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SPECIAL SERIES

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

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ABSTRACT **Background:** *During the 20th century medical education has been preoccupied largely 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 a technically efficient but increasingly narrow, monocausal, reductionistic view of health and disease. 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 new physics and systemic views of biosystems have extended the Newtonian scientific paradigm beyond its materialistic boundaries, which still determines most of the medical sciences.*

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

Results: *The extraordinarily productive contemporary biomedical model should be expanded to include meaningful information about how each patient's experiences impinge on health status.*

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

Introduction

The European development of universities in the 19th century and Abraham Flexner's (1866–1959) landmark report (Flexner, 1910) required us to focus on *where* medicine is best learned. Universities, hospitals, and clinics became the major venues. Subsequently, exponential expansion of laboratory and population-based research led to the substantial expansion of our "biomedical" science institutions. With their growing importance and power, these institutions became the *settings* for the foundation experiences in medical education. Clinical departments, on the other hand, began to play the somewhat secondary role of applying the biomedical "basic sciences." (Some retained power by adopting the strategy of developing large biomedical units.) Advances in educational psychology after World War II lead to a growing focus on *how* medicine should be learned. Curriculum reshuffling apart, small group teaching, mentoring, and problem-based learning became the preferred modalities (Kaufman, 1985; Ludmerer, 1985). Our most daunting task, however, has been to determine *what* should be learned—irrespective of the institutional or disciplinary context.

We do not view this issue primarily in terms of the highly productive contemporary "basic sciences" or the rapidly proliferating clinical specialties. Instead we consider it in terms of the assumptions, organizing concepts, and principles of science and medicine in the contexts of contemporary conditions of health and disease and the organization of resources to cope with them. Our contribution is intended to be heuristic rather than prescriptive. It is not a call for more humane treatment of patients or more humanistic health care, as important as these goals may be. And it is not a "how to do it" piece on the "art of medicine." Our aim is to generate discussion as well as new and different approaches to thinking about and understanding the maintenance of health and the genesis of disease. We make no claim that the model we espouse is established beyond question but only that it seems to account for many variables that are excluded in the contemporary monocausal, reductionistic, biomedical paradigm. There may well be other paradigms that offer better fits and in the future undoubtedly there will be. Above all, we urge empirical research to test or refute our model. Our ultimate hope, of course, is that critical thinking about the issues we raise will help to optimize our capacities to heal.

To us, the health professions generally should expand their vision of the overall scientific medical paradigm that underlies the conduct of research, the assessment of professional competence at all stages of education and practice, and the organization of effective, efficient, and balanced health services (Pauli, 1990). Before examining these matters, however, one must ask whether it is helpful to engage in what some might define as "philosophizing" or critiquing the "received wisdom" of the profession. Indeed the busy practicing physician, the over-burdened academic, as well as harried students in the health professions, have little recourse but to take for granted the dominant philosophy and seldom have the time or too often, regrettably, the curiosity to question it.

Impressed by the growing global consternation with the inadequacies of health services in the face of the phenomenal success of biomedical research and technological advances, a small group of European and North American academics who dubbed themselves the Berne Group had the temerity to attempt this task. Based in part on their deliberations this essay and the two that follow consider some of the conceptual, theoretical, and empirical ingredients of such a vision. Our discussion emphasizes the educational, research, and practice implications of this new vision for the health professions generally and for primary care especially. It is this latter, fundamental component of the health services enterprise that cares for patients in health as well as at the earliest stages of disease. Primary care health professionals are in the best position to know the domestic, social, occupational, cultural, and biological environments in which their patients' disorders arise, and with whom they have the longest and closest relationships. The research we deem essential can best be conducted at the level of primary care, more often than not in full partnerships with geneticists, molecular biologists, immunologists, neuroscientists, epidemiologists, psychologists, and other scientists. Primary care has the opportunity, indeed the responsibility, to integrate, synthesize, and expand medicine's scientific paradigm for medical education, practice, and organization.

