“It is not the strongest of the species that survives, nor the most intelligent, but the one most responsive to change.”

-Charles Darwin
Whither Medicine? Bioengineering and the Future of Medicine

Franklyn G. Prendergast, MD, PhD
Edmond and Marion Guggenheim Professor of Biochemistry and Molecular Biology
Professor of Molecular Pharmacology and Experimental Therapeutics
Discuss two megatrends in medicine

- Personalized Medicine
- Health-care Economics: dollars rule
- Linked solutions
Must Read:

The Creative Destruction of Medicine
How the Digital Revolution Will Create Better Health Care
ERIC TOPOL, M.D.

The Innovator’s Prescription
A Disruptive Solution for Health Care
Clayton M. Christensen
BESTSELLING AUTHOR OF THE INNOVATOR’S DILEMMA
Jerome H. Grossman, M.D. & Jason Hwang, M.D.
Personalized Medicine as:

“The Science and Medicine of Human Variation and Individualized Medical Need”
Human Variation as the Principal Basis of Individualized Medicine
Causes of Human Variation

Genetic variation
- Inherited traits
- Somatic genetic mutations
- “Epigenetics”

Biological plasticity
- Neuro-psychological plasticity
- Immunological plasticity

Life induced changes: Individual medical need
“Precise” diagnosis (disease stratification) is the hallmark of Personalized Medicine.
Patient and Disease Stratification

Patients Diagnosed with “Syndrome”

Stratification Process
“Syndrome Dissection”

Multiple “bins” of patients
Caveat regarding “stratification”

- Cancer as personalized medicine archetype
- The “antibiotic” treatment paradigm
How do we change the “healthcare cost curve”?
FIGURE 1.1 Model of disruptive innovation

Sustaining innovations, whether incremental or radical, make good products better.

Pace of performance improvement that companies provide

Performance improvement that customers can utilize

Disruptive innovations make products simpler and more affordable

The Innovator’s Prescription Clayton M Christensen
Table 4.1 Conditions managed by MinuteClinic

<table>
<thead>
<tr>
<th>Common Illnesses</th>
<th>Skin Conditions</th>
<th>Vaccines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allergies</td>
<td>Athlete’s foot</td>
<td>DTP (diphtheria, tetanus, pertussis)</td>
</tr>
<tr>
<td>Bladder infections (females)</td>
<td>Cold sores</td>
<td>Flu (seasonal)</td>
</tr>
<tr>
<td>Bronchitis</td>
<td>Deer tick bites</td>
<td>Hepatitis A (adult)</td>
</tr>
<tr>
<td>Ear infections</td>
<td>Impetigo</td>
<td>Hepatitis A (child)</td>
</tr>
<tr>
<td>Pink eye and styes</td>
<td>Minor burns</td>
<td>Hepatitis B (adult)</td>
</tr>
<tr>
<td>Sinus infections</td>
<td>Minor skin infections</td>
<td>Hepatitis B (child)</td>
</tr>
<tr>
<td>Strep throat</td>
<td>and rashes</td>
<td>Meningitis</td>
</tr>
<tr>
<td>Swimmer’s ear</td>
<td>Minor sunburn</td>
<td>MMR (measles, mumps, rubella)</td>
</tr>
<tr>
<td>Flu diagnosis</td>
<td>Poison ivy</td>
<td>Pneumonia (Oct.-Dec.)</td>
</tr>
<tr>
<td>Mononucleosis</td>
<td>Ringworm</td>
<td>Polio (IPV)</td>
</tr>
<tr>
<td>Pregnancy testing</td>
<td>Wart removal</td>
<td>TD (tetanus, diphtheria)</td>
</tr>
</tbody>
</table>
A Holistic Clinical Value Chain

**Susceptibility**
- Monogeneic: Dominant/Recessive
- Complex Disease

**Risk Analysis** (modeling)

**Prediction**

**Risk Mitigation**
- Prevention
- Risk monitoring

**Early Detection/Dx**

**Prognosis**

**Interventions for Disease Management**
- Stratification: patient and disease profiling
- Therapeutic Target ID/Validation
- Therapeutic algorithms
- Pharmacogenomic: drug/genome interactions
- Therapeutic monitoring

