The Quantum Physics of Consciousness: Towards a New Psychology

Fred Alan Wolf, Ph.D.

Summary. *After a brief overview explaining the discoveries of quantum physics relevant to biopsychosocial synthesis, the profound connection between human consciousness and quantum physics is made. The observer effect, also known as the "collapse of the wave function," is explained in terms of human tolerances that affect the complementarity between location and energy of a physical system. A simple model of feelings and thoughts based on the energies and locations of typical channel protein molecules embedded in a neural membrane illustrates the observer effect acting in the human brain. Implications and directions for future research are explored.*

Introduction

Each of us believes in the existence of a real physical world. We argue or, perhaps if we doubt our own belief, succumb to rational arguments, that such a world exists objectively and independently of our minds, our thoughts and prejudices, our feelings and ideas about the world, our emotions, and regardless of whether anyone lives or dies. This belief, or this argument, has provided a baseboard for objective science ever since Galileo and Newton explained the marvelous workings of the clockwork universe.

More than likely, particularly if we have been trained as scientists, we sense an ingrained prejudice that the world is solid, objective, and independent of human consciousness. As we peer inside our own brain and nervous system, we seek chemical units of living stuff hoping to find the unit that causes that feeling to occur. We search for "hard-wired" engrams and attempt to apply Boolean binary logic to brain functioning. Perhaps we hope to find, in this manner, the very origin of human thought itself.

Much of today's scientific thinking and research support is based upon such lines of reasoning, which have remained within our educational system despite the fact that quantum physics is nearly 90 years old. It is remarkable that we still follow such lines of research, particularly as we delve deeper into the molecular biology of brain functioning, in spite of the findings of quantum physics. These findings now convincingly indicate that the world—the physical world of hard matter, light, and energy—simply does not, and cannot, exist independent of human consciousness.

In this article, I hope to show how and why there is an interdependence between the physical world and human consciousness. It should be pointed out that this is not a "chicken and egg" controversy in which consciousness is cause and matter is effect or vice versa, but a necessary whole or correlation between the two. It is, in fact, perhaps just as meaningless to require that either consciousness or matter was primary as it is to ask, “Which came first, the chicken or the egg?”

A Brief Overview of the Discoveries of Quantum Physics Relevant to Biopsychosocial Synthesis

There are many proponents of the connection between human consciousness and quantum physics (1). Briefly, those who believe that consciousness acts on the physical world believe that the action lies in the phenomenon known as the “collapse of the wave function.” This “collapse” is the sudden change in the probability of observing some property of matter brought on when that property is observed. The following example illustrates how an ordinary event “collapses” an everyday probability function.

Suppose you flip a coin and catch it without noticing which side is up. The probability that “heads” is up is 50%. But suppose that someone actually saw the coin land. Is the probability still 50%? Just the knowledge that the coin has been seen changes the probability the instant it is viewed. Instead of 50%, the probability after viewing is either 100% or zero. This sudden change in a probability brought on by observation is no mystery for ordinary objects. Ordinary objects, such as coins, “possess” two sides, and the result of observing one of the sides in no way alters the coin, just our knowledge about the coin. When the object being observed is an atomic, molecular, or subatomic particle, however, the action of observation not only changes the probability, but also changes the object itself.

According to Heisenberg’s principle of uncertainty, such particles were not particles after all. They were perhaps fuzzy particles. Each particle was fuzzy because it was impossible to determine its position and momentum at the same time. Any effort to measure the location of a subatomic particle, such as an electron, disturbed the particle so much that its momentum (its mass multiplied by its velocity) was rendered indeterminate. On the other hand, if the momentum was measured, the measurement necessarily caused one to lose information about the location of the particle. It became indeterminate. If one attempted to measure both momentum and position simultaneously, one had to compromise, giving up, for example, momentum knowledge to gain position knowledge. Thus, the particles existed, but they appeared a bit fuzzy as in a photograph of a moving object taken with a long exposure time.

Some physicists tried to “render the photographs clearer” by formulating theories involving hidden parameters that governed the movement of the assumed real, solid particles (2). If the particles existed, then the fuzziness was entirely due to the human failure to control the hidden parameters governing the movements of the particles during the measurement process. Usually the measuring device consisted of enormously larger numbers of particles interacting with the observed particle. The sheer magnitude of these numbers implied that interactions between the observed particle and the device would introduce uncontrollable interactions. These interactions would then be responsible for the blurry picture of the observed particle.

Whether or not the uncertainty principle is due to uncontrollable interactions or to an intrinsic property of matter—that it exists in a form, neither matter nor non-matter, which is known as a quantum wave function—is still debated today. Regardless of the outcome, physicists accept the existence of the quantum wave function, either as a real physical field existing in space and time or as a mathematical artifact needed to calculate the properties of real physical matter.

The main problem is how to interpret the wave function itself. The best description of quantum physics, now accepted by most physicists, has come to be known as the Copenhagen Interpretation. It was first pronounced by Niels Bohr who, like his yin-yang principle of complementarity, is often considered to be both the mother and father of quantum physics. Today there are, I suppose, as many interpretations of the Copenhagen Interpretation as there are physicists (3). My interpretation of Bohr's explanation is no exception to this. In my view, the world exists in two complementary guises. Each complements the other in the sense that you cannot experience one guise while you are experiencing the other.

Physicists have come to picture this complementarity in terms of waves and particles. Thus, all of the fundamental particles of physics are no longer imagined to be solid and substantial all of the time. Sometimes they exist as waves spread through space. For example, in the simplest atom of hydrogen, which itself is sometimes pictured as a wave, its single subatomic electron is no longer considered to be a point particle. Instead, it is pictured as a wave called a quantum wave function (*qwiff*) which is spread over a volume of space. This qwiff can be viewed as an undulating wave cloud only so long as no experiment attempting to locate the electron is performed. Molecules are then "built up" from atoms with overlapping electron wave clouds that interact electromagnetically.

