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SPECIAL SERIES

Medical Education, Research, and Scientific Thinking in the 21st Century (Part Two of Three)

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ABSTRACT **Background:** *During the 20th century medical education has been largely preoccupied with discussions of the venues and methods for teaching. Little attention has been paid to what should be learned about the scientific paradigm underlying research and practice. A 17th century model has gradually produced an increasingly narrow, monocausal, reductionistic view of health and disease. Much good has resulted, but this "belief system" fails to accommodate or explain the meaning and impact on patients' health of diverse internal and external experiences and influences. During this period quantum mechanics and its ever-expanding capacity to accommodate new information and enhance understanding have superseded Newtonian physics in much scientific thinking.*

Methods: *A broad range of historical and contemporary scientific literature is examined in support of four central questions in this three-part series: (1) Are there reasons to examine these matters now? (2) How is medical scientific thinking influenced by the general reorientation of science during the 20th century? (3) Are there reasons now to examine the impact of these changes on medicine? (4) Will a change of paradigm affect medical practice, research, and education?*

Results: *The extraordinarily productive contemporary biomedical model should be expanded beyond the physical and biological to incorporate meaningful information about how each patient's experiences impinge on health status.*

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Conclusions: *Family and other primary care physicians together with collaborators in the biological and behavioral sciences and other health professions should undertake rigorous research to establish the validity of the expanded paradigm espoused. Its impact on practice, research, education, and policies could be profound.*

In the first part of this three-part series we sketched the historical development of the conceptual framework that dominates scientific thinking in medicine, and contrasted it with seminal advances in quantum mechanics and physics generally during the 20th century. We discussed the inability of contemporary medicine's theories to accommodate a host of observations and experiences bearing on disease and health. We posed four questions, the first of which addressed the "reason *now* to engage in a discussion of medicine's terms and concepts in the context of today's world-view." Here we proceed with the second question.

Second Question: How is Medical Thinking Affected by the General Reorientation in Science and by Data that Can No Longer Be Explained with the Current Paradigm?

The concepts of *causality*, *biosemiotics*, *mind–body*, and the *production of health* will serve as examples to demonstrate the directions that could shape a new paradigm for the 21st century.

Beginning with *causality*, we observe that a model based on systems theory includes a concept that is fundamentally different from that developed within the Cartesian natural sciences paradigm, based as it is on a mechanistic world-view. Long before its rise to general acceptance, a founding father of physiology, Johannes Müller (1801–1858), had developed the concept of *specific sensory energy* (Müller, 1843). A precursor of self-organization, this concept acknowledged for biology the existence of interactions between organisms and their environment that were not seen as linear and mechanistic. Müller postulated the existence of an intrinsic internal activity of the organism not directly and physically related to external factors acting on it. His successors in the development of modern physiology, representing today's scientific mainstream, considered this concept to be "*vitalistic*" and declared it to be "*non-scientific*." They preferred the linear, mechanistic, stimulus-response model that could be reduced to the prevailing "natural" laws. The aim was to explain life, health, and its aberrations on physical or chemical grounds and thereby to reveal well-defined and remediable causes of disease.

The limitations of the biomechanical line of reasoning are made evident by the seemingly trivial fact that the corpse is not identical with the living body. The latter differs from the corpse by its inherent autonomy and capacity for self-organization. Living structures are able to "*specify their individual lawfulness*" (Heisenberg, 1985). The corpse may respond to a physical or chemical

stimulus in a specific mechanistic and predictable manner. The living organism responds not only to such stimuli but also to psychological stimuli as a *whole* by changing (adapting) its process of self-organization. The relative importance of these external "stimuli" (although the use of this term is somewhat questionable) has to be qualified. Humberto Maturana (1928–) and Francisco Varela (1946–) describe them as "*perturbations*" and, rejecting objectivity of perception entirely, they speak of organisms and individuals as systems that "*bring forth their own world*" (Maturna & Varela, 1987).

At this point it might be argued that molecular and genetic biology have identified, or are on the way to identifying, many of the *agents of life processes* and their disturbances. Without minimizing the tremendous insights into biological structures and functions that have been achieved in these fields, it has to be stressed that *molecular or genetic entities are not the messages (signs and information) but the chemical carriers of messages (i.e. messengers) that maintain life processes*. Likewise, functional phenomena, such as the interaction of transmitter substances with the receptors on cellular surfaces or the flow along neural and transmembrane potential gradients, allow no conclusion concerning the content (the meaning) of the information (sign or message) that flows. They are merely phenomena of transmission without evidence of their significance for life processes in general. To use a mechanistic analogy, there is a profound difference between radio transmitters or receivers and the music transmitted.

