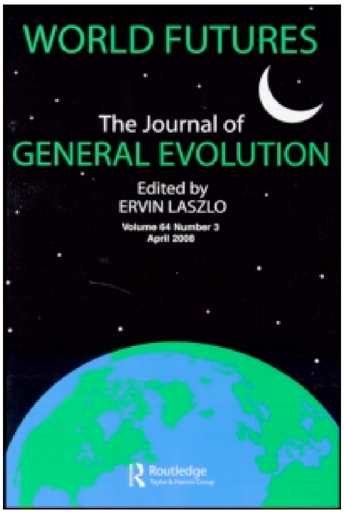

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THE ROLE OF HUMAN BEINGS IN THE QUANTUM UNIVERSE

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A profound change in our scientific understanding of the role of human beings in the unfolding of our streams of conscious experiences was wrought by the 20th-century switch from classical mechanics to quantum mechanics. The streams of consciousness thoughts of human beings were converted from causally inert passive witnesses of the unfolding of a mechanically controlled and causally self-sufficient physical universe into logically needed dynamical inputs into the physical aspects of nature. These physical aspects, as they are now understood, contain causal gaps that are neatly filled by inputs from the realm of our conscious thoughts in a way that allows our conscious intentions to tend to produce their intended consequences.

KEYWORDS: Brain, mental causation, mind, quantum collapse, quantum mechanics.

THE BASIC QUESTION AND WHY IT IS IMPORTANT

Science's conception of the physical world changed radically during the twentieth century, and the conception of the role of human beings in that world changed in a closely coordinated way.

The scientific conception of the world that prevailed from the time of Isaac Newton until the beginning of the twentieth century was that of a giant machine. The world was imagined to be fundamentally similar to a huge clock, with its interlocking cogs and wheels grinding out with mechanical precision the preordained unfolding of physical reality. The physical bodies of human beings were therefore understood to be mechanical automata, with our conscious intentional efforts considered to be passive byproducts of the complex activities of our brains. These experiential aspects of reality were considered to be causally inert, in the sense that they could produce no effects on the physically described world—beyond the effects entailed already by the purely physically described connections acting alone.

Within that earlier pre-twentieth-century conception of nature the existence of our streams of conscious thoughts constituted a major embarrassment. The

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occurrence of things having the defining characteristics of our conscious thoughts was in no way entailed by the properties of the physical world that the physicists had postulated in order to produce their causally closed theory of the physical world. Our thoughts, ideas, and feelings could be imagined to be produced—in some unexplained way—by the complex activities of our brains. But there was no logical basis in the classical physicists' conception of nature for understanding or explaining the emergence of human experience. Although philosophers wove endless tapestries of words in an effort to relate the physically described aspects of the world to the experientially felt aspects of our lives, the efforts of those thinkers were invariably judged inadequate by their critically minded colleagues. Insofar as our brains were understood in terms of the concepts of classical physics a gap persisted. A chasm resisting rational closure remained between, for example, a painful feeling and the corresponding motions—no matter how complex and novel—of the physically described parts of the associated brain.

During the twentieth century this classical-physics-based conception of the world was found to be logically incompatible with a growing accumulation of empirical data. Eventually, the classical mechanistic description of the physical aspects of nature was replaced by a profoundly different quantum mechanical description.

The orthodox formulation of quantum mechanics, which is the form used in all practical applications, was created by Heisenberg, Bohr, Pauli, and Born during the 1920s. Shortly thereafter it was cast into a more rigorous logical and mathematical form by the logician and mathematician John von Neumann.

