



INFOMEDICINE: THE NEW PARADIGM

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Introduction

The enormous volume of stored and easily available information and the rapid progress of communications technologies, two major phenomena that influence and determine life and culture in the twentieth century, make of our times the *era of informatics*.

Informatics is the technology –some already call it a science- that deals with the generation, storage, and communication of information, and more specifically, with systematized information. The computer is the paradigm, the tool *par excellence*, for the management of information.

The computer, the most complex and prodigious machine ever produced by man, has become ubiquitous and omnipresent in today's world. Although initially regarded as an exotic and complex machine of dubious utility, in much the same way as the automobile one hundred years ago, or the Wright brothers' "Flyer" of 1903, the computer has been incorporated into our daily life as universally as the automobile or the airplane.

And just as the automobile or the aircraft are amplifiers of the locomotive capacity of man, the computer is the amplifier of its intellectual power, but also of its cultural and humanistic domains, for this prodigious machine possesses an almost unlimited capacity to logically store, process, and transmit information in a variety of symbolic expressions, in real time and free of constrictions of volume, distance, or space.

The fusion of the computer with the advanced technologies of communications has become the leading impetus that remodels our world, its most forceful evolutionary thrust.

Marcelo Alonso (1990, 1996) refers to the revolution of information technologies as *infotech*, with the computer as one of its most important components.

Medical science constructs expertise, erudition, and wisdom, on the basis of accumulating information. There is increasing acceptance of the philosophy of *evidence-based medicine* teaching and practice and *evidence-based health policy* (Murray & Lopez 1996), and the medical school continuously add evidence-based medicine exercises and experiences to their curricula (Caudill et al 1995).

Infotech opens a wide horizon for acquiring and expanding medical knowledge originated in any part of the world, without limitations of time, space, volume, or distance. In the revolution created by the rapid advance of the information technologies, the computer, with its ample capacity for networking, stands out as a prime instrument in today's teaching and practice of medicine.

But the current essentially limitless availability of data in the cyberspace, in the Internet, if not adequately directed by quality selection, may mean *infomania*, or information glut, something that deviates from the objective of achieving erudition and medical wisdom. In the midst of the explosion in the volume of published scientific literature and the growing facility to access information, there is need to direct, orient, and evaluate the student's literature-appraising skills (Stern et al 1995).

Medicine and health care, which conventionally have built their knowledge and service infrastructure on the progress of the life sciences, conceptually constructed *biomedicine*, i.e., biomedical science, as their triumphant and reigning paradigm.

Nevertheless, the benefits of scientific advancement, technology progress, and accumulated knowledge and medical wisdom, which according to the morality and deontology existing since Hippocrates should be turned over for the benefit of persons and societies, are becoming increasingly interfered by the managed care structure within an expanding health-industry complex, which distorts the doctor-patient relationship and replaces the *Hippocratic imperative* with an economic-driven *corporate mandate*.

In 1987 L. Foss and K. Rothenberg published a celebrated book, "The Second Medical Revolution. From Biomedicine to Infomedicine" (New Science Library, Shambhala, Boston & London, 1987). The authors meant the transition of the consideration of the person not merely in the cartesian terms of mind and body, but rather as a complex, self-organizing, system, as a cybernetic biological and psychosocial being.

The term infomedicine acquires additional meaning when considering the perpetuation of life and the evolution of species, defined by the 1965 Nobel laureate Jacques Monod, of the Pasteur Institute, as *teleonomy*, or the transmission from generation to generation of the genetic information that assures conservation of the characteristics of the species. The *content of invariance* of a given species is provided by the amount of genetic information which, when transmitted from one to the next generation, assures maintenance of the specific structural norm. In Monod's conception, structure and functional capacity correspond to a certain volume of information, that he calls *teleonomic information*, which must be transferred to achieve structural form or to exercise function.

Applying the revolution of communications and informatics, infotech, to the Foss and Rothenberg infomedicine model and to the Monod teleonomic information conception, the term acquires a fuller and plainly contemporary dimension

research, the practice of the medical profession, and the provision of health care (Patiño 1997).