Moreover, the relations between these observed molecular and genetic entities, on the one hand, and the structure and functions of the whole organism, on the other, are far from simple and linear. Concerning the genome, another Nobel laureate, Barbara McClintock (1902–), has brilliantly demonstrated its actions but more importantly its reactions to a multitude of challenges coming from inside and outside the organism. In her words, the genome is "a highly sensitive organ of the cell that monitors genomic activities and corrects common errors, senses unusual and unexpected events, and responds to them, often by restructuring the genome. We know about the components of the genome that could be made available for such restructuring. We know nothing, however, about how the cell senses the danger and instigates responses to it that often are remarkable" (McClintock, 1984). Genetic expression (the transformation of genetic messages into structures and functions of biological systems) thus has been shown to be a highly complex process including "*epigenetic*" elements, incompatible with the spectacular hopes and predictions of genetic technology enthusiasts. The molecular biologist, Richard Strohman (1927–), who does not share these hopes, writes that "the Watson–Crick era, which began as a narrowly defined and proper theory of the gene, has mistakenly evolved into a theory and paradigm of life: That is, into a revived and thoroughly molecular form of genetic determinism" (1997).

Contemporary science, by reducing all life phenomena to their physical or biochemical mechanisms, and their roles in communication to that of carriers of

communication, profoundly limits the understanding of disease and even more so of health (see below). Simpler and more convincing explanatory models will emerge when initial emphasis is placed on the flow of information rather than primarily and exclusively on material elements such as structures and signals (Foss, 1989; Foss & Rothenburg, 1987; Weiner, 1989). In terms of scientific understanding this implies the essential need for *biosemiotic thinking*, i.e. the interpretation of signals and the assignment of meaning to them (Uexküll & Pauli, 1986). In assessing the utility of radio transmission we require as much emphasis on the quality of the music as on the constituents of the wiring which, nevertheless, are indispensable preconditions.

Beyond the scope of biology and medicine we should consider the impact of scientific concepts and scientists on contemporary culture. There is currently a tendency to consider our modern or postmodern era as representing a "third culture," succeeding the "two cultures"—"literary" and "scientific"—originally identified by C.P. Snow (1964). In a recent volume described as "the most important book on how science is done since *the Double Helix*," John Brockman summarizes the views of prominent scientists on the components of this third culture (1995). He presents an array of creative concepts that illustrate the diversity and richness of contemporary scientific thought. Medicine, on the other hand, tends to confine its conceptual thinking to a much narrower range of ideas focused largely on reductionistic processes. Brockman's selection has two categories of subjects and concepts, one covering the mathematical/technical domain (e.g. artificial intelligence), and the other representing a systemic paradigm introduced by the "*new*" physics and embraced by the "*new*" biology (e.g. complex adaptive systems). In our view the inauguration of the "*third culture*" is more realistically associated with the end of the predominance of a mathematical/materialistic paradigm, as fascinating and productive as it has been, and the acceptance of a systemic/biosemiotic paradigm.

Two short case reports can serve as clinical metaphors:

1. A married couple were residents of former West Berlin. While visiting his parents in Eastern Germany in 1961 the husband had been surprised by the erection of the Berlin wall. There was no legal way for him to return. Over a period of several months he prepared to cross the wall illegally, thereby risking his life. Through secret channels the wife was informed of the plan and of the night of its attempted execution. A phone call to her was promised for a specified time immediately after the successful crossing. During the much expected and dreaded night the exhausted wife falls asleep. *At 3 a.m. the phone rings …*
2. Assume the same couple is in a different situation. The wife has come back at midnight from the hospital where her husband is under intensive care in a state of prolonged shock following a massive myocardial infarction on the previous day. After anxiously staying at the bedside of the slightly improving,

but still critically ill patient, the physicians recommended that the wife return home for rest. She is assured that the condition is under control and that no news will mean good news. At home, the wife immediately falls into deep sleep. *At 3 a.m. the phone rings …*

In both cases initially comparable processes at a material level can be described. The immediate reaction to the ringing phone will evoke, among others, symptoms connected with a surge of adrenaline such as an increased heart rate and blood pressure. The further courses in the two cases will be different. One can assume the occurrence of thousands of different observable patterns of neural activity and endocrine and neurotransmitter metabolism. These will accompany emotions of joy and relief in the first case and of despair and mourning in the second. Furthermore, bodily symptoms of well being in the former can be compared with "psychosomatic" organ dysfunction in the latter.

How is this possible? How can two different immaterial and interpretative activities of the mind, the *res cogitans* (according to Descartes) in each case, causally interact with similar initial conditions in the "extended" substance of the body, the *res extensa*? Can meaning override chemistry? How can similar telephone rings have such distinctly different biosemiotic meanings for the recipient in two different life situations and evoke such different emotional and somatic responses? The question is a major stumbling block for the contemporary Western medical model. The short answer is: in the current vocabulary, it cannot.

The preceding arguments concerned with causality and semiotics conceptualize health and disease as due in part not just to our material circumstances (e.g. genes and germs) but also to our life situations and the meanings we assign to these and other non-material circumstances. Even the use of these terms manifests, and in turn consolidates, today's imbalance of the concept of "life." Adding the root "bio-" to the terms natural sciences, medicine and psychology translates them into "biology," "biomedicine," and "biopsychology," which paradoxically emphasizes their material (e.g. biochemical, molecular) elements at the cost of their non-material meaning (Ulrich, 1997).

