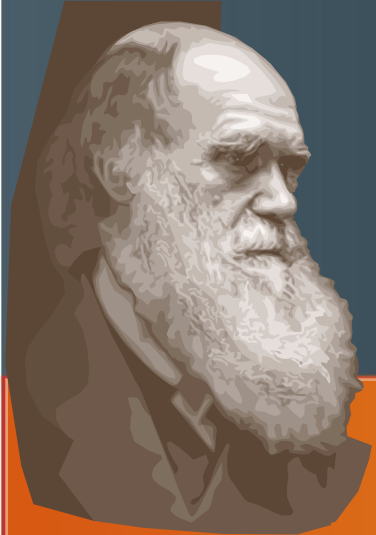


“It is not the strongest of the species that survives, nor the most intelligent, but the one most responsive to change.”

-Charles Darwin



Whither Medicine? Bioengineering and the Future of Medicine

Franklyn G. Prendergast, MD, PhD

Edmond and Marion Guggenheim

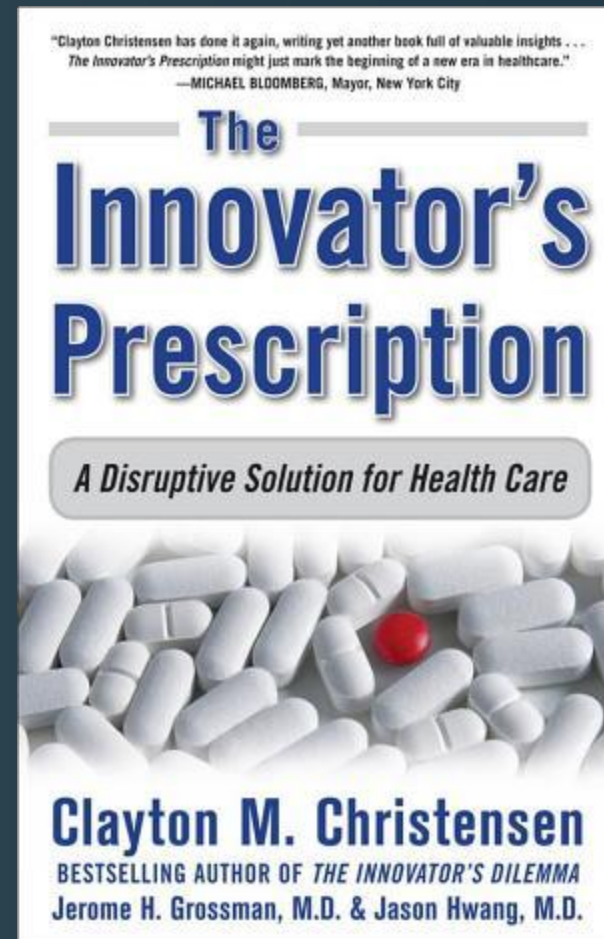
Professor of Biochemistry and Molecular Biology

Professor of Molecular Pharmacology and Experimental
Therapeutics

Discuss two megatrends in medicine

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

Must Read:



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”

Nature

Biological plasticity

- Neuro-psychological plasticity
- Immunological plasticity

Nuture

Life induced changes: Individual medical need

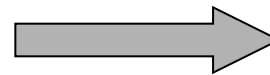
“Precise” diagnosis
(disease stratification) is the
hallmark of Personalized
Medicine.

Patient and Disease Stratification

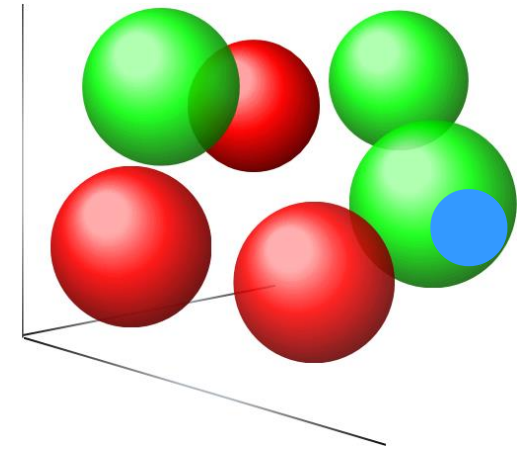
Patients Diagnosed with
“Syndrome”



