Big Data and the Evolution of Precision Medicine

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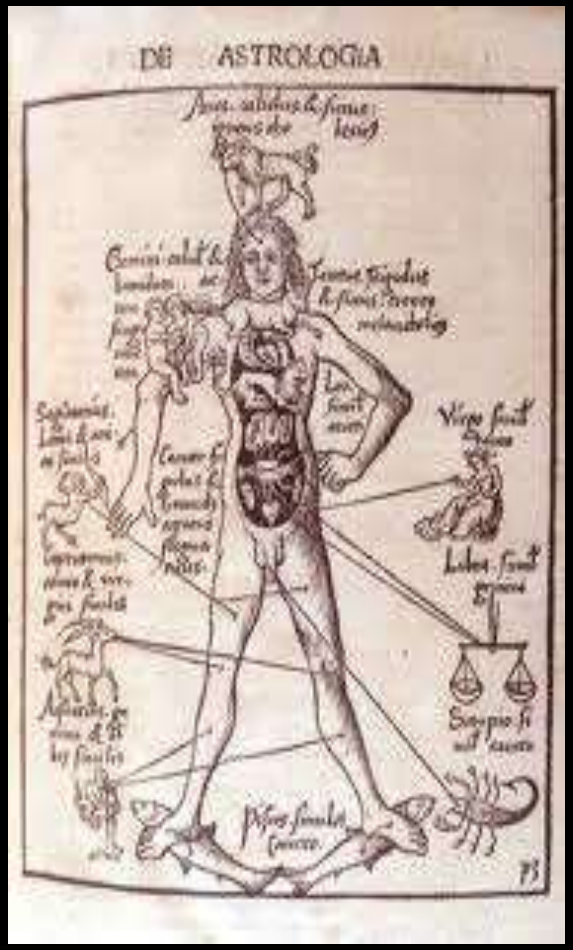
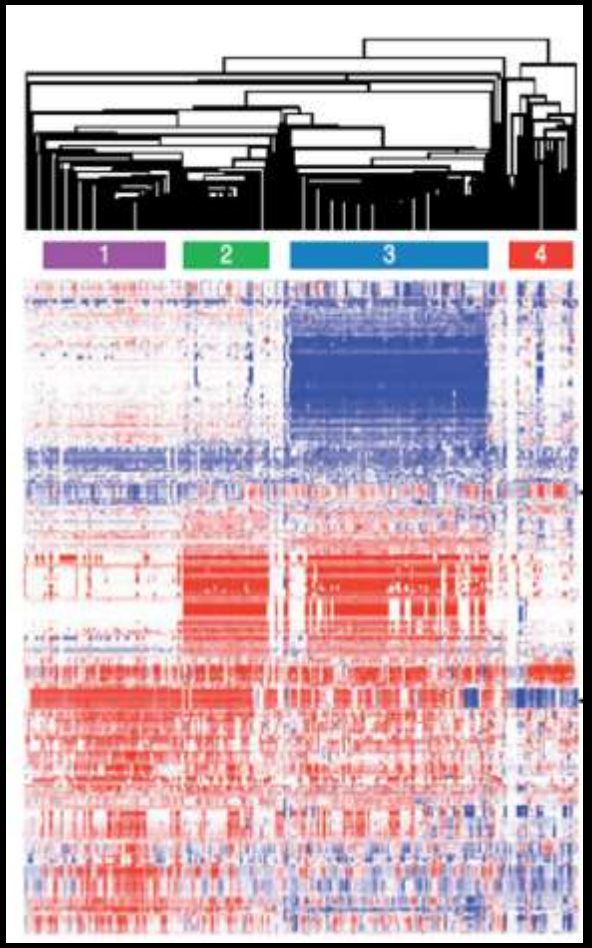
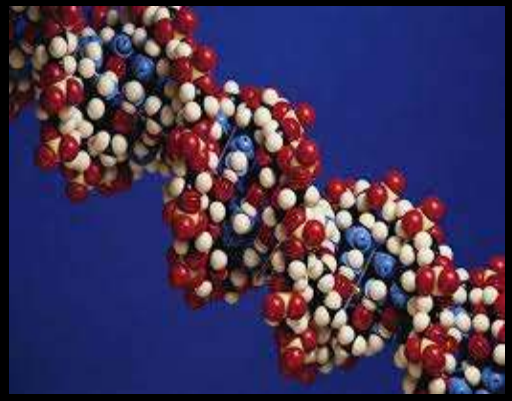
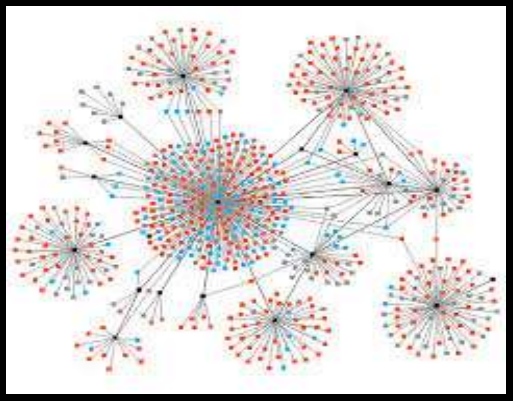
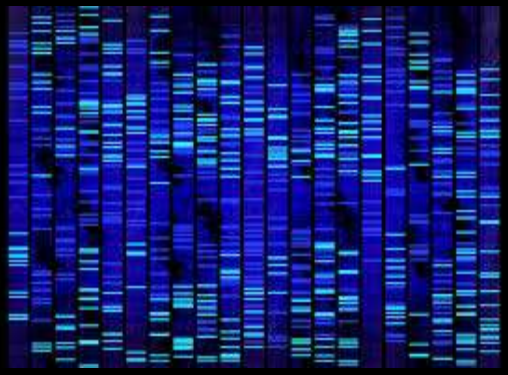
Medical Progress:
From Superstitions to Symptoms to Signatures

