Where is Technology Leading Us?

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We are in the midst of history’s next major technology-induced paradigm shift in medicine.
Disclosures:

• I am neither historian nor philosopher
• I am a clinician and educator
• My views arise from the need to ensure medical education anticipates, rather than reacts to, changes in medical care
  • Johns Hopkins School of Medicine Genes to Society curriculum
• I have no financial interest in any content of this discussion
“Variability is the law of life, and as no two faces are the same, so no two bodies are alike, and no two individuals react alike and behave alike under the abnormal conditions which we know as disease. “ William Osler, 1903
What is a Paradigm?
Paradigm

- Webster: An outstandingly clear or typical example; an archetype
- Kuhn (1962): a set of beliefs that
  - Sufficiently unprecedented to attract an enduring group of adherents away from competing modes of scientific activity
  - Sufficiently open-ended to leave unresolved questions for investigation
Scientific Progress Occurs Via Paradigm Shifts

- Research under one paradigm induces paradigm change
  - Novelties of fact induce inventions that lead to novelties of theory and paradigm shift
  - Science does not advance in a linear fashion
- A new paradigm must seem better than its competitors but need not explain all facts
- Paradigm Shift is usually induced by technological innovation
  - Fact vs ‘Truth’
Medical Paradigm: 500 BC

Asclepius

- divine visitation
- symptoms
- course
- divine appeal or magic
Technological Innovation
400 BC - 200 AD

Hippocrates
460-370 BC

Galen
131-201 AD
Humoral Medicine Paradigm
400 BC-1500 AD

Man and Nature in the Renaissance, 1978 (pg. 56)
Modern Medicine Paradigm
1630-2003

William Harvey (1578-1657)

Anton von Leeuwenhoek (1633-1723)

Sanctorius (1561-1636)
Modern Medicine
1630-2003

Louis Pasteur (1822-1895)

Robert Koch (1843-1910)

James Watson (1928- ); Francis Crick (1916-2004); Maurice Wilkens (1916-2004); Rosalind Franklin (1920-1958)
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The Individualized Medicine Paradigm

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Classic Disciplines vs. Individuality

1992
Typological (classic case)
- Molecular Biology
- Physiology
- Pharmacology
- Pathology
- Etc.

2009
- Society
- Community-Family
- Environment
- Latent Disease
- Risk
- Critically Ill
- Organ Failure
- Patient phenotype
- Organ physiology
- Cell biology
- Genomics

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Variation In Bone Mineral Density (BMD)
“There is no science of the individual, and modern medicine suffers from a fundamental contradiction: its practice deals with the individual while its theory grasps universals only.” 1963

Oswei Temkin, 1902-2002
“Genes to Society”—The Logic and Process of the New Curriculum for the Johns Hopkins University School of Medicine

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Abstract

In August 2009, the Johns Hopkins University School of Medicine implemented a new curriculum, “Genes to Society” (GTS), aimed at reframing the context of health and illness more broadly, to encourage students to explore the biologic properties of a patient’s health within a larger, integrated system including social, cultural, psychological, and environmental variables. This approach presents the patient’s phenotype as the sum of internal (genes, molecules, cells, and organs) and external (environment, family, and society) factors within a defined system. Unique genotypic and societal factors bring individuality and variability to the student’s attention. GTS rejects the phenotypic dichotomy of health and illness, preferring to view patients along a phenotypic continuum from “asymptomatic and latent” to “critically ill.” GTS grew out of a perceived need to reformulate the student experience to meet the oncoming revolution in medicine that recognizes individuality from the genome to the environment. This article describes the five-year planning process that included the definition of objectives, development of the new curriculum, commission of a new education building, addition of enhancements in student life and faculty development, and creation of a vertical and horizontal structure, all of which culminated in the GTS curriculum. Critical ingredients in meeting the challenges of implementing GTS were leadership support, dialogue with faculty, broad engagement of the institutional community, avoidance of tunnel vision, and the use of pilot courses to test concepts and methods. GTS can be viewed as the foundation for the scientific and clinical career development of future physicians.

Individuality Model of Medicine

- How do we define disease?
  - Alteration in individual homeostasis
- Why do humans get disease?
  - Intrinsic make-up and external factors
- Why does this person have this disease?
  - Why do these people not have this disease
- Why does this person have this disease now?
- What can we do to restore this person to their unique steady state?
- How can we utilize our knowledge of this individual to prevent disease and maintain health?
Breast Cancer Prevention Based on Gene–Environment Interaction

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Breast cancer, the most common cancer in women, results from combined effects of genetic and environmental factors. Although a number of preventive measures have been suggested to reduce the risk of breast cancer, only a few (e.g., regular mammogram, etc.) proved to be efficient preventive modalities. Among many potential reasons, differences in individual susceptibility factors may complicate the efficacy of the intervention. A growing body of evidence shows that the strength of association between various dietary, behavioral (exercise and obesity), and environmental exposures, and breast cancer risk may be modified by individual genetic factors. Preventive strategies against breast cancer will be discussed considering the findings of the gene–environment interaction of breast cancer. These include behavior modification for high-risk subjects (primary prevention), early detection and extensive monitoring of genetically susceptible subjects and noninvasive treatment of early stage cancer cases (secondary prevention), and finally prophylactic and therapeutic intervention to slow the progression of diseases (tertiary prevention). The accumulating evidences of the gene–environment interactions provide a better understanding of the breast cancer development and enable us to adopt individualized preventive strategies for personalized health care.

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Key words: breast neoplasms; gene; environment; interaction; prevention
Clinical assessment incorporating a personal genome


Summary
Background The cost of genomic information has fallen steeply, but the clinical translation of genetic risk estimates remains unclear. We aimed to undertake an integrated analysis of a complete human genome in a clinical context.

See Comment page 1497

Lancet 2010; 375: 1525–35
Individualized Gene-Environment Interaction
Implications of Individuality Paradigm

- Appreciation of complexity/systems biology
  - Mechanisms of disease- 21st century
- Risk and Prevention
  - Individuals
  - Public Health
- Evidence-based medicine
  - Average vs. Individual
- Pharma/Industry
  - Individuality-based Diagnostics and Therapy
  - Health Information Systems based on Individuality
Summary

• We are in the early phases of a paradigm shift in medicine relating to individuality and variability
• Health care is/will be changing practice in context of risk, prevention, diagnosis, and therapeutics
• There are tremendous opportunities in innovation and technology development to improve care within the Individuality paradigm
“Diseases are caused by the independent action of neither genes nor experiences, but by the influence of each on the protein products that are unit steps of the homeostasis of specific individuals in whom they coincide for reasons traceable to phylogeny and culture.”

Barton Childs, MD (2003)
Thank you!

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