What, then, are the elements of this vital branch of medicine? Since ancient times Western physicians have used their senses of hearing, sight, touch, and smell to observe and listen to their patients. For centuries they have also formulated theories, and periodically the theories influenced their interventions, even when contradicted by clinical observation. In the 16th century, anatomists began to explore the dead body, sometimes describing pathological changes. Until the early 19th century disease categories were arbitrary groups of symptoms with no predictive value. One exception was the 17th century physician Thomas Sydenham (1624–1689), who made careful clinical observations of his patients and followed the natural history of the diseases he described. The results were the first clear descriptions of cholera, dysentery, measles, "scarlatina," gout and "chorea." By studying his patients over the course of their illness Sydenham added the element of time to his disease categories, thus giving them predictive power (Greenhill, 1848–1850).

Sydenham's successors did not follow his example and it was not until the early 1800s that the French clinician pathologists made the next big step in clinical method; they began examining their patients. By linking signs and symptoms with postmortem findings they made morbid anatomy the foundation for a new nosology with greatly increased prognostic reliability. Rather than observing the body they examined the body, and René Laennec's (1781–1826) stethoscope became the first of many instruments designed to enhance the clinician's sensory perceptions (Laennec, 1819).

The second great exception to the prevailing patterns was that hero of family physicians the world over, Sir James Mackenzie (1853–1925). Starting his career as a general practitioner, he combined meticulous concern for the meaning and progress of symptoms and signs through clinical observation, his own innovative instrumentation (the polygraph), and long-term follow-up of patients. His investigations revolutionized research in both cardiology and general practice. Mackenzie emphasized the importance of studying each patient's natural habitat and the environment in which the illness occurred as well as the natural history of patients' diseases (Mair, 1973). In spite of his great fame and prolific writing, however, Mackenzie's views on primary care research rarely have prevailed.

In the middle of the 19th century these means of acquiring clinical data were augmented by statistical methods to validate the data, refine study designs to quantify the benefits and risks of interventions, and to assess the health of groups (Louis, 1834). In recent decades the earliest instruments of primary perception, i.e. what is directly registered by the sensory organs, have been superseded by the breathtaking development of technology, such as imaging devices, starting with X-rays and progressing to nuclear magnetic resonance and positron emission tomography. All this was meant to diagnose derangements of health ever more subtly and then to treat or repair, and occasionally to prevent illness, but rarely to maintain good health.

What, then, were the assumptions and theories underlying these impressive developments? Perpetuation of the rational and materialistic thinking founded during the Enlightenment in the 17th century provides the conceptual basis for our contemporary worldview of the natural sciences. René Descartes (1596–1650) was the central figure (Engel, 1997). By the 19th century a one-dimensional, linear, cause-and-effect model, and its predominantly technological construct, had begun to dominate scientific thinking (Cassell, 1979). From this, a seemingly logical line of operational sequences was deduced, at the core of which is the idea of a reified "disease." Categorizing diseases according to stable, visible, and describable phenomena promised to, and indeed did, deliver physicians from the incoherent and inconsistent nosologies of the 17th and 18th centuries (Faber, 1930; Foucault, 1973).

At the heart of this model is the concept of a linear monocausality. A given physical cause, or in some cases an interactive cluster of causes, results in a specific disease, i.e. somatic (mechanistic) "cause" → somatic lesion → diagnosis (classification of disease) → disease → therapy → non-disease. This doctrine of specific etiology is biased in favor of mechanistic phenomena, laying the ground for the subsequent tremendous development of technology in medicine (e.g. "body-shop medicine"). A biomechanical or biotechnical paradigm, highly productive and in line with an era of industrial development, came to dominate virtually all aspects of medical research, education, and service. There can be no question, however, of the extraordinary success of this paradigm, whose cornerstone was philosophical positivism.

The psychological and social domains are considered to be a matter of intuition on the part of health professionals—usually consigned to the rubric: "the art of medicine." The patient, scientifically speaking, becomes a machine; the focus of attention becomes that part of the mechanism that functions or—in the case of disease—does not function according to (bio)engineering prescriptions. An eminent Dutch pathologist captured the tenor of our times when he wrote:

> Today in the biomedical sciences the human body seems to be the only legitimate subject for study. In so far as they cannot be reduced to their biochemical, endocrinological, neurophysiological, or behavioral manifestations, the feelings, the mind, and the individual center of personal identity, have been placed outside the boundaries of the biomedical paradigm. They have been considered epiphenomena. (De Vries, 1981)

