The Advent of
Integral Quantum Science

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***The Connectivity Hypothesis*, Chapter Nine.**

Historians and sociologists of science often remark that scientific knowledge grows not only, or even primarily, through the sustained accumulation of observations built into preexisting theories, but through leaps from one fundamental theoretical conception to another. Such paradigm-shifts, termed scientific revolutions, occur periodically in the course of science's development.

In the period from the seventeenth to the nineteenth century science was in rapid yet relatively linear evolution. It built on the paradigm provided by Galileo, Kepler, and Newton and, emancipating itself from religion gained a dominant position in the Western world. The twentieth century witnessed a number of revolutions, first in physics, and subsequently also in biology, cosmology, and consciousness research. Science's impact in society grew, mainly through physics-based breakthroughs in transportation, production, information-processing, and communication. However, toward the end of this period researchers in fundamental physics, cosmology, biology, and consciousness studies encountered deepening anomalies. Now another leap is about to occur - another scientific revolution.

The outcome of the coming revolution is variously assessed. A number of observers believe that, given current advances in genetics and the spread of an organic approach to natural as well as human ecology, the twenty-first century will be a century of biology. This view has much to recommend it, but it does not grasp the full range of the anomalies that drive the current development. In the opening years of the twenty-first century the evolution of science is driven by the discovery of space- and time-invariant coherence not only in quantum physics, but also in

biology, cosmology, and consciousness research. Quantum physics gives a sophisticated mathematical account of quantum coherence (although it fails to give a realistic explanation of it), but in most other fields the analogous forms of coherence are mainly anomalous. Space- and time-invariant coherence in the diverse domains of investigation conflicts with the paradigm of local action and localized causality that dominates the biological and human sciences.

The finding of enduring, instantaneous coherence in phenomena is not just a paradox; it is also a spur for theory-innovation. As a quasi-universal phenomenon it requires a new conceptual framework, one that can exhibit the unity of the main branches of the empirical sciences including physics, cosmology, biology, and the transpersonal and quantum brain - theoretical schools of consciousness research.

Coherence, of course, is not the only factor arguing for the unity of the physical, the biological, and the psychological sciences. Despite important differences at the level of observation, on deeper analysis significant continuities are coming to light among the phenomena investigated in these sciences. Evolution in the universe and evolution on Earth, though phenomenologically different, prove to be continuous and in some respects mutually consistent. There is, for example, a continuous and consistent buildup of free energy density in physical and biological systems. Eric Chaisson has shown that F m , the value of free energy rate density (the unit of energy per time per mass, erg S -1 g -1) increases throughout the range of physical and biological evolution. For stars the average value of F m is 2; for planets such as the Earth it is 75; for plants in the biosphere it is 900; and in the human body it is 20,000 (Chaisson 2000).

Beyond free energy density a wide variety of physical-biological invariances have been investigated by such "transdisciplinary disciplines" as cybernetics, information theory, and general systems and general evolution theory (Laszlo 1987). Building on these continuities and invariances, science is currently growing beyond physics and beyond biology, into the dimension of transdisciplinary theory.

The rise of an integral science of truly transdisciplinary scope is radically new, it constitutes another scientific revolution. The hitherto advanced unified and grand-unified theories, and the string and the related "theories of everything" are mono-disciplinary: they are unified *theories of physics*, at best theories of every *physical* thing. By contrast the integral science now on the horizon promises to be a science of physical as well as of biological, and even of psychological "things." It will embrace quantum physics and quantum biology, as well as quantum cosmology

and quantum brain and consciousness research. It will be a transdisciplinary field of research and experimentation applying concepts developed in the microscopic domain across the full range of observed phenomena.

BASIC CONCEPTS - Two concepts will function as root metaphors of the integral quantum science of the twenty-first century: *fields* and *information*.

The sustained investigation of the cosmic plenum as the basis of the entire realm of manifest phenomena, including mass, energy, and information, will highlight the role of fields not only in physics and cosmology, but throughout the range of observed phenomena, including the phenomenon of mind. The reinterpretation of general relativity's geometric space-time as the locus of a universal field that not only gives rise to matter-energy entities and systems, but also links them and conserves their traces, will shed light on the phenomenon of anomalous coherence and will build it into the scientific world picture. A sound hypothesis of connectivity will lay the foundation for a science that is more inclusive, and penetrates deeper into the realms of reality than the mainstream sciences of the twentieth century. The integral quantum science of the twenty-first century will offer a realistic mapping of the pertinent facts, regardless of whether they pertain to the physical aspect of reality, or to its biological or psychological aspect.

