

The rise of health information technology

Henry Milgrom^a and Zung Vu Tran^b

^aNational Jewish Health and ^bUniversity of Colorado
Denver, School of Medicine, Denver, Colorado, USA

Correspondence to Henry Milgrom, MD, National
Jewish Health, 1400 Jackson Street, Denver, CO
80206, USA
Tel: +1 303 398 1999; fax: +1 303 270 2189;
e-mail: milgromh@njhealth.org

**Current Opinion in Allergy and Clinical
Immunology** 2010, 10:000–000

Purpose of review

The purpose of this review is to discuss transformational changes taking effect in biology and medicine and to place them in a broad historical context.

Recent findings

Recent findings suggest that in the new millennium, information technology will promote great changes in the study of biology and the practice of medicine. Digital information, more readily assessed, analyzed and manipulated, will be used to integrate large and disparate data sets. Systems biology emerging as an interdisciplinary field will focus on complex interactions in biological systems. Health information technology will make possible efficient healthcare that is predictive, personalized, preventive and participatory.

Summary

Systems biologists' understanding of biological information will promote conceptual insights and practical innovations. Predictive, preventive, personalized and participatory medicine will help patients and physicians make optimal treatment decisions.

Keywords

evidence-based medicine, health information technology, personalized, predictive, preventive and participatory, systems biology

Curr Opin Allergy Clin Immunol 10:000–000
© 2010 Wolters Kluwer Health | Lippincott Williams & Wilkins
1528-4050

Introduction

Since the beginning of time man has sought to acquire skills and tools to relieve suffering. Many millennia before the written word our forbearers were sharing medical information. Archeological findings dating back to the Stone Age show evidence of surgical expertise, broken limbs set and healed, dislocations reduced and wounds treated. Bone needles from the Upper Palaeolithic (30 000 years ago) suggest that cuts may have been sutured. Trepanation flourished in Neolithic Europe (7000 years ago). Reasons for this practice remain uncertain, but major blood vessels had to be avoided, bleeding had to be controlled and surgical sites had to be kept free of infection. The survival of those so treated evident by the healing and remodeling of bone shows that the ancient practitioners had acquired considerable knowledge of operative manual and instrumental techniques [1].

About 5000 years ago, societies in ancient Sumeria, China and South America invented writing, an achievement that continues to sustain human capacity to accumulate and share knowledge [2]. Evidence from earliest recorded time attests to mankind's interest in healing the sick, first by looking to nature for remedies. A Sumerian clay tablet (2150 BCE) describes wounds being washed in beer and hot water, poultices made from pine,

prunes, wine dregs and lizard dung. Other texts describe the symptoms and prognosis of epilepsy, bronchitis and scurvy. A list of 230 medicines using plant, animal and mineral ingredients was found in an Assyrian pharmacy [1]. Ephedra, also known as 'ma huang', may be the world's oldest medicinal herb cultivated nearly 5000 years ago for therapeutic purposes, among them the treatment of asthma (www.botgard.ucla.edu/html/botanytextbooks/economicbotany/Ephedra/index.html).

The human mind can construe a particular scenario in multiple ways. Each idea has distinctively human quirks that make it useful for reasoning but that can also lead to fallacies and confusion [3]. All human societies through the ages have had beliefs that account for birth, death and illness. In these beliefs factors such as destiny, sin, and astral influences often played a critical role fostered in some measure by the fact that often the priest had also been the physician and that the guardians of the medical texts had been followers of particular religious devotions. In the West starting in 12th century medicine was established as a faculty along with law and theology in the great European universities. A most notable advance in the dissemination of health knowledge was the printing press first assembled around 1440. Prior to this development Cambridge University library owned a total of 122 books; each had the value of a farm or a vineyard (<http://en.wikipedia.org/wiki/>).

The modern era began in the mid 19th century when students of animal physiology applied science to the art of healing [4]. The philosophical origins of evidence-based medicine (EBM) extend back to the same time as medical practice based on experiments and data slowly began to supplant practice based on authority and precedent [5]. EBM calls for clinical decisions supported by relevant research into the accuracy and precision of diagnostic tests, the power of prognostic markers, and the efficacy and safety of treatment regimens [5]. Evidence-based medicine seeks to establish the most effective algorithms of practice through the use of systematic reviews and meta-analysis. It draws support from modern information science to collect all evidence and analyze it according to accepted protocols.

In the past century and a half scientific medicine has made great steps forward in accuracy and effectiveness. For the first time it has been possible to manage successfully or even cure a wide range of illnesses. In the 20th century translational biomedical research emerged with the aim 'to integrate bedside and biology' and to bridge the gap between clinical care and medical research. We have seen vast advances in knowledge of the properties of matter and of the molecules of life, all coincident with the digitization of information. But, we have yet to develop effective approaches for predicting and preventing the occurrence of complex diseases [6].

The 21st century began with the sequencing of the human genome, an advance setting off a revolution in life sciences. Systems biology has emerged as an interdisciplinary field that focuses on complex interactions in biological systems. A 'system' is a group of independent but interconnected elements that function together to comprise a unified whole (www.systemsbiology.org/Systems_Biology_in_Depth). Systems biology studies the hierarchies of biological information: DNA, RNA, proteins, macromolecular complexes, signaling networks, cells, organs, organisms, and species within their environmental and temporal contexts. Biological networks capture, transmit, integrate, dispense, and execute biological information [7]. Systems biology promotes conceptual insights and practical innovations that will profoundly transform societies with not only scientific and medical, but also ethical, social, legal and political consequences [6].

Health information technology will propel the revolution in 21st century biology and medicine. Digital, as opposed to analog information, is much easier to assess, analyze and manipulate. Bookkeeping of biology and medicine will be digitized. Relevant information will be extracted from single molecules and from single cells. The logic of life will be revealed computationally, although the interplay of environmental information with the digital genome information will still require experimentation [6].