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

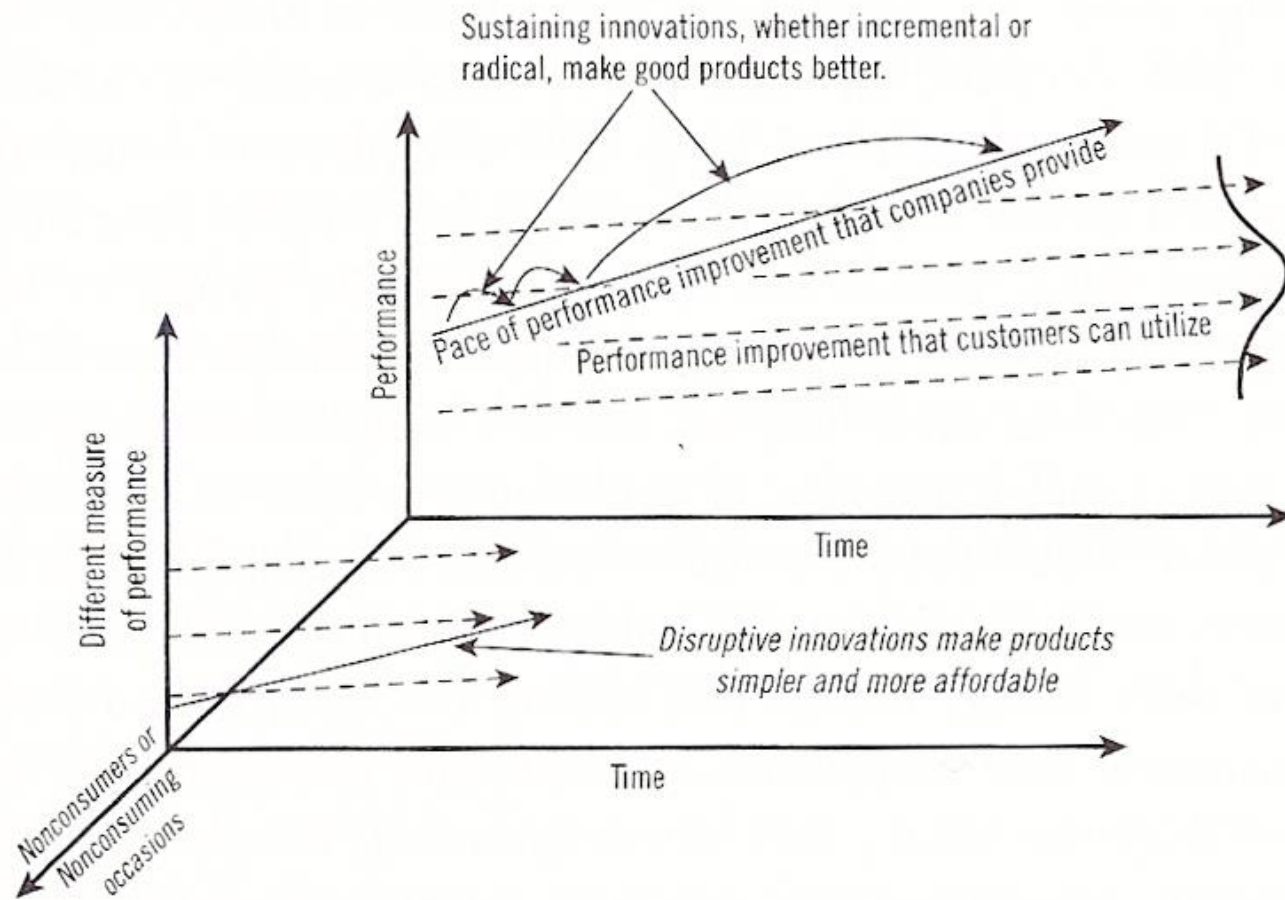


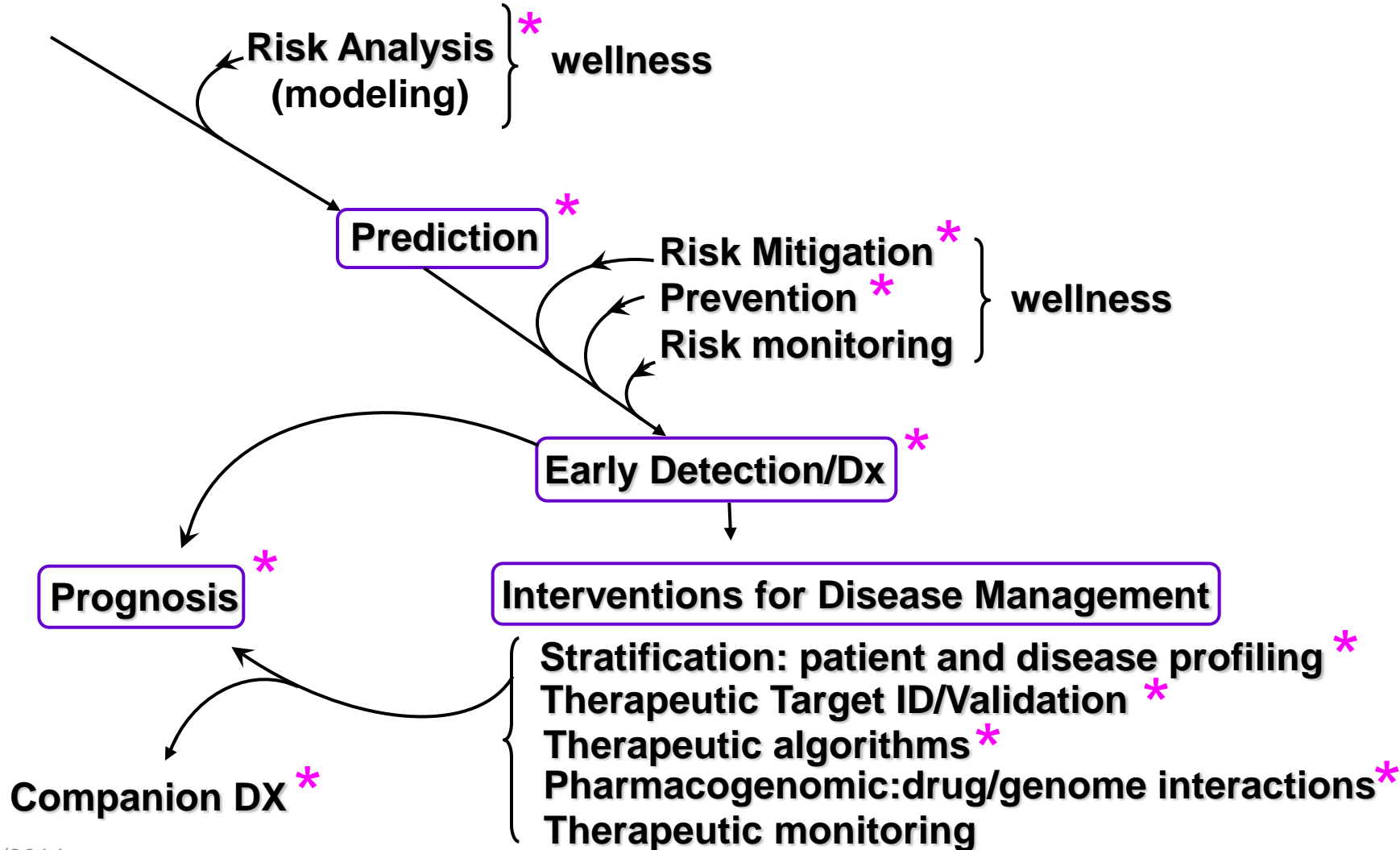
Table 4.1 Conditions managed by MinuteClinic

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

A Holistic Clinical Value Chain

Susceptibility *

- Monogenic: Dominant/Recessive
- Complex Disease



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^o 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.