Information will be the second root concept of integral quantum science. Information is not only the dominant reality of technological civilization; it is also emerging as a basic feature of the investigation of nature. According to Roy Frieden, it is the foundation of the laws of physics (Frieden 2001). His work demonstrates that the laws that govern the physical world are derivable from the amount of information present in observed phenomena. Frieden points out that the much vaunted equations of quantum physics, considered the most basic laws of the known world, derive their legitimacy from the fact that they work: they have been tested over and over again, with a number of predictions confirmed up to ten places of decimals. However, today's quantum theories do not disclose why the laws take the form they do. Frieden finds that the form of the laws can be derived by applying I, so-called Fisher information (the formula for determining how much information one can obtain from a physical system) to J, the amount of information bound up in the system being measured. Both I and J can be calculated for a wide range of phenomena. To derive a law of physics (more exactly, the Lagrangian that defines that law) we need to define the precise location of the system in space and time and subtract J from I. This leads to the appropriate Lagrangian , and when it is made as small as possible, the pertinent law of physics emerges. Information, Frieden maintains, is what physics is all about.

Information is what all empirical science, and not just physics, is all about, yet the origins and status of the information discovered in nature remain to be clarified. Following Wheeler's suggestion, that observer participancy gives rise to information, and information gives rise to physics, Frieden speculates that the quantity of information inherent in a system under observation is created in the act of observation. However, information may also be objectively present in nature. If so, the act of observation does not create the information we find, but merely *elicits* it.

Integral quantum science will recognize that information not only defines the form taken by the laws of nature, but also is a physical factor that connects phenomena and informs their behavior. Information in this sense is "in-formation": the nonenergetic "formation" of the recipient by the message.

In the 1950's David Bohm's hidden variable theory contained an explicit - if still classical - concept of in-formation: the "quantum potential." A complex factor that reflects the entire context of quantum measurements, the quantum potential guides the path of the electron and allows a causal interpretation of quantum phenomena. Though a classical factor, the quantum potential was said to act by form alone, and hence it anticipated the notion of physically active in-formation. The latter Bohm developed in the late 1980's in his "ontological interpretation of quantum theory." Here quantum processes - the processes by which a determinate physical outcome emerges out of a multiplicity of potentialities - are accounted for in reference to a holograph field that produces active in-formation (Bohm 1980, Bohm & Hiley 1993).

This concept had precedents throughout the twentieth century. Einstein's own concept of the Chrungsfeld (guidance field), mentioned by him in the 1920's, was basically a nonenergetically in-forming field, governing the motion of particles in space-time. Although Einstein came close to incorporating this concept in his subsequent unified field theory, he did not develop it in theoretical form. In general relativity he opted instead for the geometry of spacetime to guide the motion of particles - possibly because too little was known at the time about the quantum vacuum to permit the assumption that it would constitute a physical field capable of affecting the behavior of charged particles. Einstein did, however, note that the concept of a "physically real ether" must be reintroduced into the worldview of physics, and his insight is now gaining validity. Bold new theories interpret the equations of general relativity as equations of motion in a physically real universal substratum - the "physical ether" - instead of as equations that define the formal geometry of space-time.

Although Bohm did not generalize the concept of nonenergetic in-formation beyond physics, it is now evident that physically effective yet nonvectorially propagating in-formation is not limited to the quantum world. Evidence reviewed in this study shows that it is a factor in the evolution of the living world, of the world of consciousness, and of the universe as a whole.

Presently Harold Puthoff, Roger Penrose, Glenn Rein, A. E. Akimov , Fritz-Albert Popp, László Gazdag , Hans Primas, Marco Bischof, and other front-line investigators follow up Bohm's and Einstein's insight and explore the fundamental role of fields and in-formation in a wide range of phenomena of scientific interest. Puthoff articulated the basic insight and the challenge it poses to science: "a dynamic equilibrium exists between the ever-agitated motion of matter on the quantum level and the surrounding zero-point energy field. Who is to say whether modulation of such fields might not carry meaningful information?" If this research comes to full fruition, he added, "what would emerge would be an increased understanding that all of us are immersed, both as living and physical beings, in an overall interpenetrating and interdependent field in ecological balance with the cosmos as a whole, and that even the boundary lines between the physical and "metaphysical" would dissolve into a unitary viewpoint of the universe as a fluid, changing, energetic/informational cosmological unity" (Puthoff 2001).

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Built on the foundation of a fully developed and consistently tested hypothesis of connectivity, integral quantum science will penetrate deeper into the domains of reality than the physical, biological and psychological sciences of the twentieth century - below the level of the quanta that populate space-time, to the cosmic plenum that generates the quanta and interconnects the particles and systems built of them. It will also penetrate wider into the cosmos - beyond the spatial and temporal boundaries of this universe, to the metaverse that gave birth to this universe and set its parameters. These extensions of the penetration of science will not be arbitrary, or even surprising: they are the logical continuation of the series of conceptual breakthroughs that extended scientific inquiry from the sphere of immediate observation to the wider and deeper domains of instrumental observation, carried ever further by conceptual analysis and mathematical extrapolation.

In the seventeenth century Newton's classical mechanics gave us the mechanistic universe, with independent mass points externally connected by deterministic causal relations. In the twentieth century Einstein's general relativity gave us the relativistically interlinked universe, where all

things are connected by signals propagating across the geometric structure of space-time. In the twenty-first century integral quantum science will give us the coherent universe, where all things are intrinsically connected by subtle yet effective in-formation conveyed by a fundamental virtual-energy field at the heart of a possibly infinite metaverse.