More recently, spectacular discoveries in physiology, biochemistry, microbiology, immunology, molecular biology, and genetics increasingly furnished explanations for the phenomena found in the living and the dead body. Based on these developments prominent representatives of the newly emerging medical sciences played major roles in upgrading their scientific concepts to a worldview. This dominance of science and medicine by the Newtonian paradigm and the persistent institutional resistance to including observations bearing on the meaning to the patient of his or her life experiences, feelings, belief systems, and other manifestations of living, have been maintained up to the present (Bloom, 1988). The Nobel laureate Arthur Kornberg (1918–), among many others, confirms the vision of the inner circle of contemporary scientists when he postulates that under the "reductionistic approach that I am espousing … acceptance without reservation that the form and function of the brain and nervous system are simply chemistry … that mind, as part of life, is matter and only matter" (Kornberg, 1987).

At best, psychological and social phenomena are then characterized by such restrictive terms as "risk factors," often placed outside of the domain defined as scientific, and seen as correlating with observed signs and symptoms at an exclusively statistical/probabilistic level. Causality in the "scientific" sense of the term still may be associated with such correlations but only under the condition that these "risk factors" have been conjoined to a mechanism or a nosology that corroborates this correlation on physical terms. Such methodologically based discrimination in the context of the 19th century scientific paradigm has led to a differentiation between "hard science," i.e. seen as precise and useful, and "soft science," i.e. seen as imprecise and not useful. Such views constitute abstractions that generalize, organize, potentially transform, and to a considerable extent simplify the perception of phenomena. There is a two-way interaction between the observations and the concepts (Fleck, 1979). One central abstraction is the concept of diagnosis, as exemplified by the *International classification of diseases* (World Health Organization, 1992–1994). We come to believe that diagnosis is the only possible *philosophical* basis for perceiving and organizing our data. Diseased individuals, however, rather than diseases are the realities. The term diagnosis represents not a statement of facts but of established medical concepts—it is based on a "belief system." As such it is an *instrument of thinking*, in the sense that its use, non-use, or alternative use will lead to different actions and effects. For example, to use the diagnostic terms of either *angina pectoris* or *coronary heart disease* in an identical situation sets the minds of those making diagnostic or therapeutic decisions in different directions. In the former case the orientation is likely to be more towards a patient's subjective perception, towards the person as a whole. In the latter, more towards the underlying mechanism, involving the vessels of the heart. One might argue that experienced health professionals are unlikely to change their views by exchanging one term for another. In accepting this argument it is important to emphasize that a paradigmatic view of illness and medicine already has been established firmly during the earliest phase of the student's medical education. Such a view and its related behavior tend to become fixed and hardened throughout a professional lifetime. A "philosophy" that guides the behavior and actions of health professionals, especially of physicians, *is established* during education. Our task in these essays is to evaluate the appropriateness of this contemporary "philosophy" and to investigate alternative or extended ways of thinking about diseased individuals, diseases, medicine, health, and the practical implications thereof for our interventions and for our health care systems.

From this brief analysis four questions arise. First, based on the historical observations above, we examine scientific developments in physics and biology, especially during the 20th century, that should influence the underlying terms and concepts that define medicine's prevailing "philosophy." The desirability, if not the imperative, of updating the latter *now*, in conformity with contemporary innovations in related fields, ensues. Second, we examine the implications of these general developments for medical scientific reasoning in the 21st century. Third, we examine the need for new or different terms and concepts upon which Western medical practice is to be based. Finally, the fourth question considers how alternative and extended ways of thinking could affect our health care systems. Because of the vital importance of the early phases of socialization of health professionals we will emphasize the implications of these discussions for their education, especially in the earliest years. We also emphasize empirical research in general and especially those aspects that are best addressed by family medicine and other primary care disciplines.

First Question: Are There Reasons *Now* to Engage in a Discussion of Medicine's Terms and Concepts in the Context of Today's Worldview?