The rules that describe these overlaps and all atomic behavior constitute the mathematical description called wave or quantum mechanics. As the size of a molecule increases, corresponding to greater numbers of atoms and their electrons, the mass of the molecule also increases. Similarly, with an increase in molecular mass, the wave description tends to "wash out," forming bonds or "electron glue," which provide a fuzzy hardness and localization in space and time to our observation of the molecule. The larger the mass, the less the wave description is needed. Along with the increase in mass, there is a greater ability to predict the future behavior of the mass. A simple quantum physical calculation shows that we lose the ability to predict the future location of a particle of mass (m) beyond a specific time (T). This time depends on the mass and the initial uncertainty or tolerance (D) with which we know the initial location of the particle. The formula is:

$$T=2mD^2/\hbar \qquad [1]$$

where $\hbar$ (pronounced h-bar) is Planck's quantum constant, h = 6.626 x 10^{-27} erg- seconds divided by twice π (3.14159...), i.e. $\hbar$= 1.055 x 10^{-27}.

The time (T) is sometimes called the "spreading time." It arises in the form of the quantum wave function representing a free particle—one that is initially located within a region (D), but is not otherwise confined by any physical boundaries. As such, it refers to how quickly we lose our ability to follow, in time, a particle's location which initially has been determined within an initial tolerance (D). The greater the "spreading time," the longer we have to predict the location of the particle in the future. Predictions of the location of the particle beyond the spreading time become more and more uncertain with increasing time.

Table 1 summarizes the predictable behavior of various mass particles as their mass increases.

Table 1. Human Tolerance and Predictable Behavior of "Particles"*

Mass, m (kg)	Initial Tolerance, D (m)	Spreading Time, T (sec)	Comments
10^{-30} (electron)	10^{-11}	$1.9 \bullet 10^{-18}$	An electron exists for about 2 attoseconds
10^{-25} (atom)	10^{-10}	$1.9 \bullet 10^{-11}$	An atom exists for about 0.2 picoseconds
10^{-21} (molecule)	10^{-8}	$1.9 \bullet 10^{-3}$	A small protein molecule exists for about 2 milliseconds
10^{-15} (dust mote)	10^{-6}	$1.9 \bullet 10^{7}$ (31.3 weeks)	A dust mote visible microscopically appears as a classical particle
10^{-4} (pea)	10^{-5}	$1.9 \bullet 10^{20}$ (600 billion years)	A pea's behavior is as a classical particle

*Adapted from a similar table in March, R.H. *Physics for Poets*. New York: McGraw-Hill, p 230.

Key to our ability to make predictions about the future of a "particle" is the tolerance given to the first observation. It can be seen that the table's values depend on the initial tolerance (D). I have chosen typical values of D to provide some idea of how quantum indeterminism arises. The tolerances specified in the table are not fixed. They depend on how we choose to look at the particle.

If the initial tolerance is small, the "spreading time" is also diminished, varying as the square of that tolerance. A larger tolerance enables one to make predictions farther in the future about the particle's location. This effect of allowing a larger tolerance in the initial location of a particle in order to gain predictability is the cornerstone of Heisenberg's principle of indeterminism. By giving up location, we gain knowledge about the future, i.e., predictability.

How and Why there is a Profound Connection between Human Consciousness and Quantum Physics

With formula $T = 2mD/\hbar$ lies the first indication of how human consciousness acting through observation affects the material universe. The tolerance (*D*) depends on how and with what we choose to measure a particle, whether it is a pea or an electron. Even a pea held to a tolerance of zero will become unpredictable in no time at all.

The choice of tolerance thus affects our knowledge of the future of matter. Normal operating tolerances of a few microns (10^{-6} m) within the world of peas, baseballs, and automobiles provide the illusion of a stable solid universe acting independent of human consciousness because with such macroscopic tolerances, large masses possess exceedingly long "spreading times." Since nobody ever attempts to resolve the location of a pea within anything but a few microns, at best, a pea remains a good solid object and is capable of being predicted to move as such. But such "normal" tolerances are inoperative as soon as we begin to look at smaller objects, such as molecules, atoms, and electrons.

Here I wish to suggest that the act of obtaining knowledge of the outside world involves the movements of such microscopic objects as molecules, atoms, and electrons within our brain, nervous system, and, perhaps, in our muscle cells as well. Thus, setting tolerances for what we observe in the outside world alters the tolerances of our "inside neural worlds." This setting of tolerance is, I believe, the fundamental action of consciousness or awareness of the outside world. This action alters our brain and nervous system by changing the tolerances for locating certain molecules acting within them.

Thus, to learn anything, each of us must in some manner, change the tolerances determining the locations of molecules within our neurons. Possibly, the differences between long- and short-term memory can be explained by different sets of tolerances for certain molecules. The wipeout of memory effect through debilitating diseases, such as Alzheimer's disease, may be due to the inability to adjust tolerances. Much as an older person begins to lose the ability to focus on objects within the near optical field (far-sightedness), our brain may lose the ability to adjust tolerances sufficiently, making it difficult to learn or remember new information. Very long-term memory may exist or remain because the tolerances are wider, allowing longer prediction times and, thus, stability for long-term memory storage. Human memory is not computer-perfect simply because there must always be a tolerance-uncertainty in storing any molecular arrangement.

Another way to describe the change in tolerance associated with a particle's location is to refer to the wave-particle duality. This duality is an oversimplified way to describe how the world can be pictured in two complementary guises. In reality, the world is never composed of particles or waves, but of something else that evades description. The changeover from wave into particle and back again is really a question of changes in tolerance, resulting in uncertainty of material knowledge. Thus, because we must set tolerances with each and every observation, there is no world of matter separate or distinct in any manner from the world of mind. Tolerance setting occurs so naturally in our everyday observations, much as we focus our eyes to see anything, that we usually never notice we are doing it. It is only in altered awareness states that we become aware of the use of different tolerances.

There is really no duality at all. There is only unity that appears as duality, depending on what tolerance we allow in our observational actions. Even this is a simplification. What is realized is synonymous with what is observed. What is not realized is not observed and remains potentially real. Meaningful observation is only possible through repeated observation or predictability, or both, and that in turn depends on how much or how little tolerance we use in determining the location of objects in the world.

The Observer Effect—How Human Choices Affect the Complementarity between Location and Energy

If we consider a simple example, known as the "particle-in-a-box," we can see how observation changes a physical system. According to quantum physics, specifically the Heisenberg uncertainty principle, it is not possible to specify in the future or present both the energy and location of the particle confined within the box.

