11. Agents and Evolution.

Human beings play a singular role in Copenhagen quantum theory: within that scheme science is viewed as a human endeavor, performed by human beings for human beings. Still, most scientists believe that *something* was going on before homo sapiens arrived on the scene, and many hold that the task of science will not be finished until we have a science-based idea of what that something was, and how our species emerged from it.

My intention here is to find the place of human beings in a broader non-anthropocentric setting, and I believe that this can be done by building upon the foundation laid by the creators of quantum theory, rather than by retreating to a mechanistic conception of nature that ignores consciousness, or tries to replace it by something else, such as classically describable brain processes. Indeed, the approach of scientists and philosophers who base their thinking on the classical conceptualization of nature depends on a promissory note that can never be redeemed. That promise, or completely unsupported and forlorn hope, is that *someday* we shall be able to understand how our conscious experiences---our feelings and knowings---can either **be**, or *be necessary consequences of*, a structure built exclusively on the elements allowed by classical mechanics. Those ingredients are the (unphysical) notions of tiny invisible atomic particles with no properties other than exact location, electric charge, and mass, moving in accordance with some simple force laws. Now one can certainly build out of these conceptual elements structures with all sorts of complex behaviors, but such complexity of behavior can never refute the assertion that a reality constructed wholly from these classically describable properties would lack feelings. Conscious experiences would be a gratuitous---not logically entailed---add-on to any structure built solely from entities possessing only the properties specified by the classical concepts. Such add-ons, being logically unnecessary, would be dynamically superfluous and without causative power, hence devoid of survival value. Nor can it be argued that feelings *must* be able to emerge from such a system because we ourselves are a living proof. For we ourselves are certainly not built out of elements that conform to the idealized unphysical concepts that are the basis of classical physics. We, insofar as contemporary science has correctly informed us, are built out a very different kind of

stuff that is, intrinsically, dynamically connected to our conscious thoughts.

So far I have restricted myself to the orthodox framework created by the founders of quantum theory, and developed by John von Neumann. But the focus of those works was on *human* agents. To proceed to a more general theory that accommodates evolution I shall need to build upon the essential core of that orthodox approach.

The first main clarification concerns the infamous "collapse". Copenhagen endorses it, but only as a feature of the subjective calculations of a human scientist who is making a computation pertaining to his future experiences. Von Neumann moves from this subjective Copenhagen position in the direction of an objective conception of nature herself. But never introduces "collapse." He includes his Process I, which can be construed as an objective expression of a choice on the part of some agent. That Process I, and the choice it implements, is real also in the Copenhagen approach. Eugene Wigner's exposition of von Neumann's theory accepts also real collapses, but von Neumann himself never makes that move.

I shall accept here the reality of Process I as an expression of a choice on the part of some embodied agent, which, however, may not be human, or even highly developed. But I reject the concept of an ensuing real collapse. This produces what I call a hybrid many-minds (HMM) theory.

This HMM approach has three important virtues: (1) It is local, like the usual many-worlds theory; but (2) It has a real process, Process I, (in addition to the usual Schroedinger process, called Process II by von Neumann) that specifies a needed separation of the Hilbert space associated with an embodied agent into two well defined separate parts, labeled 'Yes' and 'No'. This Process I allows the choice of the embodied agent to affect (via the Quantum Zeno Effect) the probabilities of courses of events; but (3) There is no mysterious choice on the part of nature between the possibilities 'Yes' and 'No' specified by Process I.

(I mention, parenthetically, for the benefit of physicists and mathematicians, that the locality property that I refer to arises from the fact that the state of each subsystem is defined by taking the

partial trace over all 'other' variables, and that therefore the state of one subsystem is unaffected by a Process I event in a distant one.)

So how does the evolutionary scenario work?

In this HMM theory, as in the usual many-worlds/minds theory, the universe initially evolves under the governance of Process II (the Schroedinger equation) alone. All possibilities are generated, indiscriminately. Given the nature of the laws implemented by the Schroedinger equation, which support, among other things, the possibility of the formation of organic molecules, the set of all possibilities will eventually lead to the formation of potential agents, which are simply mechanical subsystems that exist for a time in equilibrium with their environment, as (perhaps rudimentary) stimulus-response (input-output) system. These systems are essentially cohesive collections of quasi-classical localized states that tend to endure for intervals of time in communication with their environments.

