1. SCIENCE AND HUMAN VALUES.

This book is about what you are, and how you are connected to what you are not. It is about the impact of the revolutionary developments in physics during the twentieth century upon science's idea of you as a thinking entity, and your linkage to 'the other'.

These questions might appear to belong more to philosophy, metaphysics, or religion, rather than to physics, which is usually assumed to deal only with such tangible items as machines, rockets, transistors, and atomic bombs. But the radical change in our understanding of the physical world that occurred during the twentieth century has converted connections that formerly had been matters of pure philosophical speculation into causal properties dealt with by basic physical theory.

Science has improved our lives in many ways. It has lightened the load of tedious tasks and expanded our physical powers, and thereby contributed to a great flowering of human creative energy. On the other hand, it has also given us the capacity to ravage the environment on an unprecedented scale and obliterate our species altogether. Yet along with this fatal power it has provided a further offering which, though subtle in character and still hardly felt in the minds of men, may ultimately be its most valuable contribution to human civilization, and the key to human survival.

Science is not only the enterprise of harnessing nature to serve the practical needs of man. It is also part of man's unending search for knowledge about the universe and his place within it. This quest is motivated not solely by idle curiosity. Each of us, when trying to establish values upon which to base conduct, is inevitably led to the question of man's role in nature. The linkage of this philosophical inquiry to the practical question of personal values is no mere intellectual abstraction. Martyrs in every age are vivid reminders of the fact that no influence upon human conduct, even the instinct for self preservation, is stronger than beliefs about one's relationship to the power that shapes the universe. Such beliefs form the foundation of a person's self image, and hence, ultimately, of his values.

It is often claimed that science stands mute on questions of values: that science can help us to achieve what we value once our priorities

are fixed, but can play no role in fixing these weightings. That claim is certainly incorrect: science plays a key role in these matters. For what we value depends on what we believe, and what we believe is increasingly determined by science.

A striking example is the impact of science upon the system of values promulgated by the church during the Middle Ages. That structure rested on a credo about the nature of the universe, its creator, and man's connection to that creator. Science, by casting doubt upon that belief, emasculated the system of values erected upon it. Moreover, it put forth a credo of its own. In that "scientific" vision human beings were converted from sparks of divine creative power, endowed with free will, to automatons---to cogs in a giant machine that grinds inexorably along a preordained path in the grip of a blind mechanical process.

Gone from this "scientific" picture of our species is any rational basis for the notion of a person's responsibility for his own actions. Each of us is asserted to be a mechanical extension of what existed prior to his birth. Over that earlier situation one has no control. Hence over what emerges, preordained, from that prior state one can bear no responsibility.

Given this conception of man, the collapse of moral philosophy is inevitable. This notion of human beings provides no rational basis for any value but self interest: behavior promoting the welfare of others, including future generations, becomes rational only to the extent that such behavior serves one's own interests. Hence science becomes doubly culpable: it not only undermines the foundations of earlier value systems, but also strips man of any vision of himself and his place in the universe that could be the rational basis for any elevated set of values.

This mechanical picture of man is the image created by the science that reigned early in the twentieth century. According to that view the physical universe is composed of tiny separate bits of reality, and the unfolding, or evolution in time, of nature is completely fixed by direct contact interaction between these localized microscopic parts. Human beings, insofar as they belong to this physical aspect of nature, are simply conglomerations of these elemental material bits.

During the twentieth-century this simple picture of nature was found to be profoundly wrong: it failed not just in its fine details, but at its

fundamental core. In place of the old idea Heisenberg, Bohr, and their companions erected a vastly different conceptual framework. They were forced to a radical alteration of the very subject matter of physical theory itself by the strange character of the new mathematical rules, which were invariably validated by reliable empirical data.

The new theory accounts in a uniform manner for all the successes of the earlier physical theories, plus the immense amount of newer data where the earlier methods fail abysmally. However, it describes a world built not out of bits of matter, as matter was understood in the nineteenth century, but rather out of bits information. Straightforwardly interpreted, the quantum rules describe a universe built out of *a new kind of stuff* whose properties combine features formerly conceived to be imbedded in the physical world with aspects that belong our streams of conscious thoughts.