If we take the particle to be a channel protein molecule embedded in the neuron membrane, its mass (m) will be approximately:

$$m = 10^{-21}\ \text{kg} \qquad [2].$$

Typically, these proteins are spaced apart at a distance (D) of approximately:

$$D = 10^{-8}\ \text{m} \qquad [3].$$

The lipid molecules of the membrane act as boundaries for each "boxed" protein molecule. Thus, we assume that these protein molecules are each in tiny boxes of the order of 10 nm wide, separated by molecules of closely packed lipids constituting the membrane wall.

Following from the uncertainty principle and Table 1, the protein molecules will not have well defined positions within the membrane, but will spread out in a time of the order of 2 ms within the tolerance of the width of the box. Each particle will take the form of a wave function, and can be visualized as a wave motion of a rope or string bound at two ends. There are an infinite number of such wave modes, known as standing wave patterns.

Associated with each standing wave mode are an energy (E) and an oscillation frequency (f) related by Planck's formula:

$$E = hf \qquad [4]$$

Each mode or harmonic is called an energy state. For simplicity, I will assume that there are only two energy states, *E(1)* and *E(2)*—the first and second harmonics, respectively.

Thus, each particle will exist in either the first or second energy state and, correspondingly, have a matching quantum wave function. The square of the wave function is interpreted to be the probability of locating the particle somewhere in the box.

In contrast, when the particle is in any of these energy states, it is not possible to say on which side of the box the particle exists. Each wave is distributed through the box so that the probability of locating the particle on the right or left side of the box is equal. The probability pattern remains constant or stationary in time. Thus, once a particle is in one of these states, it remains there so long as one does not attempt to measure the actual location of the particle within the box.

A measurement can also be performed, locating the particle either on the left or right side. In so doing, the energy state is disturbed so that the particle no longer has a specific energy. The particle now takes on a different quantum wave function.

When such a location measurement is carried out, for example, by observing the particle either on the left (L) or right (R) side of the box, the particle no longer exists in either stationary energy state. Rather, it is found to be in a position state that is a linear superposition of the two energy quantum wave function states (either a sum or difference).

The probability of locating the particle on the left or right side of the box now no longer remains constant in time. It oscillates with a frequency given by the difference in the frequencies of the two energy states. This means that the particle location states change in time. During a half-cycle of oscillation, the particle is more likely to be found on the right side of the box while a half-cycle later it is more likely to be found on the left side. Under these circumstances the particle cannot be said to have a definite energy. If one attempts to determine the energy at any time, the probability will be 50% that the particle will be found in state 1 or in state 2.

The inability to know both the location of the particle in the box and its energy simultaneously means simply that the particle is either in a position wave function pattern or in an energy wave function pattern. Observation of the particle location implies knowledge of the position wave function which requires that both energy wave functions be present simultaneously Observation of the particle energy implies knowledge of the energy wave function. If either harmonic wave is present alone, the energy of the particle will be specified, but the location of the particle will, correspondingly, be uncertain or undetermined.

Herein lies the reason for the complementarity of location in time and energy of a particle. Observation of position "collapses" the energy wave function, much as the observation of "heads" collapses the everyday probability function of observing a coin's side.

A Simple Quantum Physical Model of Feelings and Thoughts Illustrating the Observer Effect

I propose that a similar complementarity exists between human feelings and thoughts. Of course, such a primitive "cell" as a particle-in-a-box will not possess anything like a human feeling or thought. In much the same manner, an atom does not show anything like the range of energies expressed by the human nervous system. Yet, without atomic energy levels present, the human nervous system would not operate the way it does.

In a similar fashion, I propose that our emotions or feelings and thoughts are composed of basic feelings and thought states occurring at some quantum microscopic level. It now seems evident that emergent patterns of cortical excitation can depend critically on chemical processes. The rates for these processes depend on sensitive interactions involving processes such as quantum mechanical barrier penetration, which may occur at synapses. Thus, it would appear plausible that changes in quantum states of molecules, such as the energy position states of protein gates within the neural wall, could give rise to feelings or thoughts in much the same way that neural firing gives rise to muscular movements.

To date, this has not been postulated. What is needed at this point is a simple correspondence between energy states and "atomic" feelings. Based on Jung's discovery of the complementarity between certain basic personality functions, such as feeling and thinking or sensing and intuiting, I propose that there is a one to one correspondence between "atomic" feeling and energy, with a concomitant relation between spatial-temporal locations of molecules, such as protein molecules involved in gating function, and primitive thought processes.

Thus, basic feelings are expressed without any words attending them. Certainly, deeds of the outside world, such as someone shaking a finger or shouting some obscenity at us, can cause us to feel anger or hatred. Again, these feelings seem to appear to arise out of nowhere. I propose that these feelings do arise as charges in energy states of sets of more primitive "atoms." such as given above by the particle-in-the-box model.

I ascribe to the particle-in-the-box two basic "feeling" states, *F(1)* and *F(2)*, which are exactly the same as the energy states, *E(1)* and *E(2)*, previously described. I also ascribe to the particle-in-the-box two basic "thought" states, *T(1)* and *T(2)*, associated with the two possible position states, *L* and *R*. The lower "feeling" state, *F(1)*, is the ground state feeling end, as such, produces “no feeling” in the system. *F(1)* acts much as a drone state of vibration characterizing Indian music and symbolizing the fundamental vibration or zero-point motion of me void or universal harmony of Eastern mysticism.

The first excited state, *F(2)*, corresponds to a state of aroused feeling in the particle-in-the-box system. Although aroused, it is not expressed until the system de-excites and energy is transmittal along the neural membrane as a surface wave carrying the energy of the difference between the states with it. This, then, is the expression of “feeling.” If a number of similarly excited systems transmit energy in the brain along the neural membrane, a feeling or emotion will be felt or expressed.