Each of these subsystems has, due to its wave-like nature, or the effects of the uncertainty principle, a tendency to decay into less cohesive states. However, nature has armed all agents (and potential agents) with a counter-weapon: access to Process I.

We have as our building blocks the assumed existence of Processes I and II, and the known existence of feelings. A particular feeling is assumed to be associated with the 'Yes' branch specified by a Process I event.

Here is how I think it works. Within the collection of possibilities represented by the quantum state of the agent there may be a large-scale state of equilibrium in which various modules within the agent are acting together in a state of mutual support. This state extends over a large region in the agent, and cannot be quickly identified by the local Process II acting within the agent. But it can be specified by a projection operator P acting on the degrees of freedom of the agent. The complex structure of this large scale state of mutually supported equilibrium is asserted to be expressed by a "feel." If the feel reaches a sufficient quality of satisfaction then a Process I event occurs, and the state associated with this feel becomes one branch of the state of the agent. If the rapidity of nearly identical Process I

events is sufficiently great then the probability associated with this evolving branch will not decay as quickly as it otherwise would: this state of mutually supported equilibrium sustains itself, by means of the Quantum Zeno Effect, in the face of mechanical processes that tend to destroy it.

But what is the empirical significance of the "probability associated with this evolving branch" if there is no collapse; i.e., if *both* the 'Yes' and the 'No' branches continue to exist in parallel?

What must be appreciated here is that the meaning of 'probability' is a matter of dispute among the experts. We all have a pretty clear intuitive idea of what it means for some possible future event to be 'highly probable' or 'highly improbable', and we are all familiar with the definition of probability in terms of the fraction of outcomes 'Yes' in a long sequence of trials. But how long should this sequence be. "Infinitely Long" is the only precise answer. But no such series exists.

Consider the following conundrum. Suppose the predicted probability for 'Yes' is zero, but in a series of a million trials the outcome is 'Yes' every time. Is the prediction proved false by this empirical evidence? No! For in all the millions and millions of future trials on the way to infinity the outcome might always be 'No', so that the limiting fraction of 'Yes' outcomes would be zero, in agreement with the prediction.

The origin of this problem is that in classical physical theory the notion of probability is not intrinsic: probability is a human addition connected to our human lack of knowledge. But probability is intrinsic to quantum ontology. All that is needed is to grasp its meaning there.

The meaning is this: If in a Process I event the mathematically defined quantum probability of the outcome 'Yes' is p, then the experiences of all agents will be *as if* the actual state prior to the event were one of an infinity of equivalent states, and the fraction of them that moves to the 'Yes' state is p. A sufficiently rapid sequence of nearly identical Process I actions will then have the effect of keeping both the subjectively and objectively defined probability of the evolving 'Yes' branch larger than it would be without the effects of Process I.

According to this conception, probabilities are again subjective in the sense that they influence the structure of the experiences of agents. But this structure is rooted in the laws of nature, not in ignorance, and it influences equally the experiences of all agents. These probabilities are carried forward by Process II in the separated branches, specified by Process I, of the objective mathematical state of the universe.

This extension of von Neumann's ontology removes the anthropocentric bias: human beings no longer occupy a favored status. Von Neumann was, in fact, working on these issues at the time of his early death, and I suspect that he would have moved in a direction similar to the one outlined here, which seems to me to be the natural prolongation of his line of attack.

A key consequence of this development is that qualities of feelings can influence the statistical weightings of the objective physical states of the agents already in the evolution and development of the physical structure of these agents: feels enter efficaciously into the evolutionary process that controls the development of these agents.

This HMM theory is by no means a wild extrapolation beyond present theory. Already many thoughtful physicists endorse the usual many-worlds/minds approach to quantum theory because of its avoidance of nonlocality, and the mysterious global acts of nature that collapse entails. However, I strongly doubt that von Neumann's Process I can be eliminated in a logically coherent way the preserves the statistical predictions of quantum theory. The HMM elimination of the anthropocentric bias coupled with the retention of "feels", the seeds of consciousness, is, I believe, the most natural extension of von Neumann's approach, and it provides a mechanism by which qualities of feels can influence first the immediate physical activity, and thence the physical development, of agents of all sorts.