Quantum mechanics differs from classical mechanics in deep mathematical ways. In order to tie the new mathematical structure to empirical data in a practically useful way the founders of quantum mechanics instituted a profound break with one of the basic principles of classical physics: they inserted the conscious experiences of human beings into the dynamical workings of the theory. Human beings were allowed, and indeed required, to act not merely as passive witnesses but also as causally efficacious agents. Specifically, orthodox quantum mechanics requires every observation to be preceded, logically, by an action that specifies a "Yes-or-No" question, which a feedback "observation" will immediately answer either by a "Yes" or by a "No." Both of the two actions, the query and the feedback, are causally efficacious: they alter in different non trivial ways the physically described state of the universe. Each of these two actions is described in two different ways. It is described first in the psychological language that we use to communicate to each other, and to ourselves, the structure of our experiences. And this action is described also in the mathematical language of quantum physics. Each psychologically described event becomes thereby linked, *within the theory*, to a mathematical description of the physical world.

In this quantum mechanical description, the unfolding of the universe is no longer governed exclusively by the physical aspects of the description of nature. Neither of these two actions, neither the query nor the feedback, is linked within the orthodox theory to some prior physically described sufficient condition. In particular, within orthodox quantum mechanics, our causally efficacious conscious intentional efforts are free of any specified physical coercion.

But why are these seemingly arcane matters important? Why, in the context of the major concerns of the human race, are these scientific considerations pertinent?

They are important because science's pronouncements on the nature of our own being, and on the character of the connection of our conscious intentional efforts to the unfolding of the physical reality, underlie much of the rational discourse on urgent societal issues.

The classical-physics-based conception of human beings has had a highly corrosive impact on societal matters because it paints us as, on the one hand, mechanical automata, whose conscious intentional efforts can have no causal effects whatever on the physically described aspects of nature, and, on the other hand, as mechanical consequences of a dog-eat-dog competition for survival. The consequence of the first effect is to discourage effort as pointless and irrational; and the consequence of the second effect is to promote anti-social behavior directed toward self-aggrandizement at the expense of the welfare of others, and of other social and cultural groupings.

Our beliefs about our relationship to the world around us underlie our values, and our values determine the sort of world we strive to create. The main social problems we face today stem primarily from the fact that different approaches to this basic question of our own nature, and our connection to the physically described world lead to different conclusions, and hence to conflicting values, and consequently to conflicting actions. Thus an important question is this:

What does basic physics—namely quantum mechanics—say about the nature of the physically described world in which we are imbedded, and about the connection of our thoughts, ideas, and feelings to that world?

FROM THE CLASSICAL TO THE QUANTUM MECHANICAL CONCEPTION OF THE ROLE OF HUMAN BEINGS IN THE UNFOLDING OF REALITY

Quantum mechanics rests on a mathematical foundation provided by classical mechanics. The latter rests on the idea of "particles" and "fields." A particle is supposed to have, at each instant of time, a position and a velocity in three-dimensional space. A field is supposed to have, at each instant of time and each location in three-dimensional space, a "value," specified by a real number. The field variables are connected to the particle variables in a way that allows one to compute the forces upon—and hence acceleration of—each particle due to the presence and the motions of the other particles.

Newton conjectured the existence of repulsive forces that prevent particles from coming too close to each other. This condition combined with his other laws appears to entail "causal closure of the physical": the description of the physical aspects of the state of the universe at one single time, or perhaps over some short interval of time, determines the physical aspects of the state of the universe for all times.

This closure feature allows the evolving state of the universe to be pictured as a block physical universe; namely by a collection of infinitely thin "wires" running through space–time, in the direction of increasing time, and in a way that is uniquely determined for all times by this physical structure at any single instant of time. (The "fields" should also be represented, but the pictorial image is slightly more complicated.) No representation of experience, or knowledge, or experienced intent need be added. That is why this imagined property is called "causal closure of the physical."

The transition from classical mechanics to quantum mechanics brought human knowledge and experience into the theoretical framework. The reason, basically, is this: the way the mathematical/physical description enters into practical applications is closely analogous to the way that the mathematical/physical description enters into classical *statistical* mechanics. But classical statistical mechanics is, in regard to its practical applications, closely tied to human knowledge: A sudden change in "our knowledge" causes, in classical statistical mechanics, a sudden change in the mathematical/physical representation of our knowledge.