Suitable terms have yet to be coined but the integrative elements are subsumed under the label "*psychosomatosociosemiotic.*" This model, an extension of George Engel's (1913–1999) innovative "biopsychosocial" paradigm (1977), seeks to explain why in a living, self-regulating system informational inputs are essential regulators of biological processes. They activate system receptors that convert them into messages that initiate physiological changes. In this way the messages sent through our systems are themselves etiologic factors. That is, *belief impacts biology*. Furthermore, the messengers' structures, e.g. molecular or genetic entities, in contrast to the messages or signs, are strictly limited to the confines of the "body" (including the corpse). Life processes, however, transcend these confines. The body, then, in the context of the living organism, becomes a scientifically questionable concept. *Mindbody* (or the

mind–body–environment system) appears to be the most realistic framework for the study of life processes. For those so inclined, such a concept can readily accommodate the existence of a "soul" to replace or supplement the "mind" (Bisht, 1985). We are invoking the relativistic space–time concept in modern physics' scientific model that must include all the discernible data and all rationally founded views of a given phenomenon.

These conclusions should encourage Western medicine to broaden its concepts, research, and practice to include credible information about the patient's experiences, responses, and problems in addition to considering information about physical and chemical (e.g. molecular) interactions. In the paradigm that we advocate the patient is not a "silent" biological organism, nor is disease a deviation from the norm of biological parameters alone. Our concerns are less with the validity of medicine's current paradigm but with its adequacy to encompass all the available information that impinges on each patient's health.

The final major reservation to the core concepts of the established medical sciences, in stark contrast to their predominant preoccupation with illness, refers to the *production of health*. The phrase "production of health" is an unusual notion in the context of today's medical thinking. Health tends to be regarded as an unexamined, preexisting, statistical norm, a selection of physical and chemical nominal values, which potentially are exceeded or not attained in ill-health. On close examination of empirically founded, circular (systemic) models for the living organism and its environment, such as the *functional circle* (Uexküll, 1957, 1982, 1986), or the *situational circle* (Uexküll & Wesiack, 1997), the human–environment system makes the production of health a strikingly fruitful model. It introduces the post-biomechanical concept of *meaning*. That is, an informational or semiotic modality, as distinct from the materialistic or somatic one.

This model proposes that the living organism makes use of selected items in its environment by assigning meaning to them. Survival, including the avoidance of harmful influences, is then the result of utilizing this meaning. The everyday terms of utilization and survival have to be specified. The first should be understood in the sense of *assimilation*; that is, the building up of structure by embracing or absorbing material, social, cultural, and spiritual elements available in the environment (Piaget, 1975).

Survival denotes *accommodation* to a changing environment. It is a precondition for the maintenance of the systems. When these adaptive responses are taxed too suddenly or for too long, difficulties such as impairment and destruction may ensue. The models of the functional and situational circles thus represent the development and maintenance of living structures, the phenomenon of dynamic self-organization of living systems. In a medical perspective this can be seen as the production and maintenance of health.

Aaron Antonovsky (1923–1994), a medical sociologist, in a parallel but independent development, followed this line of thought (1987). He was among

the first in our era to criticize the shortcomings of today's almost exclusive fascination of the medical sciences with *pathogenesis*. In order to deal with the hitherto uncharted areas on the medical scientific map concerned which the production and the maintenance of health, he proposed a new term: *salutogenesis*. Antonovsky has integrated three central preconditions for salutogenic phenomena and processes in his concept of the *sense of coherence*. Its main features are the *comprehensibility*, the *manageability* and the *meaningfulness* of the environment that a person—or a living system generally—perceives as its own. As *assignment* and *utilization* of meaning are a precondition for these features, Antonovsky's salutogenic model is in agreement with the circular models described by Jacob von Uexküll (1865–1944) (1957, 1982) and Thure von Uexküll (1908–) (1997). Although such systemic views are supported by empirical data (Margraf *et al*., 1998), their acceptance among medical scientists is marginal. Meanwhile, pathogenic models of thinking have extended into a gigantic field or "industry" consisting of "scientific" knowledge, medical experience, and commercial production.

As a consequence of a health-oriented and expanded medical model, illness and disease can be seen, in part, as a person's or an organism's failure to find or to generate meaning from her or his internal and external environmental experiences and opportunities. This is in accord with the literature on stress theory. It is not the stressor as such that is the relevant etiologic factor in the first place, but the meaning assigned to it by the person. We now recognize that the intrinsic (e.g. molecular) nature of an agent and the meaning the living system attaches to that agent (conditions of gross mechanical destruction excepted) are co-determinants of disease and of health.

Our answer to the second question, then, is that close examination of the concepts of causality, of biosemiotics, of mindbody, and of the production of health can elevate historically generated models of living systems to the level of scientific explicability. In Part Three of this series we deal with the last two of our four questions.

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