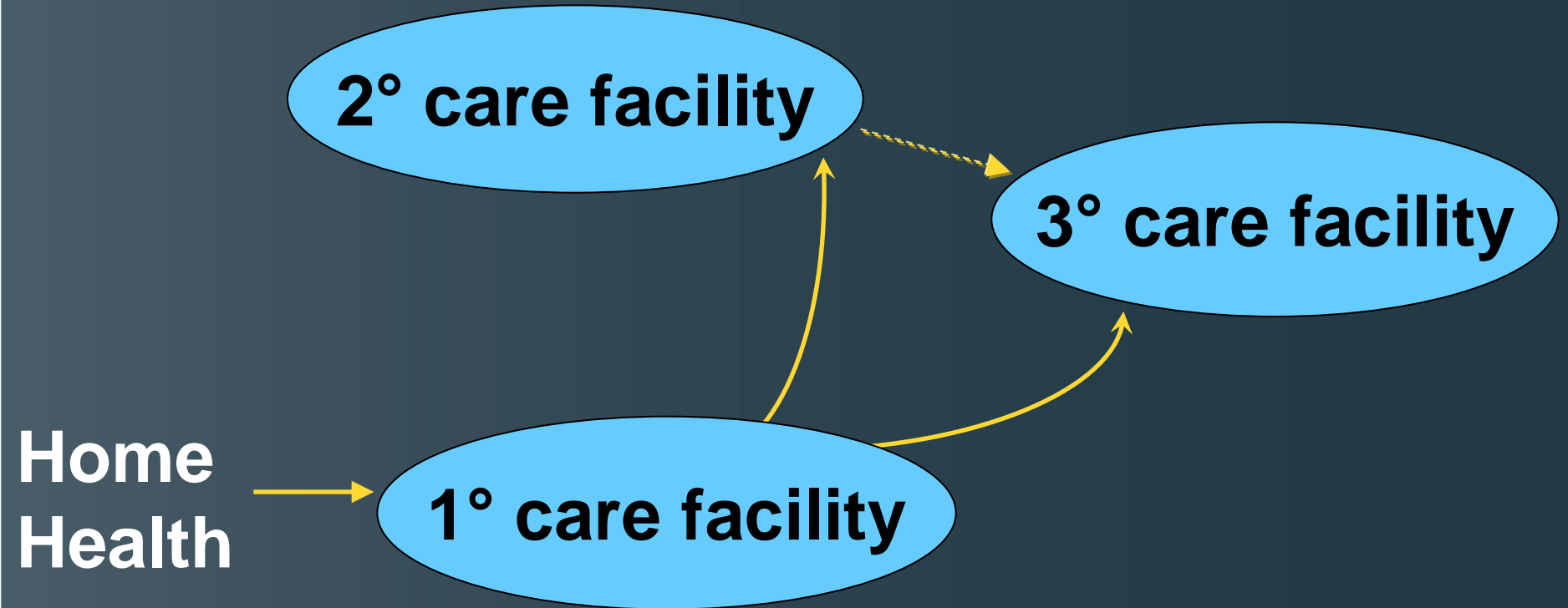
Specialized Diagnostics for Personalized Medicine