Health information technology and systems biology will have a major role in creating a predictive, personalized, preventive and participatory approach to medicine [7].

Recently, National Alliance for Health Information Technology (NAHIT) established definitions for electronic medical records (EMR) and electronic health records (EHR).

EMR is the electronic record of health-related information on an individual that is created, gathered, managed, and consulted by licensed clinicians and staff from a single organization who are involved in the individual's health and care. EHR is the aggregate electronic record of health-related information on an individual that is created and gathered cumulatively across more than one healthcare organization and is managed and consulted by licensed clinicians and staff involved in the individual's health and care. An EHR will provide a more comprehensive view into a patient's health and history by pulling information from other systems, providing clinical decision support and alerting providers to health maintenance requirements. It will help providers report and measure quality indicators for pay-for-performance incentives [8].

Enormous computational power can be delivered in forms so small and inexpensive that individual patients can use them. Data captured by these digital devices can be turned to intelligence because we now have the processing power and analytical methods to make sense of it all. We are generating a mounting quantity of data that can be made more useful by integrating clinical research projects with data repositories built up by documentation of routine clinical care [9]. In 2007, the United States Congress passed a law instructing the Food and Drug Administration to make use of the terabytes of data on drug exposure and clinical events that the health system generates [10^{••}]. In 2009, the Institute of Medicine in response to a congressional directive released a report recommending a portfolio of 100 study topics related to a range of diseases, research methods, and care models that are important to the United States population [11^{••}]. Health information technology allows comprehensive management of medical information and its secure exchange between healthcare consumers and providers. Interoperable health information technology can be expected to bring about:

- (1) complete, accurate, and searchable health information, available at the point of diagnosis and care, allowing more informed decision making
- (2) elimination of delays in the exchange of records and of unnecessary/repetitive tests or procedures
- (3) earlier diagnosis and characterization of disease
- (4) reduction in adverse events through an improved understanding of each patient's particular medical

history, potential for drug–drug interactions, and ultimately enhanced understanding of a patient's metabolism or and molecular profile

(5) increased efficiencies related to administrative tasks.

(Health Information Technology for the Future of Health and Care <http://healthit.hhs.gov/portal/server.pt>)

Conclusion

The ancient Greek concept of *techné* describes a fundamental and defining feature of humans – the capacity of thought to inform productive action. *Techné* is a special form of practical knowing; the capacity to undertake reasoned activity for the production of *ergon* or work. In the context of medicine, the Aristotelian idea of *techné* comprises listening skills directed to the lived experience of the patient so that scientific knowledge can be applied to the healing. This constitutes medicine's existential focus [12]. We now have the capacity to inject new intelligence to health delivery systems. Our challenge is to continue to apply *techné* to enlarge the scope and improve the quality of our work.

References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

- of special interest
- of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 000–000).

- 1 The Origins of Ancient Medicine. Series: What the Ancients did for us. [Internet] BBC/OU TV; 2005 [updated 2005 November 1; last accessed 2010 March 19]. Available from: <http://www.open2.net/whattheancients/medicine1.html>.
- 2 Dehaene, S. Reading in the brain: the science and evolution of a human invention. New York: Viking, 2009.
- 3 Pinker S. The stuff of thought. New York: Penguin Books; 2007.
- 4 Aldhous P, Coghlan A, Copley J. Animal experiments: where do you draw the line? let the people speak. New Sci 1999; 162:26–31.
- 5 Sackett DL, Rosenberg WM, Gray JA, Haynes RB, Richardson WS. Evidence based medicine: what it is and what it isn't. BMJ 1996; 312:71–72.
- 6 Health Care in the 21st Century: P4 Medicine™: Predictive, Preventive, Personalized, and Participatory. [Internet] Seattle WA: Institute for Systems Biology, 2009 [updated 2009; last accessed 2010 March 19]. Available from: http://www.systemsbio.org/Intro_to_ISB_and_Systems_Biology/Predictive_Preventive_Personalized_and_Participatory.
- 7 Weston AD, Hood L. Systems biology, proteomics, and the future of health-care: toward predictive, preventive, and personalized medicine. J Proteome Res 2004; 3:179–196.
- 8 Neal, H. EHR vs EMR – What's the Difference? [Internet] Software Advice; 2008 [updated 2008 November 14; last accessed 2010 March 19]. Available from: <http://www.softwareadvice.com/articles/medical/ehr-vs-emr-whats-the-difference/>.
- 9 Prokosch HU, Ganslandt T. Perspectives for medical informatics. Reusing the electronic medical record for clinical research. Methods Inf Med 2009; 48:38–44.
- 10 Avorn J, Schneeweiss S. Managing drug-risk information: what to do with all those numbers? N Engl J Med 2009; 361:647–649.
- The authors describe a system with the potential to identify and quantify adverse-event signals with unprecedented power and speed. They write, 'If someone can go to an ATM in Peru and obtain funds from a bank in Peoria, it should be possible to ascertain whether someone who filled a prescription for rosiglitazone is the same person who was later hospitalized with a myocardial infarction... Hard work, but not neurosurgery.'
- 11 Institute of Medicine. Committee on Comparative Effectiveness Research
- Prioritization. Initial National Priorities for Comparative Effectiveness Research. Washington, D.C.: Institute of Medicine of the National Academies, 2009.
- The Recovery Act (ARRA) contains \$1.1 billion for comparative effectiveness research. The Institute of Medicine report contains the first set of priorities for maximizing the value of this research.
- 12 Warsop A. Art, science, and the existential focus of clinical medicine. Med Humanities 2002; 28:74–77.