The laws that govern the evolution of the world over the course of time differ significantly from the pre-twentieth century idea of these rules. According to the new physics, this evolution is specified not by a single causal process but rather by an interplay between two very different ones. The first of these is analogous to the operation that fixes the development of the material world in classical physics, and it is "locally deterministic": what occurs at any point is completely fixed by what has just happened at nearby points. But that local rule is not the whole story. At certain instants *second kind of process* intervenes: a "quantum jump" occurs. This intervention is highly non-local: it involves, in a well specified way, coordinated changes in regions that can lie far apart. The structure of these abrupt changes are mathematically similar to sudden increases in knowledge or information. Indeed, the original, and still orthodox, "Copenhagen" interpretation of quantum theory associates each quantum jump with an actual increase in somebody's knowledge. Thus our basic scientific theory of the physical world, in its orthodox formulation, has become intrinsically entwined with our streams of conscious knowings.

The existence of this "second process" provides a reprieve from the classical-physics verdict that human thoughts and feelings can make no difference in the flow of physical events. The new theory involves choices that are not determined by any currently known law of nature, but that can nevertheless strongly influence the course of physical

events. This means that contemporary science accommodates causally efficacious free will. The new physics allows, and in fact demands, the occurrence of happenings that, on the one hand, are fixed by no known law, statistical or otherwise, yet, on the other hand, can influence in mathematically determined ways, the flow of our experiences about the physical world. The details of how this influence works match beautifully with the empirical findings that have accumulated over the past few decades in the field of the psychology of attention.

The potency and novelty of the new dynamics both stem directly from the property of “quantum entanglement”, and the closely related feature called “quantum nonlocality”. Entanglement is the property of two (or more) systems that have strongly interacted with each other but then moved far apart, to become, according to the theory, a single unified entity until observations are made that re-establish independent properties for the spatially separated parts.

This entanglement feature leads to the truly remarkable property of non-locality: in certain cases the behavior of the faraway partner of an entangled pair of objects or systems depends upon **what you decide to do** to its mate. Moreover, the behavior of that faraway system is influenced **before** the information about what you do to its mate can arrive---traveling at the speed of light.

These strange features of the quantum world need to be thoroughly comprehended before any real grasp of your role in nature is possible. Accordingly, those oddities will later be described in detail. But the upshot of these radical changes is this: Taken at face value, the new mathematical description of the universe portrays you as an integral aspect of a partially thought-like, and malleable, nonlocal world that is not identical to your body/brain; but that can, by free-willed actions, influence what happens in your body/brain. This participatory view contrasts starkly with the earlier science-based image of the human person as a disconnected and accidental conglomeration of atoms being mindlessly buffeted about by the chance collisions of atoms.

But what impact, if any, does this altered idea of what you are have upon your life ? Does not a completely rational approach still lead you to value only your own well being? Perhaps so! But this leads to the further question: What is the self whose well being one values?

Values arise from self-image. Generally one is led by training, teaching, propaganda, or other forms of indoctrination, to expand one's conception of the self: one is encouraged to perceive oneself as an integral part of some social unit such as family, ethnic or religious group, or nation, and to enlarge one's self-interest to include the interests of this unit. If this training is successful your enlarged conception of yourself as good parent, or good son or daughter, or good Christian, Muslim, or Jew, causes you to give weight to the welfare of the unit as you would yourself. In fact, if well conditioned you may give more weight to the well-being of the group than to that of your bodily self.

In the present context it is not relevant whether this human tendency to enlarge one's self image is a consequence of natural malleability, instinctual tendency, spiritual insight, or something else. What is important is that we humans beings do in fact have the capacity to d our image of "self", and the enlarge concept can become the basis of a drive so powerful that becomes the dominant determinant of human conduct, overwhelming every other factor, including even the instinct to survive.

But where reason is honored, belief must be reconciled with empirical evidence. If you seek evidence for your beliefs about what you are, and how you fit into nature, then science claims jurisdiction, or at least relevance. Physics presents itself as the basic science, and it is to physics that you are told to turn. Thus a radical shift in the physics-based conception of man from that of an isolated mechanical automaton to that of an integral participant in the nonlocal process that gives form to the evolving universe is a seismic event of potentially momentous proportions.

The quantum concept, being based on objective science equally available to, and applicable to, all men, rather than arising from special personal circumstances, has the potential of providing a universal system of values suitable to all people, without regard to the accidents of their origins. With the diffusion of this quantum conception of Man science may fulfill itself by adding to the material benefits it has already provided a philosophical insight of perhaps greater ultimate value.

This issue of the connection of science to values can be put into perspective by seeing it in the context of a very brief historical

account. For this purpose let human intellectual history be divided into five periods: traditional, modern, transitional, post modern, and contemporary.

