery consists in nothing but cutting off the affected part of the body and help the patient to manage without that part or with an artificial substitute. Surgical science looks upon the human body as a mere machine. Certainly, all these procedures prolong the life, but often one wonders at what price and for what. A realization of this side of modern medicine has catalyzed the growth of other kinds of medicines, which follow a holistic rather than a mechanistic approach. Chiropractic, homeopathy, and ayurveda in India are a few examples of these alternatives.

There is also a more human side to this problem. In the case of modern medical techniques, there seems to be a one-to-one correspondence between the rise in sophistication and the rise in cost. Hence today the expenses for these treatments are becoming beyond the reach of even the middle-class, not to talk of the poor. This not only widens the chasm between the rich and poor, but also worsens the situation of the latter since development of such advanced techniques will drain off the available resources considerably.

Perhaps the notorious "sex test" can dramatize the harm that can be perpetrated by advancements in medical science. The sex test enables the couple to find out the sex of the fetus. In countries like India where so much premium is placed on a male child, this test can and does lead to the destruction of the female fetus. India already has a sex-ratio in favor of the males (929 females for every 1000 males in 1991). In fact, Kerala is the only state with a sex-ratio in favor of the females (1040 for every 1000 males). Nationally this ratio is getting worse for women. Sex tests in this context will accelerate the loss of balance in the number of males and females with very serious social, psychological, and emotional consequences.

Genetic engineering can be a double-edged sword in this context. Although this wonderful field can do unbelievable good to humankind (it is being used to cure many genetically related diseases, hitherto thought to be incurable, by rectifying the genetic defects), it can be used in the opposite way also. Plans are afoot in certain corners of the world to use it to create special humans of ones choice, to make the dream of a super-man or super-race come true.

B. Science and Knowledge

Recent developments in philosophy, especially in philosophy of science, have forced scholars to look at scientific knowledge more critically. In the light of such a critical and balanced view, our idea of scientific knowledge has been drastically revised. Today the logical positivistic idea of science is no longer tenable. Yet scientific knowledge is still considered the paradigm of knowledge, in the sense that it is the best one can get through human means. Science subjects its claims to the toughest and most critical tests. It throws its findings open to inter-subjective and international examination. Maximum care is taken that the knowledge claims of science are kept above personal biases and preferences. They are characterized by meticulous accuracy and high reliability. Obviously, one can say that science provides better knowledge than any other human source. Yet scientific knowledge has certain serious limitations.

1. *Scientific knowledge is only partial*

All human knowledge involves the process of abstraction. This implies that such knowledge originates from an external source. From this external object, presented to the knowing faculty, it abstracts or draws out certain specific features to form an idea of that object. We know that the intellect is the principal faculty for acquiring knowledge. The etymological or root meaning of the word intellect is "to choose or gather from among." This means that the intellect (or mind) by its very nature picks and chooses certain specific items only. Aristotle and Aquinas would call them the "intelligible species." Kant's theory of knowledge also, in some ways, can be looked upon in this way. According to him, our knowledge of the phenomenon is categorized knowledge, in the sense that the mind can comprehend what is presented to it only under certain specific categories. The mind is selective because it can know only those data that are presented under one of these categories.

The traditional theory of abstraction, as developed by Aristotle and Aquinas is too complex and complicated to be discussed here. Also the theories of knowledge vary from one school of philosophy to the other. Yet from all these theories certain general implications can be drawn. The human intellect has to pick and choose; it has to compare, measure, and categorize. In a process like this many aspects will be drawn in and accepted, but at least some will be rejected. This means that the ideas our mind forms will not be able to comprehend all the aspects of the reality presented to it.[11] Human knowledge is intrinsically partial; it can give us only an incomplete picture of the reality.

11. The Aristotelians would say that the human mind can know the essence of the matter presented to it, and so the knowledge obtained is not partial. This claim is highly controversial. For one thing, they cannot give a satisfactory definition of essence.

The abstraction involved in scientific knowledge is more drastic since it requires a deeper discrimination and stricter selection. For instance, science will focus on the measurable and the quantifiable. Very often a scientist will look for only those aspects that can be put into a mathematical language. Hence scientific knowledge is significantly incomplete and partial. A case in point will be a scientific study of a beautiful rainbow. It can reveal the mechanism of production of the rainbow, the seven wavelengths responsible for the seven colors, etc. But the experience of beauty, the accompanying feeling of thrill, joy, and peace are all lost in such a study. A scientific analysis of a joke will be a failure because it will be unable to capture good humor.