A key feature of quantum mechanics is the "Heisenberg Uncertainty Principle." The effect of this principle is, essentially, to convert each "wire" of the block universe picture into a smear of possibilities. More precisely, for a many-particle universe, it is to replace the one single classical many-particle universe by the collection of all such (weighted) possibilities compatible with the present state of "our knowledge." Because of the sensitive dependence of macroscopic degrees of freedom on microscopic initial conditions, the diversity of this population of possibilities tends to increase with the passage of time. But from time to time we gain, via our (sense) experiences, new knowledge. Just as in the case of classical statistical mechanics, this new knowledge will usually exclude some of the possibilities that were mathematically generated by the equations of motion acting on the mathematical representation of our prior knowledge. Thus the sudden gain in knowledge will be coordinated to a sudden "collapse" of the mathematical representation of our state of knowledge just before the gain in knowledge to the "reduced" state just after this gain in knowledge. The physically described "collapse" is thus a logical consequence of our increased knowledge.

There is nothing mysterious about such "collapses" in classical statistical mechanics, and the "collapses" that occur in quantum mechanics are, at the level of actual scientific practice, analogous to it: the mathematical representation of "our knowledge" changes abruptly when "our knowledge" changes abruptly.

But there is a conceptual problem: the different "classically conceived possibilities" interfere with each other in a way that they cannot do in classical statistical mechanics, but that would be understandable if the mathematical representation of our knowledge described an objectively real structure, instead of just an idea about a set of classically conceivable possibilities.

The resolution of this conceptual problem is to interpret the mathematically described state of the universe as a representation not of just epistemic possibilities but rather of potentialities: that is, as a representation of objective tendencies, created by past psychophysical events, for the occurrence of future psychophysical events. This interpretation is essentially implicit in orthodox quantum mechanics. This understanding places "our knowledge" in a much more central, and indeed, in a much more dynamical, position than what its place was in classical mechanics.

Of course, science has always been about "our knowledge" in a certain ultimate way. It is about what we can know, and how we can use what we know to affect what we will experience in the future. However, the effect of Newton's monumental work was to push questions about knowledge and our acquisition of knowledge out of the domain of the physical sciences themselves: human knowledge and its acquisitions played no role in the causal structure of the physically described aspects of nature envisaged in the conception of nature suggested by Newton's Principia. The elevation of the "physically represented information" of classical physics, whose causal structure is completely contained in the self-sufficient physical descriptions, to the causally efficacious "knowledge" of quantum physics constitutes a radical break with the Newtonian-physics-based model of the relationship between mind and matter.

The main idea in quantum physics is that each acquisition of knowledge occurs discretely in conjunction with "a collapse of the quantum state" to a new form that incorporates the effect of adding the conditions logically imposed by the increase in knowledge. This change forges a tight logical linkage between "an experientially recognized change in a state of knowledge" and a corresponding "mathematically represented change in the physical state of the universe." The new physical state represents, in quantum mechanics, not simply a new state of "our knowledge," but also a new set of potentialities for future psychophysical events.

A SYSTEMATIC ACCOUNT

The "Classical" Approach is Materialism

Three key ideas of the classical physics of the late nineteenth century are:

1. There exists a material universe that develops over the course of time by means of interactions of tiny material parts with neighboring tiny material parts.
2. These interactions are governed by mathematical laws.
3. These laws entail that the material future is completely determined by the material past, with no reference to human thoughts, choices, or efforts.

This conclusion is called: The principle of the causal closure of the physical. This "Principle" seemed at one time so secure, and so central to the scientific enterprise, that some scientists came to view science as not just an open-minded empirically based inquiry into the structure of the world, but also as an ideology: that is, as a tenacious defender of the dogma that we human beings are essentially material systems governed exclusively by matter-based laws and hence that our conscious thoughts can have no actual effects on our physical actions.

This dogma blocks rational action: One cannot rationally choose to act to achieve a physical effect if one truly believes that conscious choices can have no physical effects. One cannot act completely rationally while truly believing the materialist dogma!