Information, informatics, and medicine

The revolution of communications and information attains preeminent pertinence in the fields of medicine and health care, for the practice of the medical profession, individually or collectively, is nothing more than the management and use of information. A health service is, in essence, an information system.

According to E. Lledó (1996), it is through the world of symbols, language and writing, that mankind has evolved, and although man has the capability to modify its environment, he also ends being modified, or transformed, by that very environment, a fact that points to a mutant structure in the process of human development. So, at present we observe the predominance of a *secondary socialization*, whereby in the complex entanglement of the current world, we begin to observe modifications of the individual, so much so that viewed from the present social perspective, the person may be less relevant than ever. Lledó intends to outline a context in which the term man may attain sense, and in which, furthermore, resides the symbolic universe. To Lledó authentic history is the history of the senses, semantic history; not the history of facts, but the history of signs, and it is in such manner that we approximate to the symbolic universe that circumscribes and accompanies human life.

From the perspective of secondary socialization, understood as the potential to transform the individual and the structure of society, the digital revolution appears more significant than any other symbolic human expression, including writing and printing.

Man has permanently interrogated and researched the circumscribing world, and has done so through different ways and means, each one of them expressing personal attitudes, diverse methodologies and varied skills. Today we investigate through the computer interface, which is the modern manner of managing symbolic expression and symbolic logic. Much as the evolution of the human brain, the computer exhibits clear, although quite rapid quantitative evolutionary improvement (Prigogine 1988, 1993).

Simply stated, a computer is a machine containing a microprocessor, electrical circuits, and sets of instructions that provide the capacity to store, recall, process, and disseminate information. But the computer, with its capacity for linking and applying other communications technologies, is the most powerful tool for processing intellectual activity. Thus, computers and informatics must be viewed in much greater conceptual depth, beyond the viewpoints of mechanical cybernetics and communications technology. We submit that they must be conceptualized from a *metaphysical perspective*, as the contemporary American philosopher M. Heim (1993) has proposed for virtual reality.

N. Negroponte (1995), of MIT, proclaims a major social change, that of the world of atoms by the world of bits, a change that is both irrevocable and irreparable. Bits become the fundamental element of human interaction, which means a more advanced symbolic

world, quite different from the conventional universe of language and writing. This is *the new symbolic universe*, the world of informatics, the digital world.

Digital hypertext and multimedia possess a potential for expansion and independent meaning that are not possible in the printed text. Each word or phrase in the nonlinear digital text can serve as a link, or portal, to an infinite branching of pertinent digital locations. Digital texts and electronic networking have led to the flourishing of virtual medical libraries, and in essence every medical library already is, at least in part, a virtual electronic library.

And in regard to the era of communications and to the revolution of information that has created the new symbolic universe, what is the meaning, beyond erudition, of medical wisdom in the present digital world?

The foregoing and following considerations are derived from our 16 years of experience with the *Informed Program* (Informatics in Medicine and the Health Sciences), that included since its inception on-line information for physicians, medical scholars and students. *Informed* was started in Colombia back in 1981 in cooperation with COLCIENCIAS (the Colombian Institute for the Promotion of Science), and is being extended to other Latin American countries. Such experience has led us to proclaim that the academic sector in the field of medicine and health must take active responsibility - under a well thought out vision- in exercising leadership and a defined goal for the incorporation of the information technologies in educational and research activities. It is evident that never before have we been presented with such opportunity to promote greater learning and wider insight into the essence of the science and practice of medicine. At present, PAFAMS Office of Educational Resources is dedicating its entire input towards this goal, from the perspective of considering information technologies as the new format for the learning process and for the acquisition and management of knowledge. Through digital on-line computer-assisted education, learners can be placed, more than ever, not only in charge of their *own learning*, but also such methodology allows them to choose the *way to learn*. This means re-engineering of medical knowledge, the reconceptualization of medical epistemology and medical pedagogy.