Without thought occurring, feelings would simply arise spontaneously and disappear to arise again. However, introspection may take place. Introspection may be nothing more than consciousness attempting to “reason” through the feelings by changing the tolerances of the particles confined within the boxes, Attempting to reduce the tolerance by observing the particle to be either on the left or right side of the box will give rise to a thought state, *T(1)* or *T(2)*. Suppose the particle, initially in the ground state *E(1)* is later found to be on the left side (*L*). This act of observation sets up an internal oscillating state within the box. No longer is the system in one particular energy state. Correspondingly, the system will no longer possess a well defined feeling. This state is a temporary holding pattern of oscillation—a simple state of transitory memory. The internal vibration in the probability associated with attempted reduction in tolerance corresponds to a thought pattern within the primitive cell, which will only last until that pattern is read, probably only a few milliseconds.

Implications and Directions for Future Research

I should caution the reader that what is being proposed here is not a reductionistic model. Although I have described an extremely simple system of a single particle-in-a-box, I hope that the reader realizes that I am not attempting to explain consciousness reductionistically.

It is not a question of which molecules are responsible for which process. Instead, it is a recognition that thinking and feeling will not be discovered in terms of molecular identification or typical physical process involving neurotransmitter release or calcium ion modulation.

What I am proposing is that consciousness itself cannot be defined in such reductionistic terms as such, but can be defined in quantum physical terms. Much the same is true in describing an electron. We only know what an electron does and not what it is. In my model, consciousness “collapses” the quantum wave function by restricting the knowledge of the location of molecules acting within a neuron’s membrane. These molecules exist in stationary energy quantum wave states without well-specified locations. Any attempt to locate, by reductionistic experimentation, the positions of the molecules within the neuron wall may disturb them enough to wipe out the effect one is looking for.

Indeed, it is the act of introspective observing-disturbing that is responsible for changing thoughts into feelings and vice verse. Thus, a thought is created on a time scale of the same order ($\cong$ 1 ms) as the period of oscillation of the quantum wave for a protein molecule acting within the confines of a neural membrane. Of course, the words we speak take much longer to pronounce than a few milliseconds. However, I propose that our thoughts have already been registered well before we speak them. In other words, the words we speak are, more or less, nothing but scripts of thought patterns already written on a time scale of just a few milliseconds. The actual process of speaking or writing the words is similar to the process that occurs when a computer "reads out" its own memory on a screen.

The existence of "prescribed" scripts on a millisecond-nanometer time-space scale could explain how we can speak at all. We are "reading" the scripts. Errors in reading or the possibility of the existence of "multi-scripts" could result in simple confusion or, perhaps, speech impairments such as stuttering or stammering. Intelligence may be associated with the persistence of such scripts over longer periods of time or the use of groups of molecules acting in a correlated manner. It appears evident that our words and sentences follow a logical pattern. It seems quite difficult, however, to explain how a grammatically correct sentence could be expressed without having phrases or words stored ahead of time, This storage possibility may exist at the level or protein molecules in lipid bounded nanometer-sized boxes having the thickness of neural membranes.

Perhaps feeling patterns of energy seen as waves on the living membrane surface can be objectively observed and contrasted with different wave patterns associated with thought. However, such experiments should be undertaken with extreme caution. Each attempt to observe such wave forms will introduce uncontrollable factors associated with the quantum of the measurement process. The frightening prospect that emotional or thought states can be controlled by an outside influence now rears its head. The notion that a wave of feeling or of thought overcomes a person may be more than a metaphor.

Thus, consciousness in my simple model is identified with the process of wave transformation through setting tolerances for observing either energies or locations of protein gate molecules embedded in the neural membranes, and nothing else.

In my book (4), I presented many of these ideas in greater detail. I also explored another interpretation of quantum physics, known as the parallel world interpretation, and its impact on psychological functioning. In a future report, I hope to show how basic feelings, such as love, hate, sexual desire and expression, and depression associated with Freudian analysis may be described in terms of quantum correlations between molecules. Such correlations can extend over much greater distances than just a few nanometers. I also hope to show how quantum observations performed in the future can determine the state of consciousness of the present and offer a quantum model of the unconscious.

It is expected that the wide range of feelings and the great capacity for thought that mark the human condition can be explained by such considerations as I have pursued here. It may be that such lines of research will enable us to understand ourselves as quantum biopsychosocial beings. The prospect now exists for observing the influence of mind on matter and for a new quantum psychology.

References

1. Among the many supporters of the view that consciousness collapses the wave function are Nobel prize winners, Brian Josephson and Eugene Wigner. Also included are physicists Even Harris Walker and Henry Pierce Stapp. Physicist Ludvik Bass has described a specific neurological model of quantum consciousness in which consciousness collapses the wave function. See: Stapp, H. P. Found Phys 1985:15:35-47. Walker, E. H. *Math Biosci*. 1970; 7:131. Wigner, E. In: Good I. J., ed. *The Scientist Speculates.* London: W H. Heinemann. 1962. Bass L. *Found Phys*. 1975:5:159-172.

2. The main proponents of "clarifying the picture" by use of "hidden" parameters are David Bohm and his coworkers. See: Bohm D. *Phys Rev* 1952:85:166. 180. Also see other references to Bohm's work in: Bohm D. J. et al. *Nature* 1985:315:297.

3. DeWitt B. S. Phys Today 1970:23:30-35. Also see: Ballentine, L. et al. Phys Today 1971:24:36-44.

4. Wolf, F. A. *Star Wave: Mind, Consciousness, and Quantum Physics*. New York: Macmillan, 1984. Also published in Great Britain as: Wolf, F. A. *Mind and the New Physics*. London: W. H. Heinemann. 1985. Also see: Wolf, F. A. *Taking the Quantum Leap*. San Francisco: Harper and Row. 1981.

Commentary by Larry Dossey M.D.*

*Dallas Diagnostic Association, Dallas, TX.

"‧. . . the greatest mystery in all of science to this day is consciousness or, if you please, individual awareness of existence. Other concepts, like elementary particles, matter, have been reduced to more fundamental ones or are on the verge of being so reduced, and they are thereby deprived of permanence. Consciousness—in spite of the operationalist and the occasional behaviorist who laugh it off as a trivial accompaniment of organized matter—has never been reduced to anything more fundamental." (1)

Professor Henry Margenau

For most physicians and bioscientists, entering the world of quantum physics is an unsettling experience. One quickly encounters a new set of rules describing the behavior of the world that has no counterpart in everyday experience or in the descriptions that are part of the traditional, scientific, medical education. Although these strange, counterintuitive ideas have been part of modern physics for 85 years, they have yet to penetrate the day-to-day knowledge of most medical scientists.