Quantum Mechanics Rescinds the Materialist Dogma

Contemporary basic physics—specifically quantum mechanics—fails to validate/vindicate/support The Principle of the Causal Closure of the Physical!

In spite of this loss of its scientific underpinning, the classical materialist ideology, including the presumption of causal closure, continues to infect the thinking of many scientists and philosophers.

The Basic Conflict Between Classical and Quantum Physics

Classical mechanics assumed that the ideas that work well for large objects, such as planets, moons, and falling apples, will continue to work all the way down to the level of the atoms and molecules.

According to this classical notion, each particle, such as an electron, has a well-defined trajectory in space–time. This idea is illustrated in Figure 1. The classical-physics laws of motion ensure that the trajectories of all the particles (and fields) in the universe at times earlier than some fixed time t fix the trajectories of all particles for all future times.

A principal change introduced by quantum theory is the "quantum uncertainty principle." This principle asserts that each particle must be represented, NOT by one single well-defined trajectory, but by a cloud of possible trajectories, as is shown in Figure 2.

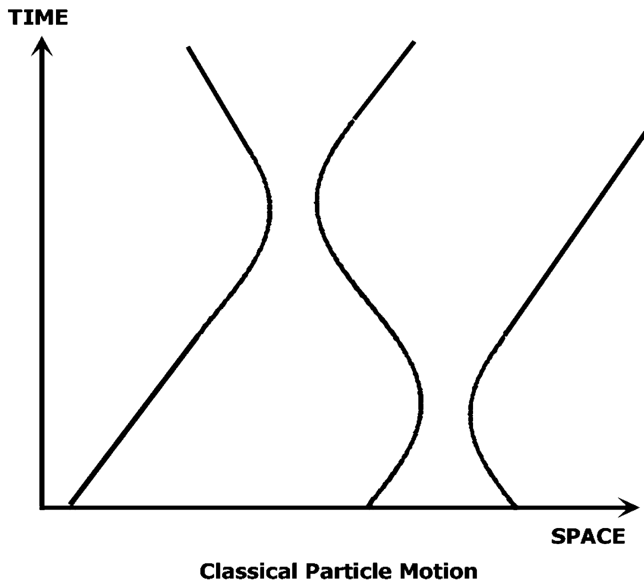
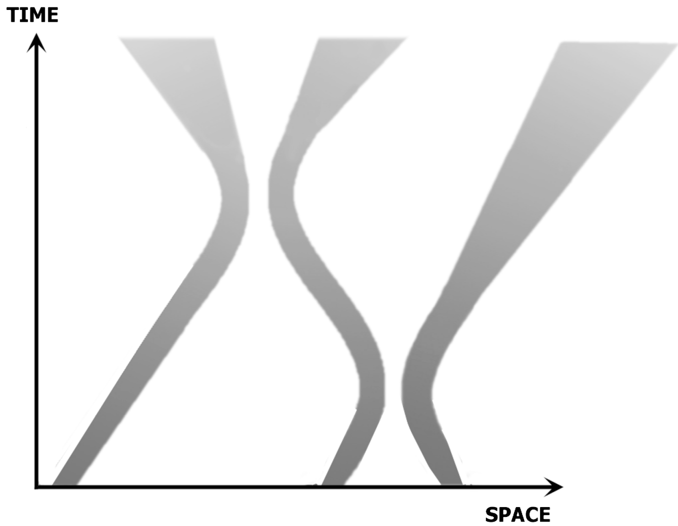


Figure 1. *An evolving Classical State.* The diagram shows a possible evolution in time of a system consisting of three classically conceived electrons. Each particle has a well-defined trajectory in space–time, and each particle repels the others increasingly as their trajectories come closer together.



Quantum Clouds of Potentialities

Figure 2. *An evolving Quantum State*. The diagram shows a possible evolution in time of a system consisting of three quantum mechanically conceived electrons. Each particle is represented by a cloud of possible trajectories.