The dominance of the biomechanical model outlined above is often explained by the fact that its application has rendered health care increasingly effective in cure and repair. Extraordinary achievements have indeed occurred under this paradigm just as Newtonian physics supported equally dramatic advances in other realms. Kuhn's (1922–1996) renowned work reminded us that paradigms might change and usually do (Kuhn, 1962). Over the centuries most theoretical formulations for understanding the world around us and ourselves have undergone profound shifts. Changes in our theories, concepts, and belief systems are most apt to occur when their underlying assumptions are examined or challenged as they have been in science generally but especially in physics and astronomy. In the 20th century, probably because of the tremendous success of its contemporary paradigm, medicine has done much less of this. Our reading of history, however, suggests that fascination with a Newtonian monocausal model prevailed *before* its utility was manifested. The following description of a physician documents this view:

> Originally concerned with natural sciences, physicians initiated the gospel that all that exists must be explained by man. For him (the doctor) the natural sciences, therefore, were the light of the world, the key to everything. From this lofty point he looked down on all those below him, fumbling in the dark and believing in things which they could neither see nor dissect… (Gotthelf, 1843)

This was written more than 150 years ago, when the natural sciences had contributed little to the success of medical interventions. Moreover, a conceptual framework for such a description by the Swiss novelist Jeremias Gotthelf (pen-name for Albrecht Bitzius, 1797–1854) was foreshadowed by an earlier critique primarily concerned with analytical scientific thought.

Johann Wolfgang von Goethe (1749–1832), the venerated author, had been deeply engaged in discussing the principles of analysis and synthesis in biology and medicine in vogue at the time. In 1798 he wrote:

> The main circumstance which seems to be forgotten when the concern is exclusively with analysis, is that the analysis presupposes synthesis … Above all, an analyst should ask himself whether he is really concerned with a mysterious synthesis or whether what he is exploring is no more than an aggregation, a coexistence … Why else should we drudge with anatomy, physiology and psychology, than to approximately grasp a complex, which produces itself permanently, as much as we tear it to pieces. (Goethe, 1979)

From the early 19th century to the present Goethe's scientific views have been considered absurd by a majority of the scientific establishment. His scientific observations have been excluded from most of the general editions of his work in the last two centuries.

At a more general level, philosophers, naturalists, poets, artists, and endowed physicians have, consciously or not, been familiar with the concepts of subjectivity, systems orientation, self-organization, and emergence. This "second track" in the historical evolution of worldviews of life started—along with the rationalistic one—during Descartes' life with the mathematician, physicist, and philosopher Blaise Pascal (1623–1662), together with Lord Shaftsbury (1671–1713), Jean Jaques Rousseau (1712–1778), and physicians and scientists of the German Romantic Age who carried it on (Meier-Seethaler, 1997).

In all these historic approaches to recognizing and organizing data and information about diverse factors that appear to impinge on health and disease, a scientific explanation, in today's sense of the term, was lacking. Rather, these more intuitively developed fundamental concepts were swept away by the perceived explanatory power generated in the Enlightenment and the post-Newtonian era. Romanticism, as it came to be called, became an epithet.

The most fundamental, and this time in a contemporary sense *scientific*, reorientation of the 17th century models has occurred in the 20th century. This process started with the introduction of quantum mechanics by Niels Bohr (1885–1962) (Bohr, 1922), Erwin Schrödinger (1887–1961) (Schrödinger, 1944), and Werner Heisenberg (1901–1976) (Heisenberg, 1985), and of relativity theory by Albert Einstein (1879–1955) among others. It has evolved with the proposition of cybernetics by Norbert Wiener (1894–1964) (Weiner, 1950), information theory by Claude E. Shannon (1916–) (Shannon & Weaver, 1949), systems theory by Ludwig von Bertalanffy (1901–1972) (Bertalanffy,1968), and non-equilibrium thermodynamics and order out of chaos by Ilya Prigogine (1917–) (Prigogine & Stengen, 1984). Three main features characterize this historic shift in scientific assumptions and concepts.

First, scientific perception, and indeed perception in general, cannot be considered as the "objective" projection within the observer's or investigator's mind of an external "reality" or immutable "truth." The perceiver codetermines the perception. Although many simple everyday observations and measurements may not be influenced to any significant degree by the inseparability of the observer and the observed, the "subject" can substantially influence more complex "objects." This effect of interaction is especially important for differentiated and insightful observations and for communication between physicians and patients. Body language, erotic responses, and blushing are responses to individuals' perceptions of their circumstances and meanings. The "placebo effect" is another example of this phenomenon.