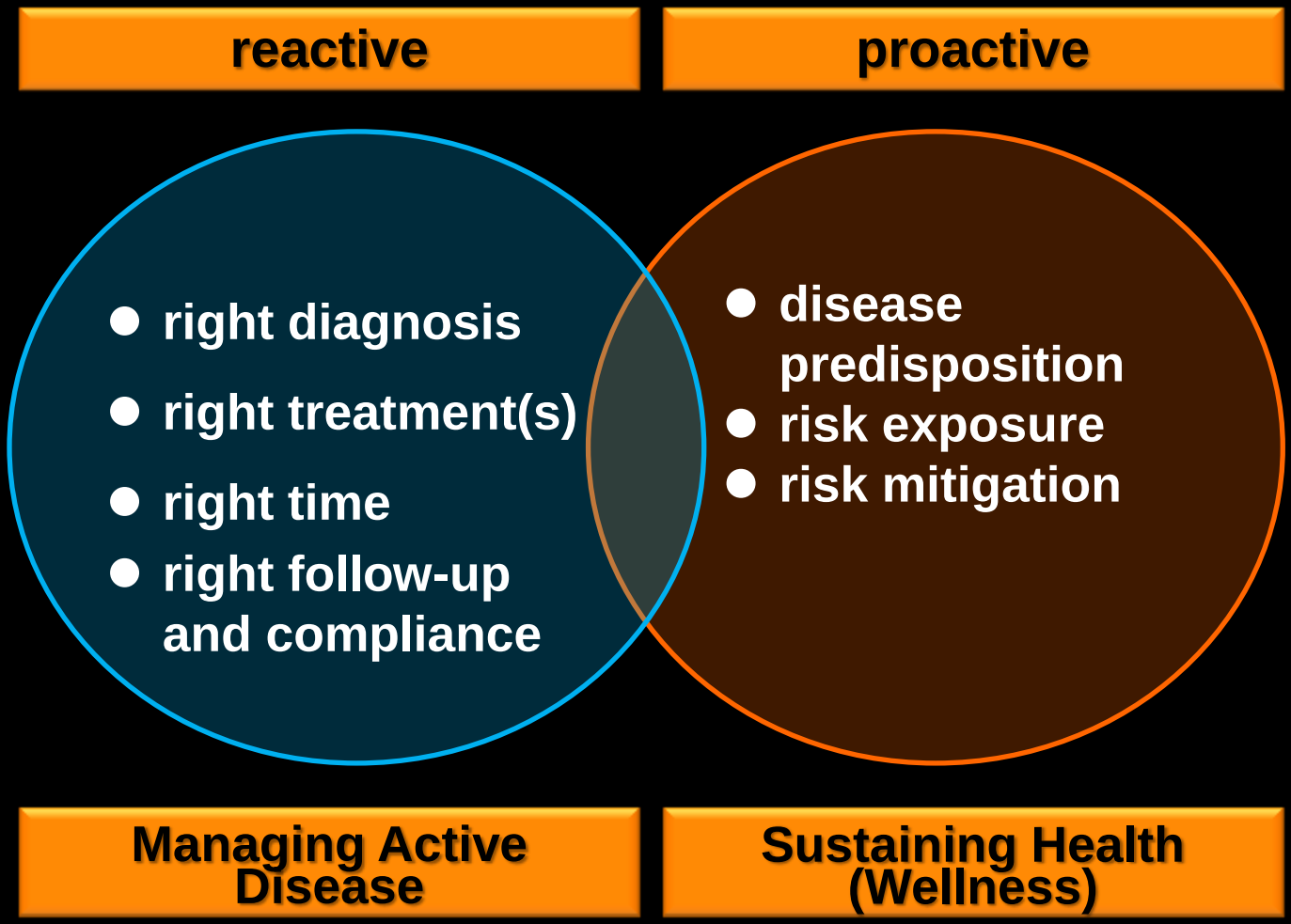




Precision Medicine: Understanding the Organization of Complex Molecular Networks in the Health-Disease Continuum

	(Epi)Genome	Cell- and Organ-Specific Molecular Information Networks	The Phenotype and Individual Variation
Health			
Disease			
	Instructional Code	Disease-Induced Network Changes	panOmic Individual Profiling and Optimum Care Decisions

Precision Medicine: Managing Individual Health Risk