Fred Alan Wolf's report is one of many signals that this situation may be changing. In medicine, we are being forced to come to terms with the physics of this century in the models of how human bodies may function. But we should not delude ourselves that the confrontation with modern physical views will be easy because they stand in stark violation of many hallowed assumptions of our traditional science, such as the proclamation by the great spokesman for molecular science, Jacques Monod, that an objective world is the very backbone of science, without which the scientific endeavor would be impossible. Yet this issue of objectivity is only a single area in which the "new physics" conflicts with the old. Other conflicts exist as well, such as the basic meanings of time, space, mass, energy, and causation.

For decades, intimations have come from physicists themselves that quantum mechanics and modern biological concepts must eventually unite. For example, the physicist, Niels Bohr, stated that the eventual addition of biological concepts to quantum mechanics was a foregone conclusion (2). Additionally, several physicists have proposed that the mind-matter dualism that has dominated traditional science since Descartes might best be resolved by invoking a principle that permeates modern physics, that of complementarity. In addition, many physicists have suggested that human thought processes require such small degrees of energy that quantum principles would eventually prove necessary to describe them.

But these sorts of predictions, which have come from within physics for decades, have largely gone unnoticed, and for a good reason. It has simply seemed unnecessary to employ this body of knowledge. Newton's physics work quite well in the relatively large-scale worlds of medicine and physiology, we have said, and we have been able to do our job and do it quite well with the traditional tools.

Yet the dichotomy between these two systems of thought is glaring. Thus, Ehrenwald was led to observe,

“It is paradoxical that more than one half century after the advent of relativistic physics and the formulation of quantum mechanics ... our neurophysiological models of the organism, our psychological and psychoanalytical concepts about “the Mind,” are located in Euclidian space, and conform essentially to mechanistic, Newtonian, causal-reductive concepts.” (3)

One of the major misconceptions of many bioscientists—and this is a crucial point in understanding Wolf’s proposals—is the assumption that the deeper we penetrate nature, the more accurate our knowledge becomes and the more control we stand to gain. This assumption lies at the heart of our faith in current methodology and theory in attempting to understand the workings of mind and consciousness. Certainly at certain levels of investigation, delving deeper into nature does yield greater information; as we go “downward” from organ systems to individual organs and, eventually, to the molecular level itself, we are rewarded with increasingly finer details of information.

However, as the physicist, Freeman Dyson, observed, beyond this level there is a bottoming-out effect where further investigation yields not greater information but less--for in reaching the subatomic world, we encounter the pesky principle of uncertainty, which sets limits on what we can know (4). This limitation comes about, physicists tell us, nor as a consequence of the clumsiness of our techniques, but as a built-in quality of the world that we can never exorcise.

The eventual hopes, then, of bioscientists, of endlessly probing nature mechanistically and garnering increasingly finer knowledge, are flawed because of an actual failure to appreciate the limits of such efforts that have been known to physicists for the greater part of this century. Yet this misconception lures us on, and the faith which it engenders, it seems to me, hides us from the limitations of the science on which we rely. Most importantly, it hinders us against considering alternative models of human function, such as those offered by Wolf and others who have suggested quantum-based models of physiological processes.

To reason, therefore, that the body and brain are objects that can be endlessly dissected, however remotely, leads to deep philosophical problems we have not appreciated. This disturbing point has been clearly made by Morowitz:

“[We assume that] first, the human mind, including consciousness and reflective thought, can be explained by activities of the central nervous system, which, in turn, can be reduced to the biological structure and function of that physiological system. Second, biological phenomena at all levels can be totally understood in terms of atomic physics, that is, through the action and interaction of the component atoms. Third and last, atomic physics, which is now understood most fully by means of quantum mechanics, must be formulated with mind as a primitive component of the system. We have thus, in separate steps, Bone around an epistemological circle." (5)

It is the relationship between what we call consciousness-by which I refer to the felt sensation of thought, emotion, and awareness--and the material stuff of the brain that Wolf is probing. In so doing, he invokes the most widely supported (though not unanimous) interpretation of quantum mechanics, the so called Copenhagen Interpretation, which holds that the act of observation (and, thus, it is said, the intrusion of human conscious activity) is required before an actual, recognizable event can occur at the subatomic level.

As Wolf puts it, this action of consciousness in obtaining knowledge of the world outside "involves the movements of such microscopic objects as molecules, atoms, and electrons within our brain, nervous system, and, perhaps, in our muscle cells as well." Wolf invokes the concept of tolerance, by which he means a kind of "fuzziness" or less than perfect degree of accuracy of our knowledge of a subatomic happening and states that the "setting [of] tolerances for what we observe in the outside world alters the tolerance of our 'inside neural worlds'." This setting of tolerance, he says, "is, I believe, the fundamental action of consciousness or awareness of the outside world." This process then alters our brain and nervous system, he proposes, by affecting certain protein molecules embedded in neural membranes. The interplay between feelings is related by Wolf to changes in energy states of sets of atoms, and he invokes a complementarity between the energy and position states of certain molecules and feelings and thoughts. Eventually, however, the origin of feelings is deeper and they "arise as changes in energy states of sets of more primitive 'atoms'," and introspection "may be nothing more than consciousness attempting to 'reason' through the feelings by changing the tolerance of the particles." What are we to make of Wolf's proposals about how feelings and consciousness originate? Is this not a complex form of reductionism, a mechanism with a vengeance, relying as it does on a world even more remote than that probed by most molecular-thinking neurophysiologists? Instead of neurotransmitters, have we not merely substituted electrons? The answer, I believe, is a decisive "no," and the reason that Wolf's model escapes the charge of reductionism lies once again in the findings of modern physicists themselves. The more remotely one penetrates the levels of nature, the less accurate one's knowledge becomes, and not vice versa as the ordinary brand of reductionism assumes. This difference is more than philosophical; it lies at the very heart of the way quantum physics is actually "done."

Consciousness, then, in Wolf's model is identified with the process of wave transformation "through setting tolerances for either observing energies or locations of protein gate molecules embedded in the neural membranes and nothing else." But Wolf does not stop here. Elsewhere, he has proposed models to account, not just for consciousness, but for specific emotions such as joy, hate, love, and sexual arousal. His quarry is larger than generic mind; it includes its various qualitative expressions as well (6).