The revolution of communications, and especially the exponential growth of Internet, permits the immediate and easy access to an enormous volume of data and information in the field of medicine and the health sciences. The phenomenon of *infomania* has been described as the obsession to access data and information without regard to quality or relevance. Infomania may not add or widen human knowledge, but rather may constitute a true negative time-consuming element. It is true that beside valuable quality information available in the net, there is plenty of material being placed in the cyberspace with no regard to the norms that govern scientific publications, among which peer review is of paramount importance. Commercially-biased information abounds, along with "trash" or negligible stuff, making it hard for the uninitiated to select the really valuable information.

Computers, informatics, the Internet, should be intended to acquire quality information, to create medical wisdom, not to generate infomania.

Alonso (1996) has warned about infotech being a boon or a curse, a two-edged sword, that may offer both unprecedented benefits and damaging consequences, depending on how it is wielded (Alonso 1996).

The starting point to achieve medical knowledge, and therefrom wisdom, is the availability of data. But *data*, from Latin *datum*, is not synonym of information. *Information* pertains to the reunion of data in a framework of contents, quality, pertinence, and opportunity. *Knowledge* is understanding, intelligence, logical reasoning, referring to ranks of information and to degrees of comprehension. *Erudition* is understood as the intermediate step between knowledge and wisdom, as categorized cognition and expertise in a particular field. *Wisdom* is in-depth knowledge, in terms of structural quantity, organization, and management.

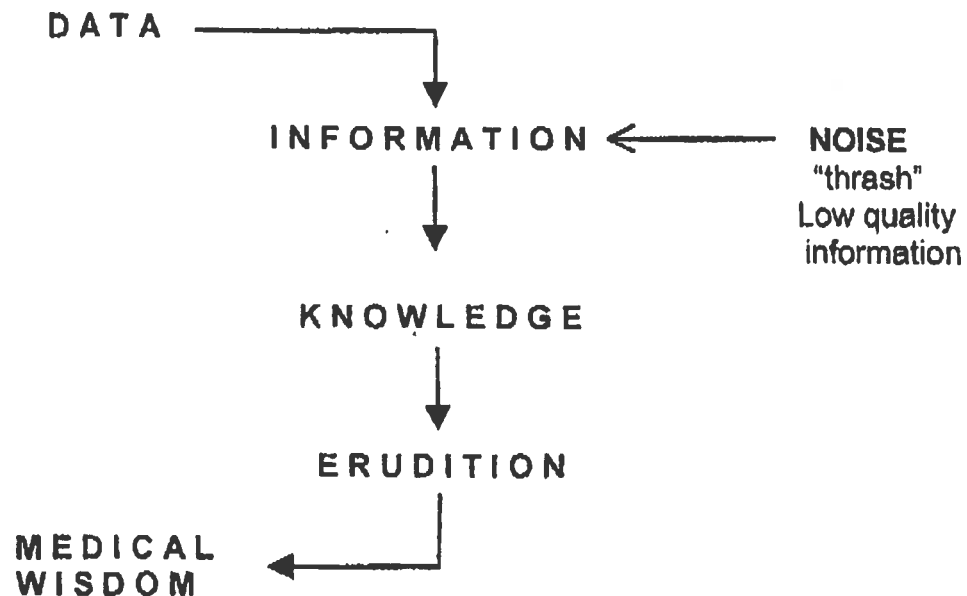


Figure 1. Flux from *data* to *wisdom*.

The purpose of previous ICUS Conferences, since the first meeting in 1972, has been to congregate erudite people who, focusing on the unity of sciences, attain an integrated worldview founded on absolute values through interdisciplinary academic dialogue. They pretend to promote wisdom and advance knowledge in diverse fields, always oriented towards the solution of global problems. One of these fields is informatics, as applied to the medical act, the *clinical encounter*, and to community health care and health promotion activities.