Precision Medicine:
The Complexity of Genotype-Phenotype Relationships

The Need for Deep Phenotyping

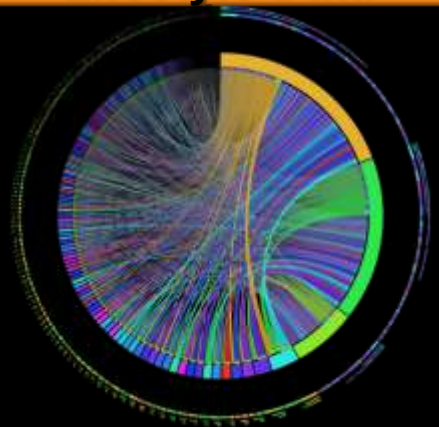
Genome Sequencing Alone Will Not Suffice

Understanding the Complex Interplay Between PanOmics, Environment and Lifestyle

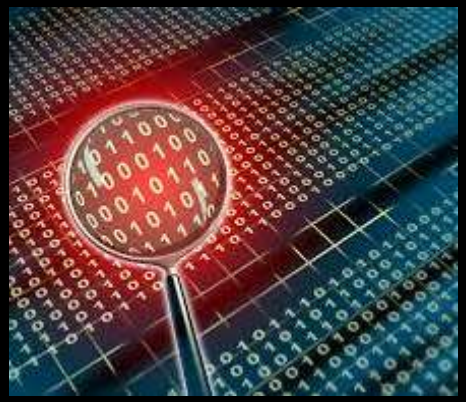
Establishment of Causal Relationships Between Alterations in Molecular Networks and Disease Risk, Disease Progression and Intervention Outcomes