- 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



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

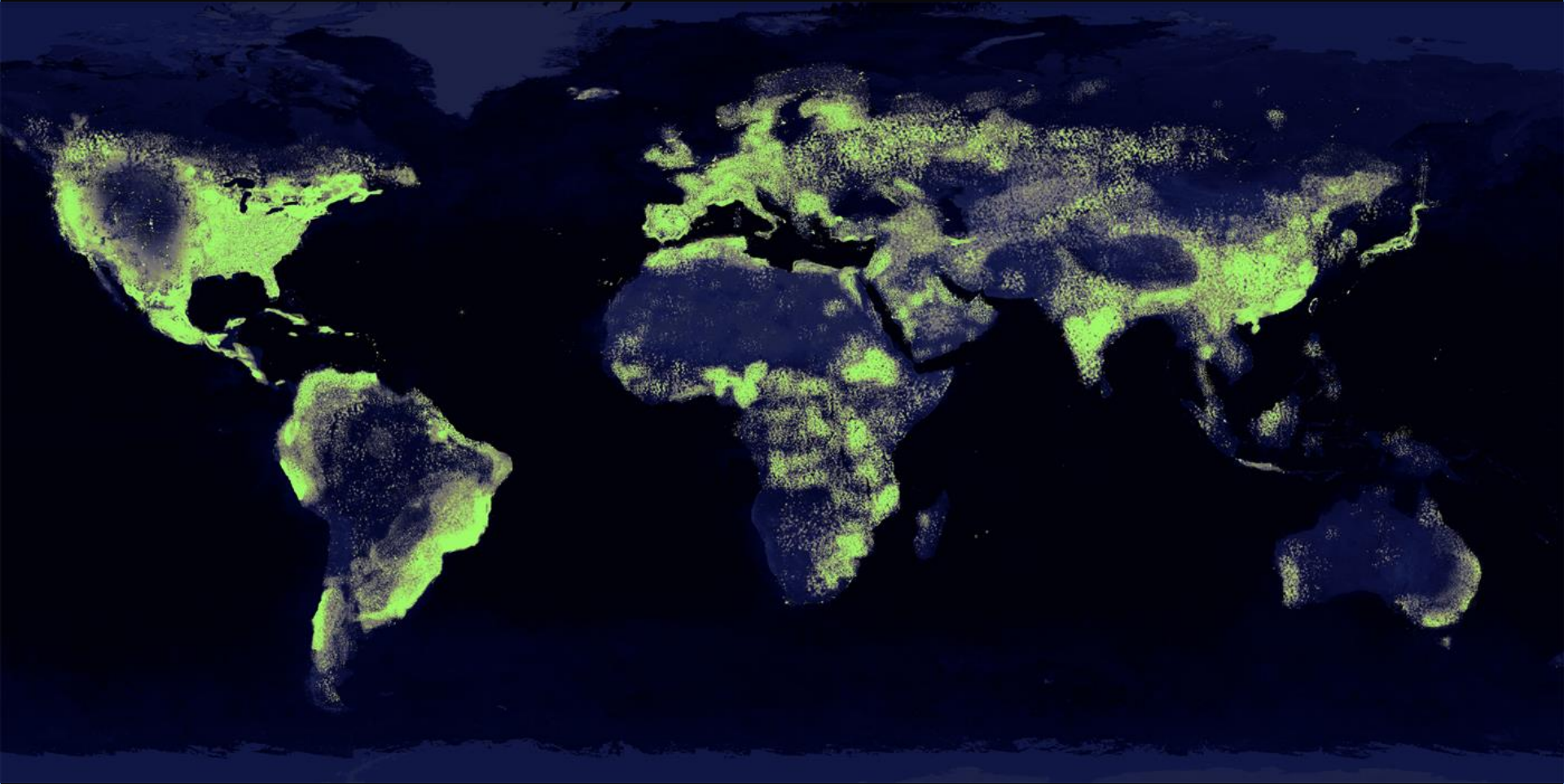


Above:

- 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:

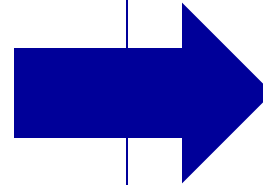
- Locations with sample volumes greater than 10/day