The clinical encounter involves the conversion of the patient's information through a documented and evidence-based reasoning process into diagnosis and treatment, which is the main objective of the doctor's action. Figure 2, modified from H.S. Barrows and

R.M. Tamblyn (1981) and H. Mandin et al (1997), depicts the inquiry process and organization of information to derive a logical approach for resolution of the medical problem.

In medical practice there is no general "standard" problem-solving process, but rather the clinical reasoning becomes tailored to the complexity of each individual case (Mandin et al 1997). Such complexity is not solely determined by the specific pathology involved, but also by a wide spectrum of epidemiologic, social, economic, ethical, and ecologic factors. In the clinical reasoning, documentation and immediately available information becomes of crucial importance. This is the essence of evidence-based medicine.

One aspect of infotech, *telemedicine*, has growing practical application in medical practice and in health care services.

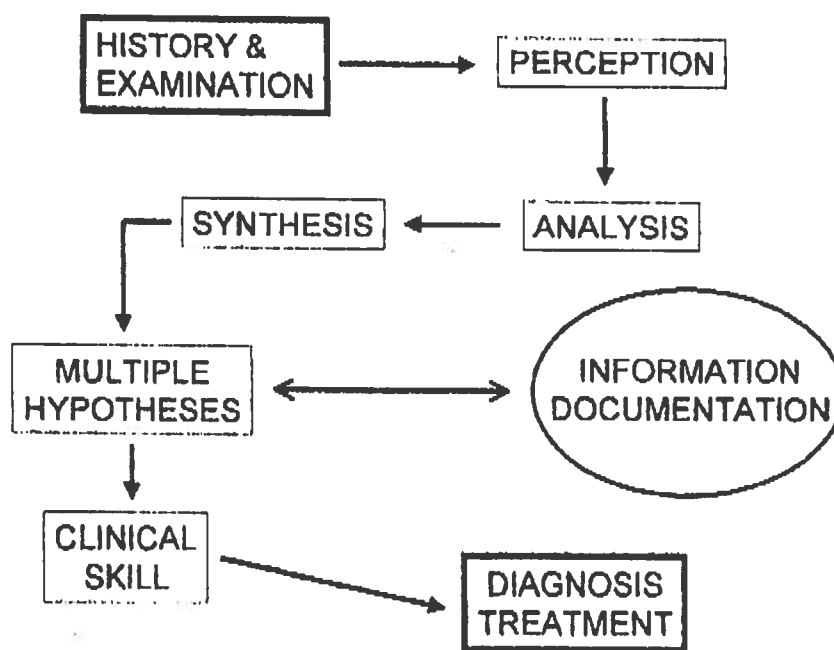


Figure 2. The reasoning process of converting the patient's information into diagnosis and treatment, the primary goal of the clinical encounter. Modified from H.S. Barrows (1981) and H. Mandin et al (1997).

Several programs intended to provide the physician, especially the doctors practicing in rural areas, with immediately available on-line information, are in operation. An innovative and successful model is the program called *Distributed Medical Intelligence* of the East Carolina University School of Medicine. Its principal characteristic is the purpose of establishing an integrating system of medical communication oriented to the promotion of expert medical knowledge in the distant site where it may be required. The model in-

corporates the presentation of medical information by means of digitalized video, audio, high resolution images and virtual reality applications to the network for medical inter-communication (Warner et al 1996).

The University of Vermont has an in vivo telepathology program serving a rural area in Vermont, which has received ample indication of satisfaction by the pathologists that are utilizing it (Callas et al 1996).

In Australia, a nation of great territorial extension and low population density, telemedicine has been focused as a logical and economic solution to the problem of how to deliver and transmit medical information, including diagnostic images, within the structure of the health system (Carabez 1997).

The University of Valle, in Cali, Colombia, has an active telemedicine program that in essence constitutes a *virtual university*. The University of Buenos Aires, Argentina, runs an innovative *Virtual Hospital Program*, which is now two years old.

Considering that public health fundamentally consists in exchange of information, telemedicine has had application even in preventive medicine (Aaron et al 1996)

Information and relevant documentation are essential tools in the medical act. Information is the patient-physician interface, as well as the community-health care service interface.