The effect of these uncertainties, if left unchecked, would be disastrous.

The uncertainties at the atomic level tend to bubble up, irrepressibly, to macroscopic levels. If the uncertainties originating at the micro-level were left unchecked from the time of the "big bang," the macroscopic world would be by now a giant cloud encompassing all possible worlds, in stark contrast to the essentially single macroscopic world that we actually observe.

For example, if the uncertainties were left unchecked then the moon would be spread out over much of the night sky; and each person's brain would correspond to a mixture of all of the many alternative possible streams of consciousness that the person could in principle be having, instead of corresponding to the essentially single stream of consciousness that each of us actually experiences.

To deal with this difficulty the founders of quantum theory were forced to draw a clean conceptual distinction between the two aspects of scientific practice, the empirical and the theoretical, and to introduce a special process to account for their interconnection.

The empirical component describes our experiences pertaining to what we human beings do, and to the feedbacks that we then receive. The theoretical component describes objectively existing "particles and fields." The process that connects these two aspects of the scientific description of the world is called the process of measurement or observation. This feature of the quantum mechanical erects a firewall that protects the empirical (experiential) realm from the intrusion of quantum uncertainties from the theoretical realm.

The Firewall that Holds the Quantum Uncertainties in Check

But how are the quantum uncertainties held in check? The theory of the process of measurement was put into rigorous form by John von Neumann, building on ideas of Werner Heisenberg.

The theory demands that each experience occur in conjunction with an associated process 1 action. This action specifies a particular psychologically understandable question that "nature" must then answer either "Yes" or "No." (Multiple choice questions can be reduced to sequences of Yes-or-No questions.)

Each such action is a psycho-physical event. *It has two related aspects*, one in the empirical domain of "our knowledge," and the other in the domain of the mathematical description.

On the empirical side the action specifies a certain possible "increment in knowledge": an experientially recognizable "Yes" response to the question.

This "Yes" answer is linked on the mathematical side, to a reduction of the prior quantum mechanical state to that part of itself that is consistent with the increase in knowledge corresponding to the answer "Yes."

If nature fails to deliver the answer "Yes," then the prior physical state becomes reduced to the part of itself that is associated with the answer "No."

The process 1 action of *posing* the question is represented in Figure 3.

Von Neumann calls the physical aspect of this action by the name "process 1." Two important facts about process 1 are:

1. The process 1 actions enter importantly into the dynamics.
2. Quantum mechanics does not identify any logically sufficient physically described cause for this action!

Consequently, the "principle of the causal closure of the physical" is not entailed by the rules and content of orthodox quantum mechanics!

The measurement process has a second part: the Yes-or-No feedback from the associated process 1 probing action. This second stage of the measurement process is called process 3. (Von Neumann gives the name "process 2" to the continuous deterministic time evolution that is governed by the Schroedinger equation.) Process 3 picks one or the other of the two possible answers, "Yes" or "No." This process 3, unlike process 1, is subject to statistical conditions. Process 3 is pictured in Figure 4.

According to quantum mechanics, the responses/feedbacks conform to statistical conditions that are specified by the theory.

The choice of the feedback (or outcome) is what Dirac called (see Bohr, 1958, 51) "a choice on the part of nature."

According to quantum mechanics, this choice of outcome is statistical, and it lies outside the hands of human beings. The choice of the process 1 probing action is what Heisenberg called (see Bohr, 1958, 51) "a choice on the part of the 'observer' constructing the measuring instruments and reading their recording."