Second, both the living and inanimate components of the universe must be seen as systems in which all that is perceived by humans is inseparably integrated within a more extended supra-system, on the one hand, which, in turn, is composed of many subsystems, on the other. Systems have properties that emerge at each higher level of organization and these emerging properties cannot be explained by the sum of the properties of their subsystems (Maturna & Varela, 1987).

Third, self-organization is one of the central phenomena that explain new qualities, especially of biosystems, emerging in the course of phylogenetic and ontogenetic development (Jantsch, 1979).

These landmark innovations emanated from empirical reevaluations of the universe's basic matter. Because the prevailing Newtonian paradigm failed to explain adequately more and more data, a new paradigm emerged. The revolutionary feature of these new concepts is their origin and gradual acceptance within physics—the core and pivotal domain of all modern sciences, especially of medicine. A number of time-honored intuitive experiences thus were elevated to the level of scientific explication.

As a turning point in the history of science, the insights introduced by quantum mechanics, among others, of a holistic structure of matter is essential to our argument (Primas, 1992; Atmanspacher,1994). If analogous insights are to inform our understanding of health and disease, empirical research is required to support or negate what still remains a defensible but unproven hypothesis.

Meanwhile, at a practical level, the tasks of health professionals should be envisioned *within their contexts.* A "touchy-feely" intuitive approach to patient care, listening, and counseling, more often than not, all provide substantial therapeutic benefit. Anecdotal evidence, case histories, astute observations of so-called coincidences, critical thinking, and an abundance of curiosity are among the initial ingredients of any scientific investigation. Alone or together, however, they do not constitute incontrovertible evidence to support the conceptual framework we are advancing. "Philosophizing" without empirical research by some who rebel against contemporary medical reductionism, sometimes within the framework of "alternative" or "complementary" medicine, has tended to weaken rather than enhance primary care generally as a scientific enterprise.Our answer to the first question, then, is that the revolutionary transformation during the 20th century in the scientific paradigm underlying medicine should no longer be ignored.

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In the 21TH century. Labour costs controlling for the knowledge economy. Aliakseyeva A. Vitebsk State Technological University, Vitebsk, Republic of Belarus . 93.Â Irrational residues arise as a result of the calculation of a piece of material in the flooring because of the non-multiplicity of the total length of the webs involved in the calculation, the length of the piece. The number of irrational residues takes a value from 0 to 4 % for different assortment groups and types of materials used. At the Department of "Designing and Technology of Clothing" of Ural State Technical University, the possibility of using inter-sheet waste by the length and width of the flooring in products for clothing purposes is being investigated. Advanced research centers opened in the early 20th century, often connected with major hospitals. The mid-20th century was characterized by new biological treatments, such as antibiotics. These advancements, along with developments in chemistry, genetics, and radiography led to modern medicine. Medicine was heavily professionalized in the 20th century, and new careers opened to women as nurses (from the 1870s) and as physicians (especially after 1970). Contents.Â It is an ancient textbook on surgery almost completely devoid of magical thinking and describes in exquisite detail the examination, diagnosis, treatment, and prognosis of numerous ailments.[21]. The Kahun Gynaecological Papyrus[22] treats women's complaints, including problems with conception. In the 21st century, there are thousands of scientific breakthroughs. These have helped in improving our way of living while some are the key to greater innovation in the future. In this article, we ranked the greatest scientific discoveries and inventions of the 21st century. Detection of Gravitational Waves. Scientists considered this as the greatest discovery of the 21st century. Let us go back to the time when Albert Einstein first predicted in his theory of relativity that time travel will be possible. Now, it has been proven by the recent findings. The LIGO project based in the United States has detected gravitational waves that could allow scientists to develop a time machine and travel to the earliest and darkest parts of the universe. @article{Pauli2000MedicalER, title={Medical education, research, and scientific thinking in the 21st century (part three of three).}, author={H. Pauli and K. White and I. McWhinney}, journal={Education for health}, year={2000}, volume={13 2}, pages={. 173-86 } }. H. Pauli, K. White, I. McWhinney. Published 2000. Medicine. Education for health. 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.