Large Scale Population Profiling

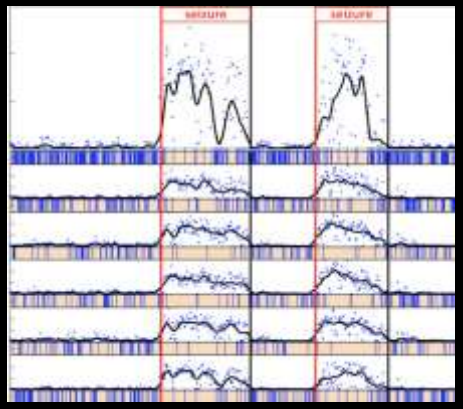
Integrated Molecular, Clinical, Environmental and Lifestyle Data



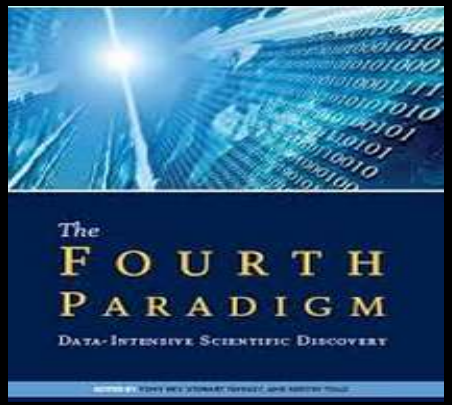
Pattern Analysis of the Health-Disease Continuum

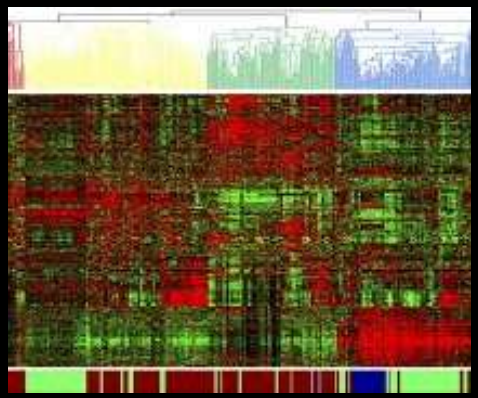


Multi-parameter Individual Risk Profile



University of Michigan Health System





Population Health Management

Big Data and Data Science

The Molecular Taxonomy of Health and Disease

Optimized Individual Care and Health Risk Reduction

The Evolution of a Data-Driven Health Ecosystem: Systematic Integration of Diverse Data Sets for Population Health Analytics

Continuity of Care Record: From Womb to Tomb








Behavior

Environment

AORTA (Always On Real Time Access): Continuous Monitoring of Health Status

- majority of events affecting an individual's health occur outside of healthcare facilities
- new technologies and real-time, remote monitoring of health status and treatment compliance
  - wearables, sensors, social media
- new patterns of consumer/patient interaction with the healthcare system and healthcare professionals ("expanded touch points")
- progressive evolution of a seamless blend of online and physical services for clinical care and individual health risk management