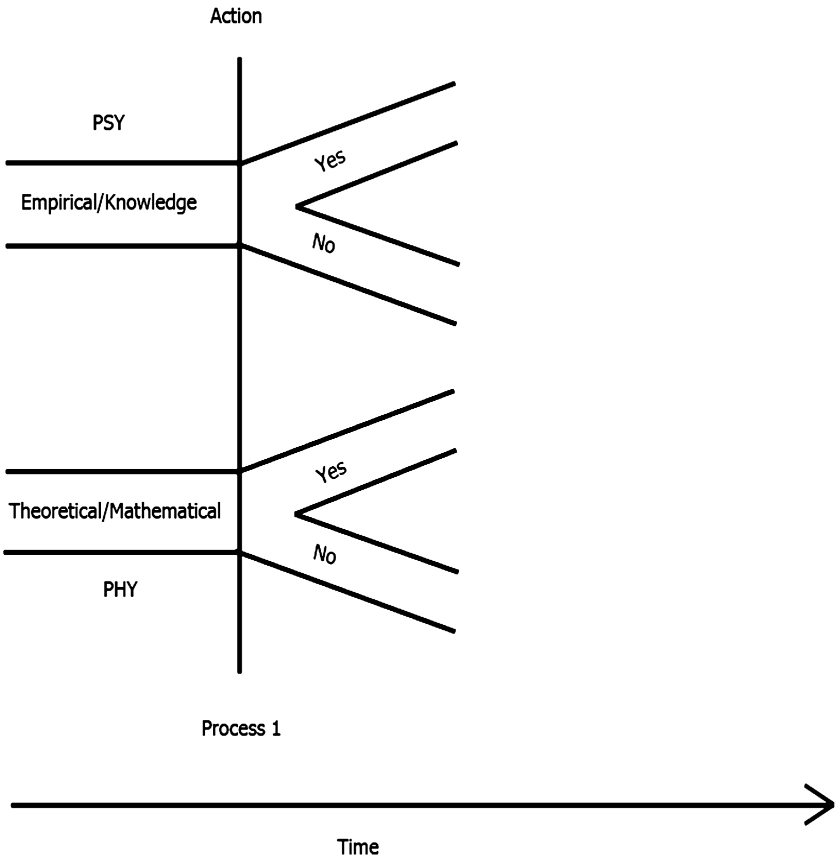


Figure 3. *Process 1*. Each quantum (reduction) event has both a psychologically described aspect and a closely related physically described aspect. Each process 1 event specifies a psychologically recognizable *possible* experience associated with an answer "Yes" to a query. This "Yes" answer is associated with a projection operator P that acts on the mathematical representation of the physical brain. The alternative *possible* answer "No" is associated with the projection operator $P' = (1\text{-}P)$.

As regards this choice Bohr (1958, 73) says: "The freedom of experimentation [. . .] corresponds to the free choice of experimental arrangement for which the quantum mathematical formalism offers the appropriate latitude."

These remarks by the founders of quantum mechanics emphasize the clear difference between the choices of outcomes, which are statistically constrained, and are beyond human control, and the choices of our actions that, in the context of orthodox quantum theory, are considered to arise from our conscious motives, reasons, and values. We consciously choose to act in one way or another because of some interest or intent.

The process of measurement creates a firewall that blocks the unfettered diffusion of the quantum uncertainties into the empirical (or experiential) realm.