The scientific practice of translating reality to mathematizable categories is a powerful technique because it renders data accurate and easy to analyze. But a heavy price will have to be paid. Not only is the knowledge thus derived highly partial, often it is also far detached from the real world. One experiences this while attempting to write a computer program for some life situation. Translating this situation into computer language certainly ensures accuracy and easy manipulatability, but a replay of such a program will easily reveal that it has failed to capture many aspects. Einstein has summarized this situation beautifully: "As far as the laws of mathematics refer to reality, they are not certain; as far as they are certain, they do not refer to reality".[12]

2. *Scientific knowledge is relative*

The consideration above may look theoretical and hence quite removed from real life. That is far from truth because it challenges the neutrality or objectivity of the knowledge acquired. Whenever there is discrimination and selection there has to be certain criteria for such a selection. Are these criteria objective ? Can they claim to be free from considerations of caste, color, creed, and culture ? If not, scientific knowledge will be at least partly subjective and hence relative.

The relative nature of scientific knowledge has been emphasized by the "historicists," a school of philosophy of science which arose

12. Quoted by Fritjof Capra, *The Tao of Physics* (New York: Bantam Books, 1977), p. 27.

around 1960s as a reaction to the extreme views of logical positivism. The fundamental idea of historicism is that science and scientific concepts are products of a particular society and by that society. Hence science cannot be detached from the historical, cultural, sociological, and psychological factors surrounding it. In other words, the *Weltanschauung*, the worldview, constituted by these and other factors, plays a central role in science. Indeed, according to them, the worldview colors and controls science. What constitutes a scientific problem, what makes a satisfactory solution, what criteria are acceptable, all these are in a crucial way determined by the worldview. The central place the worldview plays in their philosophy of science has led some to call this school of philosophy the *Weltanschauungen* view. Supporters of this view believe that all scientific concepts are relative to the worldview. I believe that, although historicists like Thomas Kuhn and Paul Feyerabend exaggerate this relativism unreasonably, a certain degree of relativism in science cannot be ruled out.

These considerations of the influence of the worldview can shed some light on the criteria for selection involved in the process of abstraction. It can be said that when the mind or intellect discriminates and selects, it is governed by a certain worldview. This renders scientific knowledge even more partial since it is restricted by a particular perspective.

Another source of relativism arises from the widely accepted belief that observations are theory-laden. According to most philosophers of science, there is no theory-neutral observation. Of course, dependence on theory need not rule it out as purely subjective and unreliable. For, after all, if the theory in question is accepted by most scientists and applicable to most, if not all, known cases, an observation based on that theory should be satisfactory. However, the fact remains that scientific observations are not unaffected by the theories one subscribes to.

There is yet another source of relativism in quantum theory. The Copenhagen Interpretation of quantum theory, developed by Niels Bohr, Werner Heisenberg, etc., is the most accepted view, despite Einstein's life-long, vehement resistance to it. According to this interpretation, the experimental setup a scientist chooses is determinative of the outcome of the experiment. This is quite conspicuous in the context of the dual nature of matter. Light and matter has a double nature: under certain conditions they behave like waves, under certain others they behave like particles. Whether a particular experiment will reveal aspects of the wave-nature or the particle-nature will depend on what experimental setup the scientist employs. Obviously, one cannot get a totally independent set of results from such an experiment. Scientific knowledge becomes relative to the choice of the experimental setup.

A further source of relativism arises from the requirement that an item to be investigated will have to be prepared in certain specific ways before it can be observed and studied. In quantum theory one cannot study a particular phenomenon in any way one wishes. Since such careful preparations based on theories predisposes the phenomenon for certain expected results, relativism cannot be avoided. The results we get under these circumstances are that of a "pre-established world."

This picture of science casts the scientist in a new light. He/she is not a super-human being, totally unaffected by passions and prejudices, feelings and biases. It projects the human side of the scientist and exposes the human face of science.