TODAY
THERE IS NO PLACE
OUT OF REACH



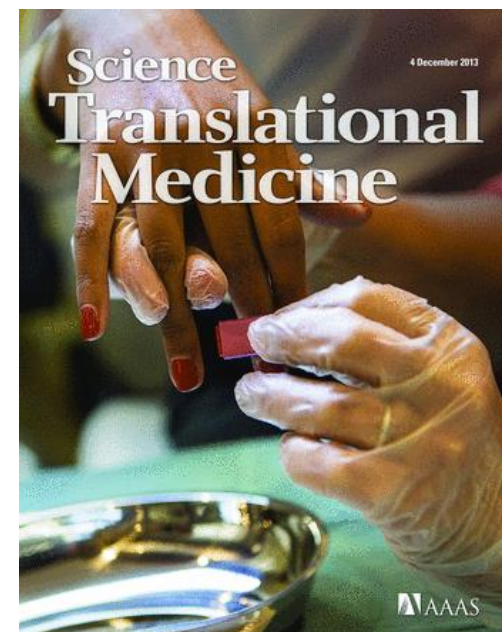
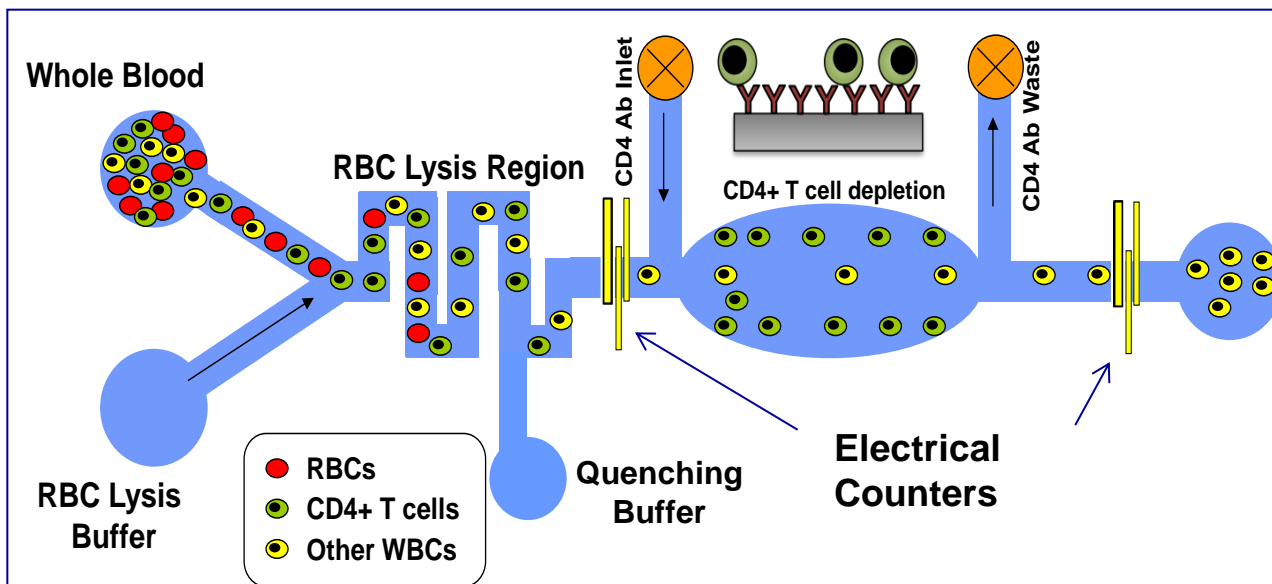
- Prick patient's finger with lancet
- Apply drop of blood to disposable cartridge
- Insert cartridge into unit
 - Washing, Capture, Measurements
- CD4 count is displayed

Research Prototype

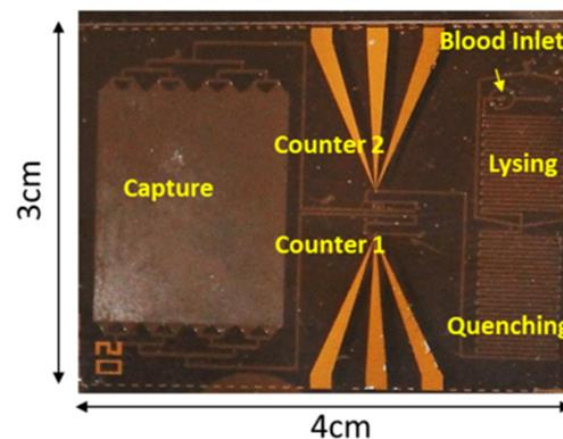
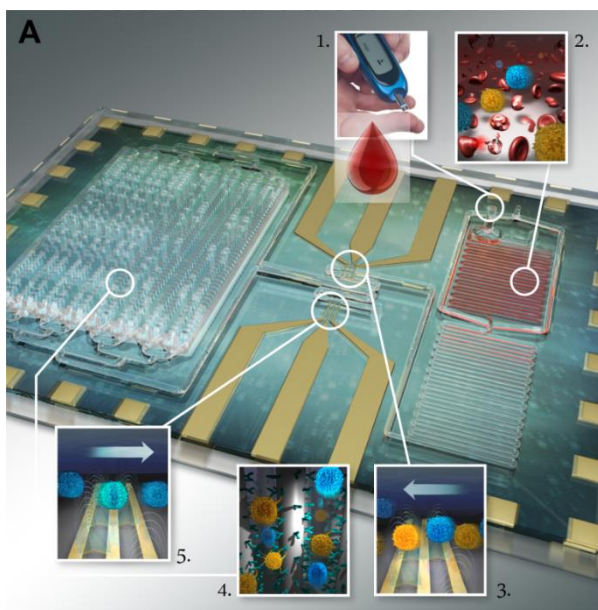