m.Health

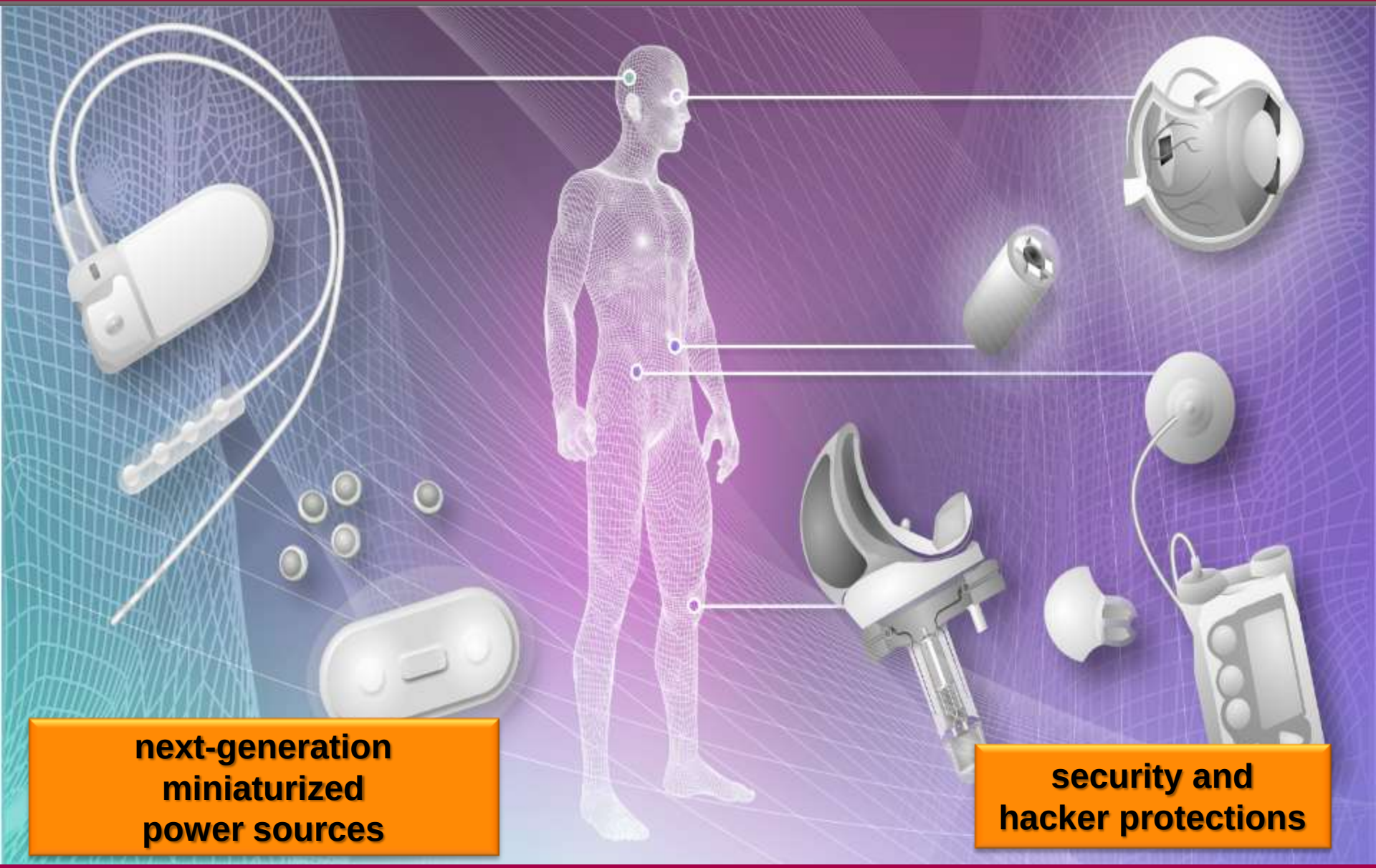
Real Time Remote Health Monitoring and Chronic Disease Management

Lifestyle and Fitness

Information for Proactive Health Awareness (Wellness)

Telemedicine: Diagnostics, Robotics, and Remote Monitoring of Health

Implantable Devices and Wireless Monitoring (and Modulation)



Gray Technologies and Aging in Place: Independent But Monitored Living for Aging Populations

Rx compliance

cognitive stimulation

in home support and reduced readmissions

reduced office visits

Mobile Apps, Wearables, Sensors and Continuous Monitoring

- who sets the standards?
- who integrates and interprets the data?
- who pays?
- who consents?
- who owns the data?