**Companion DX**

**wellness**

1/22/2014
Primary Care

The domain of primary care is dynamic. Expansion of this domain is being driven inexorably by novel technology. That expansion is commensurate with reduction of 3° care assignments.
Precision Diagnosis and Care Delivery

Technology driven precision in Dx and expert systems-based (computationally driven) clinical decision support systems increase the usefulness of non-physician care providers.
Specialized Diagnostics for Personalized Medicine

• Multi-dimensional genomics
• Multi-modality imaging
• Multi-plexed proteomics
• Multi-disciplinary bio-informatics/computational medicine
Quasi-automated primary care

- Home; doctors office; retail clinic
- Decentralized diagnostics
- Computationally driven clinical decision (support) systems
- Efficient referral
Expert System-Guided Referral

1° care facility

2° care facility

3° care facility

Home Health
Realizing decentralized diagnostic

Exemplary technologies:

• Somalogic
• Ativa
• Nanostring
• QuantuMDx
• Cepheid
• IBM/Watson (cf Diagnostics plus)
• Daktari
Ativa’s Vision to “Enable Diagnoses”
At Present Blood Testing is Highly Constrained by Requirements of Centralized Testing

Above:
- Sites that have a sample volume of 300+/day
- Infrastructure to support the logistics
Ativa’s Vision to “Enable Diagnoses”
World Wide Blood Testing Greatly Expands with Ativa MicroLAB

Above:
- Locations with sample volumes greater than 10/day
TODAY
THERE IS NO PLACE
OUT OF REACH
- Prick patient’s finger with lancet
- Apply drop of blood to disposable cartridge
- Insert cartridge into unit
  - Washing, Capture, Measurements
- CD4 count is displayed

Research Prototype

Product

www.daktaridx.com

Co-founders:
W. Rodriguez, R. Bashir, M. Toner
Point-of-Care Count of Cells from a Drop of Blood
Transdermal detection of malaria

Hemozoin

Vapor nanobubble

Laser pulse

Acoustic signal
Features of future diagnostics

• Substantially decentralized
• Modular; scalable; automated; miniaturized (portable); digital; multiplexing; optimal sampling; random access; high throughput; disposable
• Enhanced precision and accuracy
Novel Dx Enables

- Method and result standardization
- Automated QA/QC
- Commoditization
- Democratization of access and communication
- System-ization
- Reduced unit cost; capital and per result
- Enhanced privacy
- Facile result reporting and follow on
Caveat

Can Physiology Zap Therapeutic Sweet Spots in Hypertension?

Michael J. Joyner
Principal Impediments to Development and Implementation

- Physician adoption
- Perverse incentives
- Regulatory requirements
- Funding
- Risk aversion
Disruptive Medical Transformation through Informatics (Computational Medicine)

- Process control
- Technology driven decentralization
- “Big” data integration and analysis
- Clinical decision support systems/Clinical decision systems
Telemedicine

• Diagnosis
• CDS/CDSS
• Simulation
• Online training
Dominant Domains in Medicine’s Future

- Imaging
- Genomics and Epigenomics
- Immunology
- Cell Biology and Tissue Engineering
- Bioengineering
Starting points for Change

• Medical school education: new models
• Value of MD,PhD cohort
• Focus “O.U.S.” leap frogging!
• Rethinking universality of “risk-benefit” assessments
Internet-based medicine

• On-line education
• On-line practice: telemedicine, telepathology, teleophthalmology
• Real-time surgical assistance
Summary: Whither Medicine?

• Technology enabled personalization of medical care
• Decentralized delivery systems with emphasis on 1° care are inevitable
• Dominant role for point-of-care diagnostics in transformation (disruption) of traditional practice habits.
• Computational medicine is essential for data integration and analysis and for CDSS
• Bioengineering principles increasingly will drive the practice of medicine and hence medical training in all regards