Viewed as a tool for modern research, computer sciences have achieved the creation of simulated environments, which allow the performance of experiments that with traditional methodologies would result hazardous or costly.

This means that we can now add to the conventional theoretical and practical methodologies, the computational methodology, i.e., the mathematical simulation in the computer, as illustrated in Figure 3, taken from a recent publication by G. Fritsch and E. Barbosa.

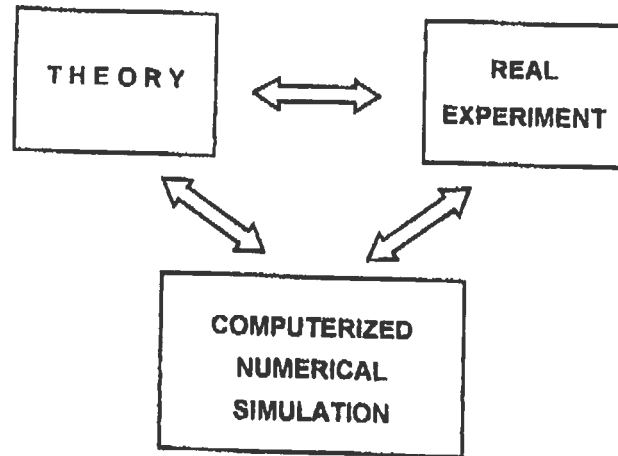


Figure 3. Interaction of the three research modalities. After G. Fritsch and E. Barbosa (1996).

Thus, computerized simulation, and virtual reality, are attaining rapid applicability in medicine. Digital surgical skills laboratories are being increasingly utilized for the training of surgeons, much in the same way as pilots are trained in flight simulators. They constitute more rational methods, less costly, thus avoiding the use of living animals for surgical training.

Anatomy is increasingly being taught in computerized "laboratories" that are gradually replacing the use of cadavers.

Minimally invasive surgery, representing the epitome link of surgical craft with communications technology, is replacing the traditional major operations. Beyond a mere advancement in technology and instrumentation, minimally invasive surgery, which utilizes the interface of video images and distant mechanical and electronic manipulation, really constitutes a *whole new surgical theory*, with radically new concepts of human intervention, new indications for surgical treatment, and different biologic and social repercussions.

Scientific triumphs and social predicaments of modern medicine

Medicine and health care are heavily dominated by outstanding technological development. They have become increasingly expensive, rising the global cost of health services, and universal coverage is but a dream in many nations, and even in underprivileged population groups in the most advanced countries. But in the midst of the glittering progress of biomedical technology, the future of medicine is under serious scrutiny. The possibility of applying the immense dimensions of accumulated biomedical knowledge to the patient's benefit may be seriously hampered, or even impeded, by economic capacity, by reasons of societal behavior, and by bureaucratic policy. While economic limitations and scarcity of advanced technology prevail in the Third World, societal attitudes and increasing regulation and management of health care affect both the rich and the

poor nations. Medicine, across the heterogeneous international panorama of health care, has a common foundation of scientific knowledge and ethical values. Physicians, the world over, face the task of fruitfully bridging the Hippocratic and scientific imperatives with the economic considerations and the economic-ridden administrative mandate that are overwhelmingly modulating and transforming organized medicine. For the physician this translates into a shift from the traditional *Hippocratic ethics*, to a new ethics, a hard to adopt *bureaucratic ethics*. In such terms, under the title "The triumph of molecular biology and the rise of biomedical science: biological paradigm and social predicament of modern surgery", I delivered a presidential address in Toronto in September of 1989 (Patiño 1989).

In the climate of an expanding health-industrial complex dominated by corporate organizations ruling medicine, many have voiced concern about the very future of medicine, and asked what the essence of being a doctor would really mean (Reiman 1987).

At the core of the problem is the relationship between doctor and patient. The new corporate managed care pattern of medical practice has introduced a new relationship whereby the patient is now called a client, a user, and the physician has become the provider, in effect an employee of a profit seeking organization instead of the patient's prime advocate (Bulger 1987).