Product

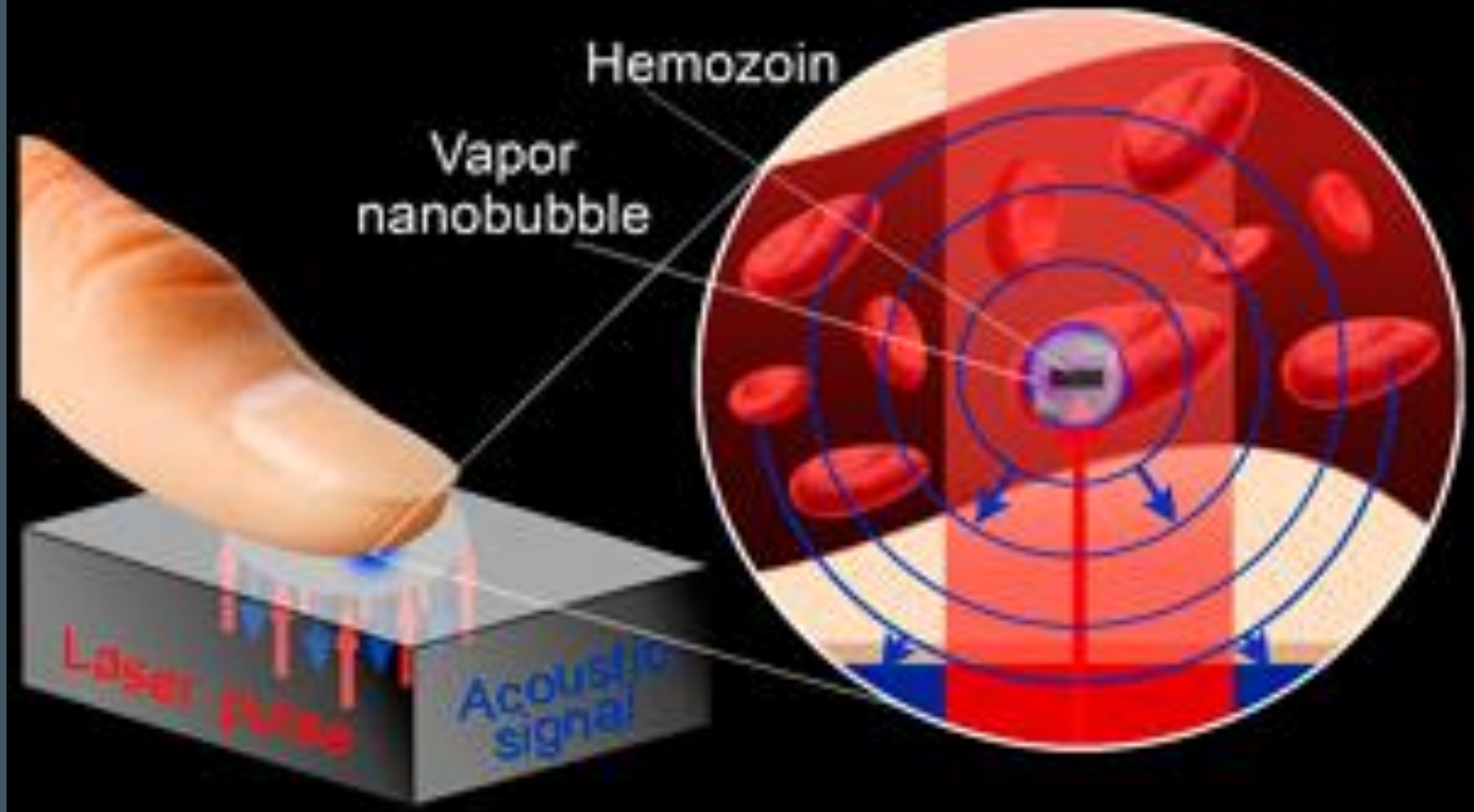
Point-of-Care Count of Cells from a Drop of Blood