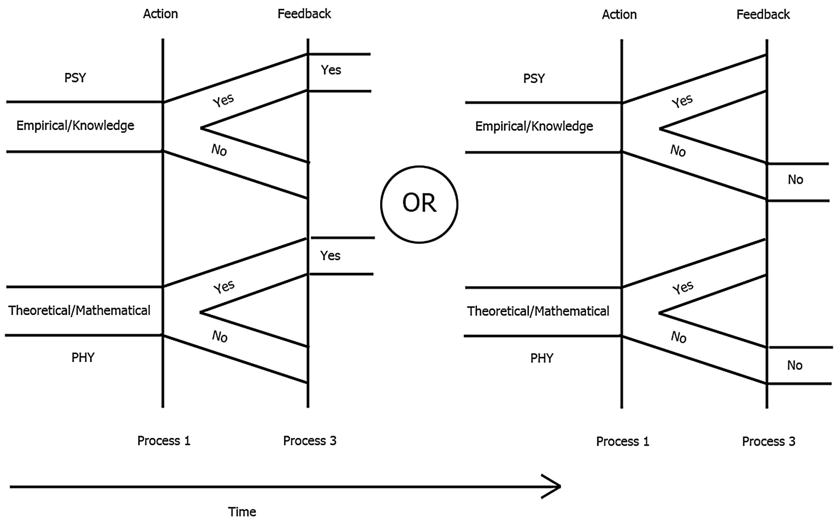


Figure 4. *Process 3*. Nature's psychophysical response to the process 1 query is either a "Yes" or a "No." The details of the association between the mental and physical aspects of the events are installed in the brain in practice by trial and error learning. This learning is made possible by the causal efficacy in the physically described brain of conscious mental intent.

It is the choice of a process 1 action, ***which is not controlled by any known process, statistical or otherwise****, but which appears to be influenced by value-based reasons, that, in conjunction with a stochastic process 3 choice of feedback on the part of nature, controls which potentialities pass through the firewall, and into the realm of our actual experiences!*

CONCLUSIONS

1. Quantum mechanics rescinds the materialistic/mechanistic conception of human beings.
2. Quantum mechanics elevates us human beings to active agents; to partial-creators of an unfolding universe that is NOT controlled exclusively by the material aspects of reality alone.
3. The process 1 action has an important mathematical property: it does not change the sum of the diagonal elements of the (density) matrix that represents the quantum state of the universe. Consequently, each process 1 action can be considered to act purely locally in some region R, independently of the process 1 actions in regions spacelike separated from R. And this process 1 action in R will have no effects on the states of systems in localized regions spacelike separated from R. This will ensure that, in accordance with the principles of the theory of relativity, no "signal" can be sent faster than light!

4. On the other hand, there is no logically possible way to accommodate all the predictions of quantum mechanics without allowing *nature's process of replying* to the questions that we are free to pose to be a "global" process, in the sense that the information about the process 1 choice made in some region R must be available in some region R′ that is spacelike separated from region R.

The effect of this altered conception of ourselves, with respect to our role in the unfolding experienced reality, is to convert us from the mechanical automata that classical mechanics has proclaimed us to be, to local agents that contribute to the evolving reality by posing questions of interest and importance to ourselves in a way that forces the global process that creates the facts of nature to respond in ways that allow us to influence the course of the physically described events. We can therefore now understand ourselves, within the structure of basic science, to be not helpless flotsam tossed about by a mindless mechanical sea, but rather as co-creators, in partnership with a global creative power, of a universe shaped in part by our own conscious thoughts.

A SCIENCE-BASED FOUNDATION OF ETHICS?

Contemporary basic physics leads to a conception of the role in nature of human beings that is profoundly different from the conception suggested by the "classical" physics of the seventeenth, eighteenth, and nineteenth centuries. According to that earlier view, we are helpless, isolated mechanisms buffeted about by a mindless mechanical process that grinds its way pointlessly into a future that was preordained from the outset. But quantum mechanics allows us to conceive our thoughts to be, from a science-based viewpoint, causally efficacious, *value-driven,* locally created inputs to a global creative process that seamlessly produces the common environment in which we all live. This understanding stems directly from contemporary science, and is therefore both science-based and equally available to all human beings, regardless of ethnic or religious background. This enlargement of our conceptual horizons provides a science-based undergirding that supports, rather than undermines, the natural human instinct to work for a common cause greater than narrow self-interest. It also provides a global species-wide overview for resolving social conflicts that have arisen from the narrow parochial origins of our diverse ethical systems.

> This quantum conception of human beings, being based on objective science equally available to all, rather than arising from special personal circumstances, has the potential to undergird a universal system of basic values suitable to all persons, without regard to the accidents of their origin. With the diffusion of this quantum understanding of human beings, science may fulfill itself by adding to the material benefits it has already provided a philosophical insight of perhaps even greater ultimate value. (Stapp 2007, 140)[1]

NOTE

1. For more technical details see also the two new chapters in the third edition of *Mind, Matter, and Quantum Mechanics*, and the recent article by Stapp (2008).

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