Perhaps never as now, it appears essential to strengthen the humanistic values, the broad cultural base, the moral attitude, the compassionate humanitarian spirit, on the part of student doctors to be, so that they can present a strong block of resistance to the illnesses that obscure the future of medicine.

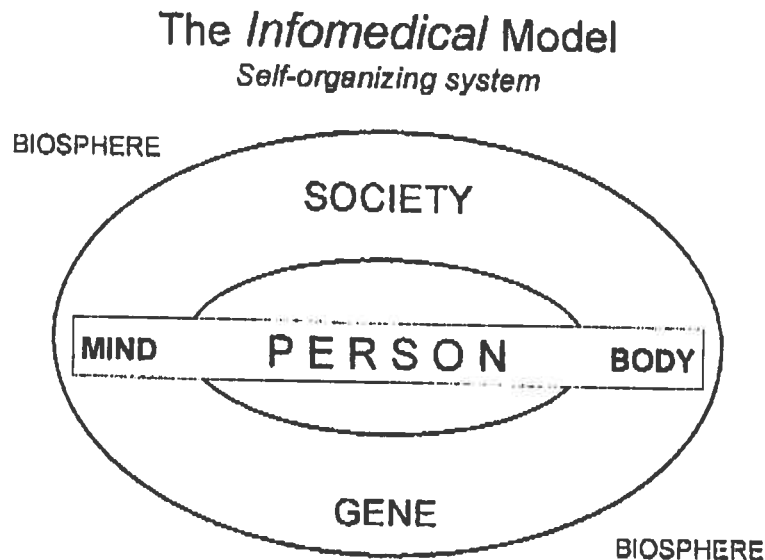
The Second Medical Revolution. From Biomedicine to Infomedicine

Foss and Rothenberg, in their aforementioned book, make a solid case to demonstrate the need to supersede the classical paradigm upon which biomedical science is founded, and propose a new model, the infomed model, that involves a conceptual shift from a biological systems infrastructure to a self-organizing system infrastructure. In the biomedical paradigm, disease is explained by means of the language of the life sciences, whose cognitive content in turn is explained by means of the language of the biophysical and physical sciences. The Foss and Rothenberg study contends that the principles, findings, and methodology of postmodern sciences permit a scientific approach to the genesis and cure of disease based on the premise that the patient is at minimum a biopsychosocial system, or, in information theory terms, an information processing system. Thus, the person is conceived beyond the mind-body cartesian dualism, to see man as a self-organizing system that incorporates the mutual causal process that are characteristic of complex systems whose states are determined by negative and positive feedback.

This change in paradigm implies a true revolution, in the Khunian sense, confronting two medical strategies: "the first is an engineering strategy based on natural science foundations, the second is a cybernetic strategy based on self-organizing systems foundations.

The dramatic differences between the two crystallize over the interactive levels of organization evident in the latter strategy."

Figure 5. The infomedical model. According to L. Foss and K. Rothenberg (1987).



This proposition has been analyzed in depth and adopted by our group at the Office of Educational Resources of PAFAMS as a valid and seminal contribution to the process of reconceptualization of health and medical education.

From the City of Learning, through the Multiversity, to the Virtual World University

The modern communications technology, infotech, and the international networks, especially Internet, bring to immediacy the materialization of two ideals that have commanded priority attention in the field of higher education, at least for the past three decades: one is the concept of the *multiversity*, of Clark Kerr, and the other, the idea of a *world university*, of Michael Zweig and many others. The university was born and evolved as a confined community of masters and students, the so called "City of Learning", which not infrequently has been labeled "Ivory Tower".