Does Wolf's model deliver what it promises? Can it account for the most ineluctable fact of anyone's experience—the fact of being conscious and the experiences of various emotions? There are reasons to suppose that it cannot. The philosopher of religion, Huston Smith, has stated (7) that there are four categories in which science is limited, "four things science cannot get its hands on": 1) intrinsic and normative values; 2) purposes; 3) ultimate and existential meanings; and 4) quality. These limitations come about, Smith claims, as a result of science's helplessness in the face of the qualitatively unmeasurable. It may also be argued that it is the qualitatively unmeasureable—consciousness and its various qualitative expressions—that is the object of Wolf's model.

Another objection has to do with what is meant by mind and consciousness. This point of disagreement is expressed by the physicist, Jeremy Hayward:

"Mind is not a 'something' separate from nature. It is identical at various levels of order with all of nature, not solely with individual brains. It emerges as a characteristic of processes of nature at a certain level of evolution. It is therefore futile to look for evidence of mental processes as located purely in the brain of an individual organism. We must look for such evidence in the entire network of patterns of interaction which that organism has with its environment . . ." (8)

This view is essentially that of Gregory Bateson:

"The individual mind is immanent but not only in the body. It is immanent also in the pathways and messages outside the body; and there is a larger Mind of which the individual mind is only a subsystem." (9)

Likewise, the eminent physicist, Erwin Schrödinger, who formulated the wave mechanics that undergirds quantum physics, went so far as to suggest that, in fact, there is only one mind that is somehow participated in by everyone, and that the idea of individual mind is illusory (10). In spite of the fact that such an idea may seem fatuous to Western scientists, it would seem improper to dismiss it out of hand for the reason that it, and others similar to it, were advanced by serious physicists who laid the framework for the most accurate science we have ever had, and because these conclusions were reached as a consequence of the implications of the physical theory itself.

It must be stated, too, that it is possible to formulate interpretations of modern physics that do not invoke consciousness as a necessary operator. This has been done, for example, by David Bohm, who denies that human observation is necessary to bring a subatomic event to completion (11). A machine could perform the act of observation, says Bohm, and store such information for later use by an observer; and, continues Bohm, one would not want to attribute consciousness to such a machine.

Even among those physicists who do agree that present day, modern physical theory does require human consciousness, there is profound disagreement whether or not this very physics can account for consciousness, feelings, and emotions. Perhaps the most outspoken physicist in this regard is the Nobelist, Eugene Wigner, who has said,

" . . . the most important phenomena not dealt with by our physical theories are those of life and consciousness. ... Even if the physical theories could completely describe the motions of the atoms in our bodies, they would not give a picture of the content of our consciousnesses, they would not tell us whether we experience pain or pleasure, whether we are thinking of prime numbers or of our granddaughters. This fact is, in my opinion, the most obvious but also the most convincing evidence that life and consciousness are outside the area of present day physics." (12)

Aside from the diverse opinions of physicists themselves about the role of consciousness in modern physics, for me, the most problematic aspect of Wolf's theory lies with the philosophical problem that has traditionally been called "the mind-body problem."

Crudely put, it is this: How does the material world-whether neurons, neurotransmitter molecules, electrons, or anything else--give rise to something that feels like consciousness? Ingenious attempts have, of course, been made through the ages to solve this question. But many thoughtful persons throughout history have considered this an utter epistemological impasse. I number myself among them in the sense of not believing that there is any logical way of penetrating this barrier, even within the context of modern physics.

One of the difficulties I have in Wolf's attempt at defining consciousness is the identicality he proposes between consciousness and the process of wave transformation. True, many physicists hold to the notion that consciousness is necessary to effect this process. But a major problem, as Wolf himself tells us, is how to interpret the wave function itself. Is it "a real physical field existing in space and time or ... a mathematical artifact needed to calculate the properties of real physical matter?" If the latter, then consciousness is identified with a symbol, which does not leave us with a satisfying definition or feeling of what conscious is. On the other hand, if consciousness is identified with something "real" and "physical," then we are back to the enigma that has dogged the various identity theories of consciousness that have emerged for hundreds of years. How does the concrete stuff of the world give rise to something that has the feel of consciousness? Thus, regardless of whether the quantum wave function is seen as symbolic or real, problems seem to arise.

An alternative view to Wolf's effort (as well as the efforts of other physicists, such as Walker, whom he cites) to get consciousness out of the quantum domain would be to regard consciousness itself as a starting point, a given, a primary phenomenon, and to work toward matter and not out of it. This would seem appropriate, especially in view of the conclusion of many physicists that a subatomic event cannot come to completeness and enter our perceived reality without human observation of some sort. This "top-down" (instead of the usual "bottom-up") approach has actually been proposed by the Nobel physicist, Brian Josephson, and it is coherent with most of the views on the origin of consciousness that have come down through a diversity of cultural, prescientific traditions (13).

Many years ago, the American humorist, Ambrose Bierce, made an observation in his *The Devil's Dictionary* that may apply to Wolf's and our efforts at thinking about consciousness quantum mechanically. The mind, Bierce facetiously stated, is a mysterious substance located deep within the brain, its chief preoccupation lying in thinking about itself, the folly of which is that it has only itself to think about itself with. Bierce's observation may prove trenchantly appropriate to our concerns here for two reasons, First, if consciousness does depend on such small energy states that quantum principles apply, then we may be frustrated in observing this process in all its facets because of the principle of uncertainty, which limits what we can know. Second, there are problems that have been found to apply to logical systems, such as those employed by our minds in thinking about our minds, if these systems are at least as logically complicated as simple arithmetic. The work of Gödel, Tarski, and Church has explicated these problems, and Gödel's theorem is, perhaps, the most well known warning that logical systems can become self-referential and, thus, limited as they begin to "talk about themselves" (14). Although the conscious brain thinking about itself may be a prime example of the dilemma posed by Gödel, these issues are too complex to explore here. Nevertheless, they suggest we take Bierce's humor seriously; the mind may forever be stymied in thinking fully about itself regardless of whether the model we use is Wolf's quantum-based model or some other classically based one.