3. *Scientific knowledge is uncertain*

One of the praiseworthy aspects of contemporary science is that it is quite aware of its own limitations and is ready to accept them. The highly successful and remarkably versatile quantum theory, for instance, admits a certain degree of uncertainty in scientific knowledge, not just in practice only, but also in principle. It also holds that all scientific laws are statistical, not deterministic. Of course, one should not be misled to believe that scientific knowledge is second rate since it is uncertain; it is the best form of human knowledge, far more certain and reliable than all the others. Yet it is not perfect; it can be improved, but only up to a certain point. The uncertainty principle discovered in 1927 by Werner Heisenberg, one of the founders of quantum theory, puts a limit to the degree of certainty attainable in science. The principle states that it is in principle impossible to determine exactly the position and momentum (i.e., velocity multiplied by the mass of the body) of a particle at the same time. Hence simultaneous and exact determination of position and velocity of a body is not possible. Since in physics the position and velocity or momentum determine the state of a particle or body, lack of accurate knowledge of the two is a serious handicap.

The uncertainty comes about because any attempt to specify the position and momentum of a body requires interaction between that body and the probing body. Such an interaction disturbs the body under investigation and this disturbance cannot be determined with absolute accuracy. For instance, if we want to measure the position of an electron, we will have to send light or photon to hit that electron and receive the deflected photon in our receiver. But this hitting will disturb the velocity or momentum of the electron. If the probing photon does not interact (hit) with the electron, we will not get any information about it. So the disturbance and consequent uncertainty are unavoidable.

The uncertainty principle, coupled with the Copenhagen Interpretation, has another important implication: there cannot be any observer-independent measurement. We have seen the experimental arrangement the observer chooses affects the outcome of the experiment. We also have seen that every measurement must be preceded by proper preparation of the items. Here we see that the act of observation or the probe used in the measurement disturbs the object under investigation and interferes with the results. Since the instruments and probes necessary for the measurement can be looked upon as an extension of the observer, it follows that the observer influences the process of observation and its outcome. According to Capra, "the human observer constitutes the final link in the chain of observational process, and the properties of any atomic object can be understood only in terms of the object's interaction with the observer . . . . In atomic physics, we can never speak about nature without, at the same time, speaking about ourselves."[13]

4. *Scientific knowledge is mutable*

The logical positivist and like minded philosophers believed that scientific knowledge and concepts, once well-established, were immune to change. Scientific theories, once established as scientific, could not be refuted. However, a more careful study of the history of science and what is happening in science today reveals that nothing in science is free from modification. The fact that a particular theory worked most effectively for centuries does not insulate it from eventual refutation and even rejection. A clear case is the Newtonian theory of gravitation. We have seen its astonishing success in predicting the existence of new heavenly bodies. Yet it was

13. Op. cit., p. 57.

shown to be false, or at least inaccurate, by Einstein in 1916. It was shown to be, at best, an approximation of Einstein's theory of general relativity. Similarly classical physics, which enjoyed hitherto unrivalled success, had to give way to quantum physics. Some other scientific theories fared even worse. They were shown to be false and rejected. For example, the fluid theory or the caloric theory of heat, according to which heat was considered a kind of subtle fluid residing in hot bodies. Since it could explain certain observed phenomena, many eminent scientists like Carnot accepted it. But later it was found to be wrong and rejected.

The changes in the case of Newton's theory of gravitation and others were not just one of accuracy; much deeper issues were involved. There was a real conceptual change taking place. For Newton gravitation was an attractive force pulling material bodies towards each other, whereas for Einstein there was no force at all, it was a geometrical property of the space-time continuum. The presence of massive bodies distorted the spacetime continuum and gravitation was this distortion.

Another example of conceptual change with far reaching consequences was the concept of material particle. Traditionally a material particle had a number of well-accepted characteristics. Challenging any one of them would have been considered sheer irrationality. Some of these are: 1) the material particle really and definitely exists, 2) it is made up of a definite stuff, 3) it is discontinuous, i.e., it has definite boundaries, 4) it has a definite nature.