Clark Kerr, former President of the University of California, in his landmark book "The Uses of the University" (Harvard University Press, Cambridge, 1964), described the change from the classical university composed of a single community of masters and students, to the postmodern university, a site of learning where multiple communities and activities are held together by a common name, a common governing board, and related purposes, the emerging "multiversity". Clark's *multiversity* is an inconsistent institution, it is not a single community, but several –the community of the undergraduate and the community of the graduate; the community of the humanist, the community of the social scientist, and the community of the scientist; the community of the profes-

sional schools; the community of all the nonacademic personnel; the community of the administrators. Its edges are fuzzy –it reaches out to alumni, legislators, farmers, businessmen, who are all related to one or more of these internal communities. Devoted to a quality of opportunity, it is not a class society. In the multiversity interests are varied, and often conflicting. The "Idea of a University" was a village with its priests; the "Idea of a Modern University" was a town -a one-industry town- with its intellectual oligarchy; the "Idea of a Multiversity" is a city of infinite variety. In the *multiversity* there is less sense of community than in a village but also less sense of confinement. There is less sense of purpose than within the town, but there are more ways to excel. There are also more refuges of anonymity - both for the creative person and the drifter. As against the village and the town, the "city" represents the totality of civilization and it has evolved, becoming more and more an integral part of it; and the movement to and from the surrounding society has been greatly accelerated.

Michael Zweig, of the University of Michigan, after considerable travel and research, in his "The Idea of a World University" (Southern Illinois University Press. Feffer & Simmons, Inc. London and Amsterdam, 1967) was the first to present the concept of a world university, a supranational institution in which the intellectual community throughout the globe would establish a world education in new institutional forms. This university, and/or world centers, could bring together scholars and students from the world's cultural, ideological, and geographical regions for common study in the arts and sciences. The world's intellectual resources could thus be placed at the disposal of all societies and nation-states for the solution of human problems.

A similar idea of a supranational university had been advanced at the end of the First World War by Paul Otlet and Henri LaFontaine. Since then hundreds of similar proposals have been made to the League of Nations, the United Nations, UNESCO, and to international organizations of scientists and scholars (Zweig 1967), and finally the United Nations created its university with its campus located in Japan.

Infotech and Internet permit the true *universalization of the university* by means of radically different institutional forms. Universities around the world are utilizing the cyberspace nets to reach off-campus and distantly-located virtual students through a variety of tele-educational programs. Virtual universities are becoming a reality under the burgeoning world of electronic distance teaching and learning.

The time is ripe for the development of a global network for education and research, utilizing infotech in meaningful, practical, and economic ways.

PAFAMS has thus established its own network for education and research, **Fepanet** (www/fepafem-bogota.org) linking all the medical schools of the hemisphere. Although recently born, it already demonstrates its benefit and capacity of service. Interinstitutional collaboration will be facilitated, and there will be ample opportunity to develop virtual educational and research scenarios.

Conclusion

Information technologies, infotech, affect profoundly medical practice, teaching and research. The patient and the community are now understood beyond the cartesian dualism of mind and body, in terms of complex self-organizing systems, as cybernetic psychosocial beings. The triumph of biomedical science and the rapid technological advance constitute unprecedented capacities to benefit health and well-being, but such capacities are interfered by new patterns of managed care and corporate medical practice that displace the traditional ethical and moral Hippocratic imperative. Information constitutes the patient-doctor and the community-health service interfaces, and medical teaching and medical practice are increasingly governed by the evidence-based medicine philosophy. The availability and accessibility of relevant high quality information and knowledge are crucial factors in the medical reasoning process and the problem solving strategies. The explosion of published medical information and the advanced technologies for information access, signify novel and practical methodologies for the management of knowledge, but paradoxically introduce the danger of infomania, abundance of low quality material, and information glut. An exponentially growing worldwide system for the provision and acquisition of data and information, Internet, provide ample and practically unlimited global intellectual exchange and dialogue and permit the universalization of the university, the creation of virtual universities with drastically different institutional forms. A global network for education and research is no longer a hopeful dream, but a conforming reality. Towards the achievement of such objective in the field medical education, research and practice, PAFAMS has created Fepanet.

This entirely new panorama can be best approached from the perspective of the *info-medicine* concept, the new paradigm that should replace the reigning but exhausting biomedicine paradigm.

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