Social Spaces and Individual Behavior Become Quantifiable

- who knows why people do what they do?
  - the fact is that they do!
- these actions can now be traced and measured with unprecedented precision
- with sufficient data, the numbers reveal increasingly predictable behavior and individual risk patterns
- rapid growth in new business opportunities in multiple sectors including healthcare
- new ethical and legal issues
  - consent and data ownership
  - privacy, surveillance, security

Population Health Research and Precision Medicine: Blurring the Boundaries Between Research and Clinical Care

- every individual is a data node
- every encounter (clinical and non-clinical) is a data point
- every individual becomes a research asset

"Do you solemely swear to have no involvement in your own care?"

The Rise of Consumerism in Healthcare

Provider Performance, Pricing Transparency Plus Choice

UX: User Experience

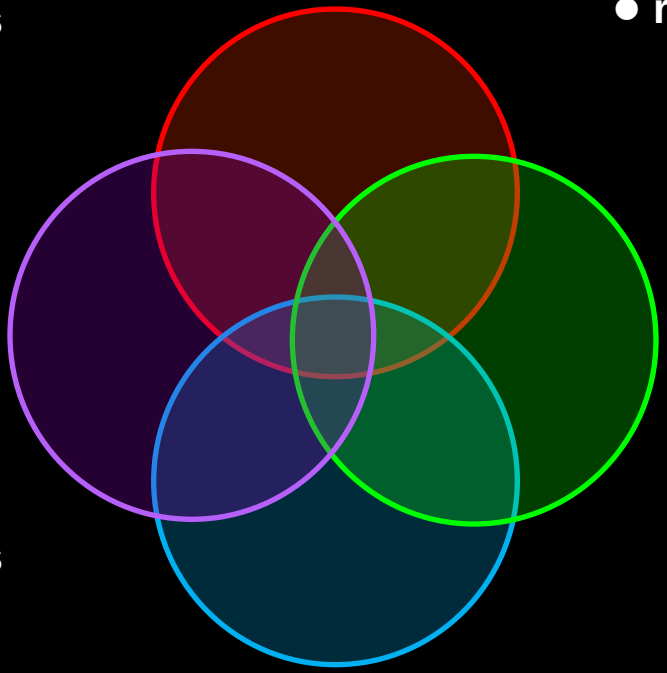
- **“liquid expectations”**
  - **positive consumer experience in one domain generates expectations of similar convenience/value in other domains**

The Principal Forces Shaping Biomedical R&D and Healthcare Delivery

engineering and device-based medicine

- wearables
- sensors
- smart implants

- remote health monitoring
- telemedicine
- robotics



molecular (precision) medicine

- panOmics profiling
- analysis of disruption in biological networks in disease

information-based healthcare

- m.health/e.health
- data- and evidence-based decisions and Rx selection

BIG DATA

outcomes-based healthcare and sustainable health

new value propositions, new business models and services


Healthcare delivery
of the future:
How digital technology
can bridge time and
distance between
clinicians and consumers
pwc


Healthcare's new entrants:
Who will be the industry's
Amazon.com?
pwc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How To Use Analytics to Create
Health Care Value: An Executive Primer
sas


accenture
Top 5
eHealth Trends
Five trends prove that digital is dramatically
influencing the industry, today, and well
into tomorrow.
1. The Internet of Me:
Your healthcare, personalized