What of Wolf's belief that the origin of consciousness can be found below the level of the atom? Perhaps most persons in medical science would agree with this approach, if not in the details, at least about where to look. It can be said, however, that most cultures and traditions have seen it the other way around; it is consciousness that gives rise to matter, and not vice versa. The Hindu tradition, for example, exemplifies the idea that mind, not matter, is primary, and that "the lower" (i.e., the material world) precipitates from the higher, from the domains of consciousness, spirit, or God. Lest we dismiss these views as fanciful productions of primitive, prescientific cultures, it might perhaps be well to swallow the obvious and prickly fact that our own reductionistic science has been unsuccessful in solving this basic conundrum that is essentially the mind-body problem mentioned above. Our failure might suggest a humility in the face of this difficult task and that we should not dismiss non-Western views out of hand.

Might consciousness be accounted for, not by looking for its origins as Wolf does in the small world of the subatomic, but in the "higher" reaches that the world's great religious and mystical traditions have always pointed to? The question at least deserves a modern hearing. If this were the case, it would matter little whether once focused on a quantum based, nonreductionistic scheme, such as Wolf does, or on an explanation based on macromolecules, neurotransmitters, or even on some as yet undiscovered chemical or physiological process describable in reductionistic, mechanical terms. For both approaches would fail and for the same reason. Their starting point is off base. From the evidence that has accumulated thus far as to the origins of consciousness, it is probably safe to say that this question is still an open one and may not hinge on whether quantum or classical explanations are utilized.

Having given several reasons why I do not feel automatically aligned with Wolf's proposals, I should like to offer a more supportive point of view. It is urgent that his ideas be given a serious hearing and that the theoretical framework in which they rest-that of modern physics--be entertained in medicine at large. I believe that the goal of a classically based, modern bioscience, that of providing a comprehensive view of the workings of man that is totally objective, has failed. The issue of consciousness that is raised by Wolf is only a single example of the deficiencies of method with which we are encumbered. It is decidedly odd that it could go almost totally unnoticed that there is a veritable scientific schizophrenia at work in science today in which one group of scientists (modern physicists) employs one set of assumptions of how the world behaves, while another group (physicians, physiologists, bioscientists of every stripe) invokes a different view, that of the traditional, classical notions of reality. Although these perspectives are not mutually exclusive by any means, the picture of the world they give us is radically and fundamentally different, and within the confines of the traditional perspective employed by orthodox medical science it has been virtually impossible to even entertain such daring proposals as those of Wolf.

What is worse, the constraints of the classical approach have led to dehumanizing notions of what human beings are all about, views that are hard to defend from the perspective of modern physics. Consider the orthodox view that is expressed by Carl Sagan, who observed that the "fundamental premise about the brain is that its workings—what we sometimes call 'mind'—are a consequence of its anatomy and physiology and nothing more" (15). As Wolf's perspective illustrates, there are points of view that flow from modern physics in which this "fundamental premise" may not be as fundamental as it has seemed, and the "nothing more" may hold some surprises.

The classical approach has led us to view our own bodies as isolated objects, and we have lost, as the nuclear physicist, Jeremy Hayward, states,

" . . . our health-giving connection with the earth. We live as if we existed in dead, empty space; therefore, all our energy and insight must come from within, and we constantly feel overcome with anxiety lest our energy run out. We live as if time did indeed flow from past to future; therefore, we do not rest in this moment at all." (16)

We have assumed that the classical view of the world that we employ in medicine is the only one that is needed to apply to living beings, such as ourselves, and that the alternative, relativistic, quantum mechanical ideas are fit only for extremely small objects, such as electrons, or for gigantic things, such as stars. That this is not so and that our world view is a crucial determinant of our physical and psychological health are the subjects of a previous work (17).

Much of the importance of Wolf's proposals for me lies in the possibility that they may help us escape our constricting views on how the world and, thus, our minds and bodies behave and what our relationship to this world is. Wolf is telling us that it is possible to formulate views of ourselves that are not reductionistic, and that it, indeed, *cannot* be only a matter of anatomy, chemistry, and physiology. Most important, he has put consciousness back in the melting pot when reductionistic science has done its best to take it out.

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Commentary by Richard M. Restak, M.D.*

*Clinical Associate Professor of Neurology, Georgetown University. Washington, DC.

Quantum physics, as propounded by Fred Alan Wolf, provides a unique and powerful metaphor by which we can explore the nature of human consciousness. Consider Wolf's example of flipping a coin and catching it. If we or some other observer glances at the coin as it lands, the probability of heads is either 100% or zero. But if no observation has been made, the probability remains at 50%. In this instance, observation changes probability without altering physical reality in any way, i.e., the coin is not altered, simply our knowledge about it.

At the level of thought and feeling, however, Wolf suggests that the act of observation may have an effect on physical structure, in this instance, of the brain.

"Indeed, it is the act of introspective observing-disturbing that is responsible for changing thoughts into feelings and vice versa. Thus, a thought is created on a time scale of the same order as ($\cong$ 1 ms) as the period of oscillation of the quantum wave for a protein molecule acting within the confines of a neural membrane."

Since Wolf provides no explanatory mechanism for this effect of thoughts and feelings on brain structure, I consider his theory metaphorical, but a useful metaphor nonetheless.

Take the time-honored search for "self-understanding." According to traditional approaches, the reasons for our actions and feelings can be understood if we probe deeply enough into ourselves. Either through self-observation or some form of directed introspection (psychotherapy), we are encouraged that it is possible to "discover" hidden things about ourselves which will explain why we feel and behave the way we do. I call this the Buried Treasure Paradigm.

Like all treasure hunts, the exact path to be followed (individual efforts, psychotherapy, etc.) is less important than ultimately discovering the riches (self-understanding). But the quantum model, as proposed by Wolf, calls all of these assumptions into question.