Three developments in the twentieth century science have challenged the traditional understanding of a particle and has brought about radical changes in it. They are the equivalence of mass and energy in the special theory of relativity, the wave-particle duality in quantum theory, and the probabilistic nature of reality. In the subatomic world we can only talk of probability, not of determinism. Here one cannot talk of matter existing with certainty at definite places. As Capra points out, one can only talk of entities having "tendencies to exist" and of events having "tendencies to occur."[14] Hence according to the quantum mechanical understanding, particles cannot be affirmed as definitely existing. Again, since according to the mass-energy

14. See *op. cit.*, p. 56.

equation, mass and energy are equivalent, one can consider mass as a form of energy. The formidable energy unleashed by the conversion of mass into energy in nuclear devices confirms this position. This means we should not consider matter particle as being made of some fundamental stuff, rather it is a 'bundle' of energy. Capra explains this point: "To understand this better, we must remember that these particles can only be conceived in relativistic terms, i.e., in terms of a framework where space and time are fused into a four-dimensional continuum. The particles must not be pictured as static three-dimensional objects, like billiard balls or grains of sand; but rather as four-dimensional entities in space-time."[15] Thus another traditional characteristic of a material particle, i.e., it is made up of some ultimate stuff, is also challenged. Finally, the wave-particle duality denies it any definite and constant nature because under certain circumstances it appears to have a particle-nature, and under some other circumstances a wave-nature. In Capra's view, "atoms consist of particles, and these particles are not made of any material stuff. When we observe them, we never see any substance; what we observe are dynamic patterns continually changing into one another – a continuous dance of energy."[16]

One may point out that the quantum theory and the Copenhagen Interpretation are very controversial and so the conclusion drawn above on the basis of them cannot be free from controversy. However, the fact remains that they, despite their apparent oddities have withstood the test of time for over half a century. They have been very successful and to this day no better system has been forthcoming.

The scientific idea of force also has undergone significant changes in recent times with the advent of quantum theory. In the classical science it involved pulling or pushing one body by the other. The bodies "felt" the force of repulsion or attraction. These were anthropomorphic ways of describing the happenings and naturally suffered from imprecision. In quantum theory one talks not of force between particles, but of interaction between them mediated through the exchange of certain particles. The electric repulsion between two electrons is mediated through the exchange of a photon: According to the quantum explanation, what takes place can be put as a follows.

15. *Op. cit.*, p. 188.
16. *Op. cit.*, p. 188.

The first moving electron emits a photon and as a result suffers deviation from its direction of motion. The second moving electron absorbs that photon and as a result suffers a deviation in its direction. But now the direction is opposite to that of the first electron. The net result is that the two electrons move apart from each other. Hence a repulsive type of result is observed.

5. *Scientific knowledge is reductionist*

In providing us with knowledge about natural phenomena science often has recourse to the method of reduction. As James Trefil writes, "Western science has been largely based on the idea that the way to understanding anything in the physical world is to break it down to its constituent parts".[17] According to him, "the basic assumption of reductionism is that the underlying reality will be simple and beautiful and that the apparent complexity of the world is the result of complex relationships between simple objects".[18] Thus reduction consists in reducing an observed complex phenomenon to the behavior and operation of some simple and more fundamental entities. For instance, in classical physics increase in heat is explained by reducing the whole phenomenon to one of atoms moving with great speed and colliding with each other and with the walls of the container. When the atoms move faster and collide among themselves more frequently, more heat energy is produced and the body becomes hotter. This method of reduction can be traced to the Presocratic philosophers. According to many scholars, it was the ingenuity of Thales of Miletus that discovered this technique in the West.[19] It is a very powerful and widely used method and has made a tremendous contribution in making many natural phenomena intelligible. But it is based on a number of presuppositions, which have been challenged in recent times. First of all, it presupposes that complex bodies are made up of simpler ones. Furthermore, it assumes that certain fundamental entities and concepts exist and these do not change. Hence all structure and composition of complex bodies can be reduced to them; all complex phenomena can be accounted for in terms of operations and interactions among them. But if no

17. *The Moment of Creation* (New York: Charles Scribner's, 1983), p. 219.
18. Ibid., p. 220.
19. R.G.H. Siu points out in his *The Tao of Science* that this method was known to the Chinese already before 2000 B.C. See p. 7.

fundamental building blocks of matter and fundamental concepts exist or if they go on changing, then reduction cannot work reliably. Today in the light of the findings of quantum theory, the existence of stable, unchanging ultimate stuff of matter is highly questionable. Moreover, many leading philosophers of science[20] argue that all concepts in science are revisable and hence non-permanent.