CLOUD ADOPTION &
RISK IN HEALTHCARE
REPORT
Q2 2015
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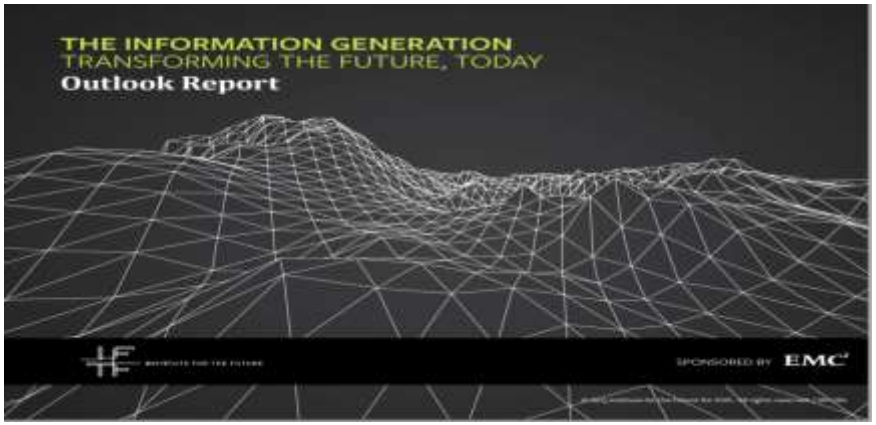
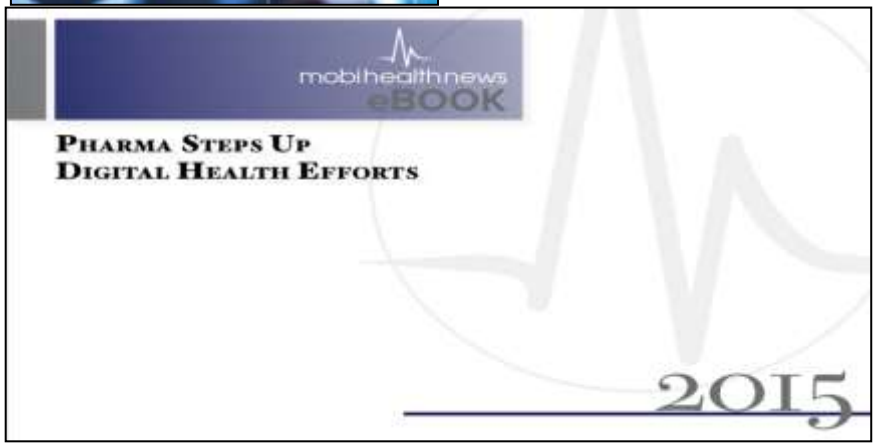
REAL WORLD
EVIDENCE AND
DIGITAL HEALTH:
PHARMA'S NEXT
FRONTIER


Transforming Health Care
Through Big Data
IHT


THE INFORMATION GENERATION
TRANSFORMING THE FUTURE, TODAY
Outlook Report
SPONSORED BY EMC


mobihealthnews
eBOOK
Pharma Steps Up
Digital Health Efforts
2015

The Worst Supply Chain in Our Society is the Health Information Supply Chain

- no area of the economy (15-20% GDP) generates as much information as the health sector yet uses it so poorly
- fragmented, disconnected data (data tombs)
- incompatible data formats as barriers to data integration
- incomplete and inaccurate data

The Worst Supply Chain in Our Society in the Health Information Supply Chain

- slow transition from paper to electronic systems
- inadequate information on behavioral and environmental influences
- poor data protection at rest and in transit
- legislative barriers to data transfer based on well intentioned privacy protections
- EMR vendor barriers to facile data exchange

The Painful Evolution of Electronic Medical Records (EMRs)

Scheduling and Billing	Compliance	Real Time Data and Decisions

The Pending Zettabyte Era
1,000,000,000,000,000,000,000

The V5 Big Data Challenge:
Volume, Variety, Velocity, Veracity and Value

Managing Big Data in Biomedicine is Not a Simple Extrapolation from Current Practices

Current Institutional Structures and Competencies Are Ill-Prepared for Pending Disruptive Change

Big Data 2025: Astronomical or Genomical?
(Z. D. Stephens et al. (2015) PLOS Biology 1002195)