Each of us has the potential for an almost infinite variety of behaviors. Further, trying to reach self-understanding, either through introspection alone (brooding about matters, engaging in obsessive dialogue) or via some form of psychotherapy, dynamically alters the situation along the same lines as observation within quantum physics alters either momentum or mass. When it comes to self-understanding, there is no such thing as an "objective" observer. Nor is there some mysterious thing (the buried treasure) waiting to be unearthed. Rather, the process of observation modifies present reality, our past interpretations, and our future prospects along lines which would not occur without our efforts. We do not so much discover something about ourselves as we create "truths" about ourselves that, for the moment at least, we choose to accept or reject. To inquire whether or not these "truths" discovered within ourselves correspond to the Truth, is no more meaningful than to insist than an electron in its orbit can be precisely located right there.

Wolf's introduction of complementarity also puts our efforts at self-understanding in a new light. If quantum principles are valid, it is likely that the brain, like the rest of reality, is organized according to the principle of complementarity. For example, we picture to ourselves a certain course of action and speculate about how we will feel when we have achieved our objective. Later, after that attainment, we discover to our dismay and disappointment that we feel very differently from our earlier expectation; "When the gods want to punish us they answer our prayers," as Oscar Wilde once put it.

The complementarity of behavior and emotion can also work the other way around. We feel the need to sustain a sense of calm and inner security. To do this, we organize our life in ways that reduce friction, conflicts, and stress. Eventually, we despair at the boredom which results from the bleak inner landscape that we have created for ourselves.

We cannot, it seems, control both our thoughts and our emotions. An emphasis on one unbalances the other. Too much rigidity in our thinking (obsessiveness) leaves us bereft of joy. Too much emphasis on inner feelings (self-indulgence, hedonism, "doing our own thing") leads to the creation of a world without meaning and values. Indeed, a person's response to the complementarity of his own mind can provide, if one wishes, a kind of DSM IV.

The obsessive individual attempts to encompass all of reality within his or her mind by means of ruminations and fantasies. The paranoid person, too, experiences no need or inclination to test his or her explanations; he or she "knows" that others are out to get them. At the other end of the spectrum, the impulsive character puts all of their emphasis on spontaneous reaction ("if it feels good, do it").

Within this framework, the mature person, it seems to me, recognizes that thought coupled with interaction within the material and interpersonal world creates a uniquely experienced reality (the "qwiff" as Wolf puts it) which could not exist other than by the exercise of individual choice. This insight brings us, within the psychological sphere, very close to Wolf's claim "That the world, the physical world of hard matter, light, and energy, simply does not and cannot exist independent of human consciousness."

Whatever one may think of such a claim in regard to the fundamental units of reality, there is no doubt of its truth at the macromolecular level wherein we have a power of choice in regard to the people, events, and situations that comprise our individual worlds. We choose one potential mate over another, move our consulting firm from Rye to Pale Alto, enter a second career in our mid-40s; in such instances, whole worlds are constructed on the basis of our decisions. These worlds do not exist independently of our actions. We could have chosen differently and, in each instance, would have created an entirely different world. Human consciousness, in short, is not simply just another component among many, but, as Meister Eckhart put it, the very "fullness of time" exists within our consciousness at the moment that we make our choice. "There everything is present and new, everything which is there ... there is no before or after, there an eternity; everything is present and in this ever-present vision I possess everything."

Assimilation of quantum principles into psychiatry would lead, I believe, to a reemphasis on the importance of will and freedom of choice. "We are what we do," as the

Zen people have insisted quite correctly for 2,000 years. The exercise of will, the selection of one course of action over another with all of the implications and consequences that follow from that choice--these are the processes by which we create a world that is totally unique and inseparable from consciousness, our consciousness which has created it. This is an awesome, humbling, even fearful vision that Wolf presents for our consideration.

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EDITORIAL

A New Manner of Thinking

Albert Einstein once observed that “The splitting of the atom has changed everything except our way of thinking, and thus we drift toward unparalleled catastrophe. ... We shall require a substantially new manner of thinking if mankind is to survive.” That phrase “a new manner of thinking” comes to mind in considering the future development of psychiatry and the behavioral sciences.

Needless to say, mankind’s survival is not contingent upon arriving at better models of normal and abnormal human behavior, but it is true that we have need for a new manner of thinking for developing models that will go beyond the dichotomies that currently inhibit progress. As pointed out in this column previously, “One must recognize that all the factors—biologic, psychologic, sociologic—are inextricably bound together in a system in which all act upon each other and thus are both products of, and inputs into, the system.”

Where should one turn for a new manner of thinking? George Engel has suggested looking at the progress in physics, not following it slavishly but utilizing the concepts of Einstein’s theory of relativity, Heisenberg’s theory of uncertainty, and Planck’s quantum mechanics to comprehend new ways of thinking of behavior.

In this issue, Fred Alan Wolf utilizes concepts of quantum physics to understand consciousness. In an article entitled “The Quantum Physics of Consciousness: Towards a New Psychology,” Wolf presents many provocative ideas that deserve careful reflection. As Richard Restak observes in his commentary, “The process of observation modifies present reality, our past interpretations, and our future prospects along lines which would not occur absent our efforts.” The very act of observation has an effect on the physical structure of the brain, social behavior and psychology, including memory. Thus, we see an interpenetration of the variables of the biopsychosocial model, so they are interwoven and inseparable. Wolf presents a new manner of thinking that commands attention.

In a previous issue of Integrative Psychiatry, Dr. Werner Koella’s ‘‘A General Theory of Vigilance’’ offered novel ways and means to look into the pathogenesis of aberrant behavior as manifested by the mentally ill. Dr. Koella applied this neurobiologically founded concept of vigilance to a fresh explication of the pathogenesis of the functional mental diseases as well as to understanding of the mechanisms of action of psychopharmacotherapeutic agents.

In this issue, R. S. Cohen and D. W Pfaff, in their “Cell-biological and Math-logical Theories of the Neuro Circuit for Steroid-dependent Female Reproductive Behavior,” not only delineate cell-biological and math-logical theories in the animal but also go on to apply these findings to the understanding of relevant behavior and mood in human beings.

All three articles provoke us to alter our comfortable fragmented manner of looking upon behavior as a matter of simple linear cause and effect and to start creating fresh systems and models better able to account for normality and abnormality. If necessary, we must be jarred into experimenting with new manners of thinking in order to insure progress in the field of behavior.

Alfred M. Freedman, M.D.
Editor-in-Chief
Professor and Chairman. Department of Psychiatry
New York Medical College. Valhalla. NY