III. SCIENCE AS THE PARADIGM OF PARADOXES

Our discussion leads us to conclude that science, as it has developed down through the centuries, is a mixed bag. It has wrought wonders undreamed of in the past, it now arouses fears equally undreamed of in the past. It is the greatest achievement of humans on earth, but it now threatens to become the greatest curse brought down by humans. At one and the same time it seems to be both the boon and bane for the human race and the planet earth. Man created science for the good of man, but today it is turning to bite the hand that has been feeding it. Man created science to be his most powerful and reliable friend, but today he is frightened of its awesome power. Man created science to help him to build a clean universe, but it has made a polluted and polluting universe. Man created science to build a world free from pain and suffering, today it is helping to make better tools of torture and mass destruction. Man created science to ennoble human dignity, today it is helping to dehumanize him to the level of a machine. Man created science to have dominion over nature, today man has become the slave of science. Indeed science today is a paradigm of paradoxes.

Another paradox arises when we consider the original goal of science. According to Francis Bacon and other founders of modern science, the purpose of science was to enable humans to rule over nature. In pursuit of this goal science seemed to have followed the strategy of divide and rule. It divided the world of experience, selected its own territory, and now gloriously rule over it. In the process it forgot the other territories; now it seems to have completely lost sight of them. This predicament has left science impoverished. Note that the original intent of the founders of modern science was not just

20. For instance, Dudley Shapere has argued this point time and again. See his *Reason and the Search for Knowledge* (Dordrecht: D. Reidel Publishing Company, 1984).

to have dominion over a small, highly restricted area of human experience; it was to have dominion over the *total* area. Hence science, as it has developed in our own times, remains *unfulfilled in its original goal*. This should be a matter of serious concern for scientists and non-scientists alike. For scientists, because the original goal of the founding fathers is something they themselves would endorse in their heart of hearts; for non-scientists, because this highly selective strategy of science deprives them of the possibility of participating fully in the successes of science. Too much selectivity and autonomy usually blocks possibilities of dialogue and interaction with other disciplines.

It is not my point that science should give up its highly successful and admirably effective strategy. Rather that it should not lose sight of its original intent and should take adequate steps to attain that without losing what it has already gained and is still gaining.

How can this paradoxical predicament be resolved? Two extreme views need to be rejected. Both follow the strategy of putting the blame on the other and placing the burden of repair and reparation on the other. The first one is proposed mainly by the non-scientists. It blames science for all the problems and believes that the solution lies in blunting the importance and effectiveness of science. The second one is suggested by some scientists. According to this suggestion, these problems are irrelevant to science and hence should be ignored. I think that both these approaches are unacceptable because we do not want to throw the baby with the bath. We need science, we want it to be powerful, effective, and productive. At the same time we do not want a scientific world heading towards its own destruction, we do not want a scientific world that is dehumanizing and heartless. Is there some way of giving science a heart without losing its head?

It is often said that science is a neutral discipline or source of knowledge because it only places almost unlimited power and possibilities in human hands and is totally neutral about the use of this power. It is for the humans to make or break the universe. A knife in the hands of an able surgeon *gives* life, the same in the hands of a criminal *takes* life. Nuclear power can be used for peaceful purposes to improve the quality of life and our planet, it can also be used to wipe out our race and planet. It all depends on the humans who make the decision and execute it. Hence, it is argued, science should be left blameless.

It should be admitted that there is a distinction between production of something and the use of it. It is unjust to put all the blame on the producer when somebody else misuses the product. In the case of science the situation is not so straight forwardly simple: on the one hand, we cannot put all the blame of the destructive use on science; on the other hand, we cannot absolve it of all responsibility. Science does not exist and operate in a vacuum. Science without humans to make use of it makes no good sense since science by its very nature is practical-oriented. Science does involve speculation and theorization, but it never stops at that. Philosophy can, and at times does, stop at that. This is one of the main differences between science and philosophy. History tells us that science originated in the context of certain need of the people concerned. For instance, Thales, the first Greek scientist made his contributions to astronomy because the movement of the heavenly bodies he considered important in the daily life of the people. The old saying, "necessity is the mother of invention," is nowhere more pertinent than in the case of science, as any student of history of science knows. If science by its nature is practical-oriented, it necessarily involves humans to make use of it. Even if it was created to satisfy the curiosity of some select persons, still it requires persons of curiosity. Humans will always be involved in the development and use of science, and if this is so, there will be good use and bad use of it. Science is for the real world, not for the ideal one.