During the “traditional” era our understanding of ourselves and our relation to nature was based on “ancient traditions” handed down from generation to generation: “Traditions” were the chief source of wisdom about our connection to nature. The “modern” era began in the seventeenth century with the rise of what is still called “modern science”. That approach was based on the ideas of Bacon, Descartes, Galileo and Newton, and it provided a new source of knowledge that came to be regarded by many thinkers as more reliable than tradition.

The basic idea of modern science was “materialism”: the idea that the physical world is composed basically of tiny bits of reality whose contact interactions with adjacent bits completely control everything that is now happening, and that ever will happen. According to these laws, as they existed in the early twentieth century, a person’s conscious thoughts and efforts can make no difference at all to what his body/brain does.

This materialist conception of reality began to crumble at the beginning of the twentieth century with Max Planck’s discovery of the quantum of action. Planck announced to his son that he had, on that day, made a discovery as important as Newton’s.

That assessment was certainly correct: the ramifications of Planck’s discovery were eventually to cause Newton’s materialist conception of physical reality to come crashing down. Planck’s discovery marks the beginning of the “transitional” period.

A second important transitional development soon followed:

In 1905 Einstein announced his special theory of relativity. It denied the validity of our intuitive idea of the instant of time “now”, and promulgated the thesis that even the most basic quantities of physics, such as the length of a steel rod, and the temporal order of two events, had no objective “true values”, but were well defined only “relative” to some observer’s point of view.

Planck’s discovery led by the mid twenties to a complete break-down, at the fundamental level, of the material conception of nature. A new basic physical theory was developed, principally by Werner

Heisenberg, Niels Bohr, Wolfgang Pauli, and Max Born, and it brought “the observer” explicitly into physics. The earlier idea of describing reality completely in terms of tiny bits of matter was abandoned, and science was construed to be a human endeavor to understand the structure of human experience, rather than a quest to discover the form of nature herself. This successor to classical physical theory is called “Copenhagen quantum theory”.

This turning away by science itself from the tenets of the objective materialist philosophy lent support to Post-Modernism. That view, which emerged during the second half of the twentieth century, promulgated, in essence, the idea that all “truths” were relative to one’s point of view, and were mere artifacts of some particular social group’s struggle for power over competing groups. Thus each social movement was entitled to its own “truth”, which was viewed simply as a socially created pawn in the power game.

The connection of Post-Modern thought to science is that both Copenhagen Quantum Theory and Relativity Theory had retreated from the idea of observer-independent objective truth: science in the first quarter of the twentieth century had not only eliminated materialism as a possible foundation for objective truth, but had discredited the very idea of objective truth in science. Yet if the community of scientists have renounced the idea of objective truth in favor of the pragmatic idea that “what is true for us is what works for us,” then every group becomes licensed to do the same, and the hope evaporates that science might provide objective criteria for resolving contentious social issues.

This philosophical shift has had profound social ramifications. But the physicists who initiated this mischief were generally too interested in practical developments in their own field to get involved in these philosophical issues. Thus they failed to broadcast an important fact: already by mid-century, a development in physics had occurred that provides an effective antidote to both the ‘materialism’ of the modern era, and the ‘relativism’ and ‘social constructionism’ of the post-modern period. In particular, John von Neumann developed, during the early thirties, a form of quantum theory that brought the physical and mental aspects of nature together as two aspects of a rationally coherent whole. This theory was elevated, during the forties---by the work of Tomonaga and Schwinger---to a form compatible with the physical requirements of the Theory of Relativity.

Von Neumann's theory, unlike the transitional ones, succeeded in integrating into one coherent idea of reality the empirical data of subjective experience with the basic mathematical structure of theoretical physics. Von Neumann's formulation of quantum theory is the starting point of all efforts by physicists to go beyond the pragmatically magnificent but ontologically incoherent Copenhagen form of quantum theory.

Von Neumann capitalized upon the key Copenhagen move of bringing human knowings into the theory of physical reality. But whereas the Copenhagen approach excluded the bodies and brains of the human observers from the physical world that they sought to describe, and renounced the aim of describing reality itself, von Neumann demanded logical cohesion and mathematical precision, and was willing to follow where this rational approach led. Being a mathematician, fortified by the rigor and precision of his thought, he seemed less intimidated than his physicist brethren by the sharp contrast between the nature of the world called for by the new mathematics and nature of the world that the genius of Isaac Newton had concocted.

The common core feature of Copenhagen and von Neumann quantum theory is the incorporation of human knowings into the structure of basic physical theory. How this is done, and what the consequences of doing it are, is the subject of this whole book. I begin by sketching out a little bit of the historical background.