Watkins, Hassan, et al. *Sci Transl Med* 4 December 2013



Transdermal detection of malaria



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

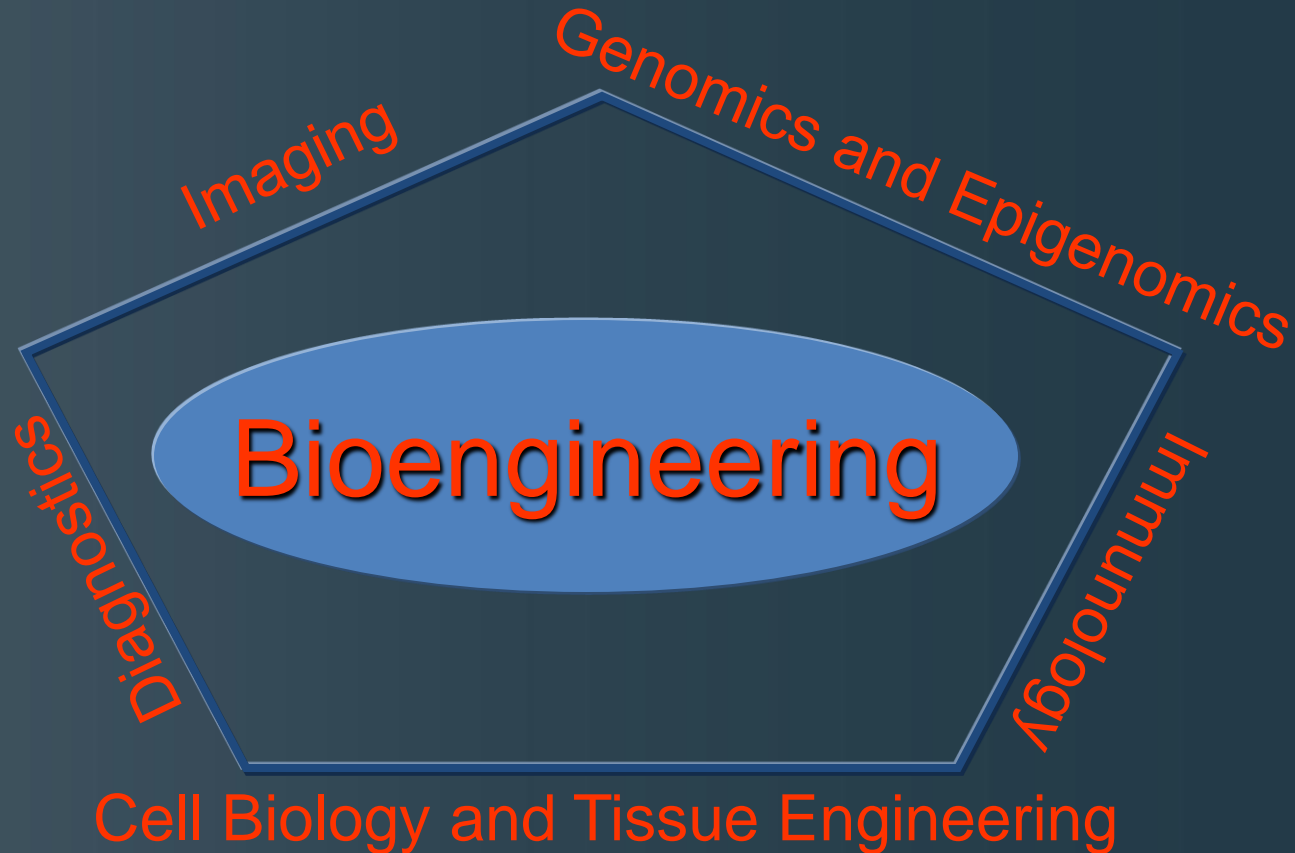
Disruptive Medical Transformation through Informatics (Computational Medicine)

- 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



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