Although an extremely complex and highly involved issue of this kind allows no easy and final solution, certain developments in contemporary science itself may give us some hints at a possible solution. The realization is gaining currency in scientific circles today that scientific knowledge of itself is incomplete and hence needs to be complemented. The principle of complementarity, developed by Niels Bohr, and the uncertainty principle, among others, point to this conclusion. Another realization that our universe is closely interconnected is also gaining acceptance even among the highly specialized scientists. On the one hand, this means that there is a deep interconnectedness among various disciplines. On the other hand, it implies that science is unable to to give us complete answers since such answers covering all the relevant aspects will necessarily involve considerations of the connected disciplines. Both of these points indicate the urgent need for appealing to other sources for a more complete understanding. Since our life is crucially based on our understanding, this refers to our life as well.

IV. SCIENCE AND RELIGION

It is in this context that religion and moral principles become significant for science. Integration of religious and moral principles with scientific activities is one way to resolve the paradoxical predicament we have discussed earlier.

Religion in this context should be understood in a very general sense. Every one knows the difficulty in defining it fully satisfactorily. For our purpose, religion can be taken to mean a set of beliefs which unites a community together and offers a certain means to relate the individuals among themselves and to what is taken as the ultimate nature of reality in order to provide them with meaning and fulfillment in life. Thus religion involves, the good of the individual, the common good or the good of the community, a relationship with the Ultimate that transcends the here and now, the quest for meaning and fulfillment in life. A religious believer cannot be lost in his/her little world. He has to rise above his personal world and be sensitive to the needs and feelings of others. He cannot confine himself to the immediately accessible, he has to transcend the world of immediate experience to recognize and acknowledge some supernatural being. All these factors go to widen the sphere of his life, concern, and operation. They transform the religious person into a cosmic being. A person with such a cosmic sense and connections will have to subscribe to sound moral principles, since by their very nature they are meant to give such a sense.

The suggestion is not that the injection of a good dose of religion will cure all the maladies. Religion is no panacea. Indeed, there are cases where religion (as it was practiced at the time) became part of the problem, rather than of the solution.[21] Historically religion often got mixed up with other factors like politics, economics, personal ambitions of individuals, etc. One often finds the religious sense discussed in the previous paragraph in the original spirit advocated by great religious founders like Jesus of Nazareth, Gautama Buddha, etc. Of course, many of their ideas were conditioned by the needs of their times and today they need to be adapted to our circumstances.

What I point out in this paper is that science has achieved its unprecedented success principally by distancing itself from certain

21. Jawaharlal Nehru in his *Discovery of India* holds an even stronger view.

parts of life and reality, parts with which it had close association in its initial stages, and by selecting and thoroughly concentrating on very limited aspects of reality This isolation and specialization has led science to forget its original goal. It seems to have lost its heart. Today it is becoming very much like a monster ready to devour its own makers. This situation can be averted if scientists and those who put science into use take seriously certain religious and moral principles. Religion can provide science with a heart. I believe that Einstein had this kind of view in mind when he declared: "Science without religion is lame, religion without science is blind."[22]

The suggestion made here is no utopian one. Take the case of nuclear power. Science has unlocked an almost unlimited source of power that can be used for the good or for the damnation of humankind. If the persons responsible for the creation and employment of this power are governed by sound religious principles of the common good and accountability to a supreme being, they will not use it for destructive purposes. The history of the major wars tells us that selfishness and unjustified pride was at the root of the development and use of weapons of mass destruction. Or again take the case of the problem of industrial pollution. When making greater profit becomes the most decisive factor in the use of technology, pollution is the direct outcome. Persons guided by proper religious and ethical principles cannot subscribe to the profit-alone-matters philosophy. The computer and artificial intelligence revolution need not lead to dehumanization, if due respect is given to human dignity, as any good religion would demand. Thus a rationally healthy marriage between science and religion can go a long way towards resolving the paradoxical situation science has reached today.

Science in itself does not need religion, religion in itself does not need science. They both are powerful and autonomous enough to manage on their own. But we have seen that science without humans makes no sense. When it has to be used by humans and for humans, religious and ethical principles will have to come in. Otherwise science may turn out to be a powerful monster whose power itself becomes its worst weakness because it will dare to devour those it came to serve.

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22. *Ideas and Opinions* (New York: Bonanza Books, 1954), p. 46.