- human genome sequencing data doubling every 7 months
- projected 1 exabase/year within 5 years
- projected 100 million to 2 billion human genomes sequenced by 2025
- data storage needs of 2 to 40 exabytes (@30x coverage)

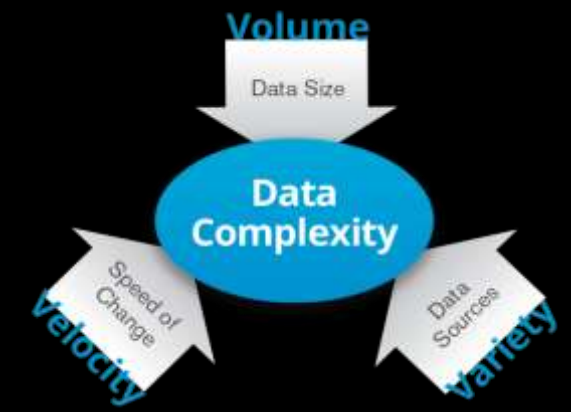
- YouTube 1-2 exabytes for video storage

- 1-17 petabytes/year

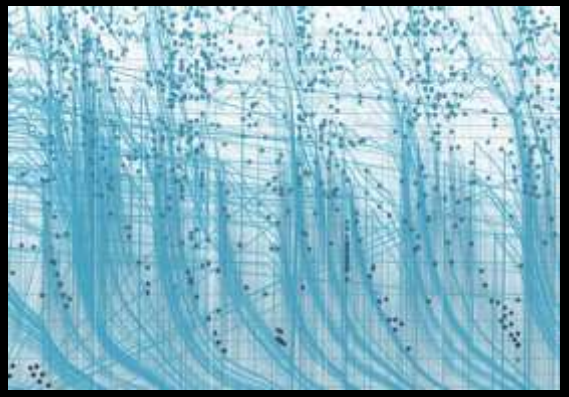
-  Square Kilometre Array 1 exabyte/year

The Unavoidable Data-Intensive Evolution of Healthcare: Major Challenges Ahead

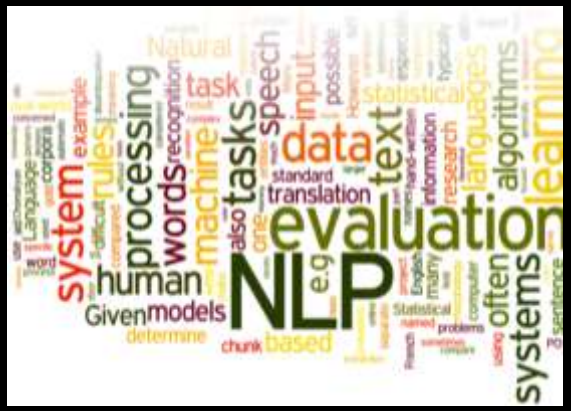
PB and TB Data Streams



Ontologies and Formats for Data Integration



Longitudinal Data Migration and Inter-operable Dbases



New Data Analytics, Machine Learning, NLP Methods

Infrastructure, Storage and Privacy

Data Science and Data Scientists

"Digital Darwinism": Stark Selection Pressures Will Create Haves and Have Nots

- growing imbalance between different end user populations and their ability to embrace large data scale and complex analytics
- institutions unable to access and analyze large data sets will suffer 'cognitive starvation' and relegation to competitive irrelevance
- understanding the structure of information and its productive application/customization will emerge as a critical institutional competency
  - "intelligence at ingestion"

The Big ‘N’ Challenge in Making Precision Medicine a Reality: Building the ‘Data Commons’

- development of a robust molecular taxonomy for the health-disease continuum will require comprehensive data capture and pattern analysis of multiple features
  - panOmics, clinical, risk exposure, life style
  - longitudinal continuity
- required scale will transcend the population cohort(s) available in all but the largest healthcare providers/payors
- new models for open data sharing and meta-analysis

The Big ‘N’ Challenge in Making Precision Medicine a Reality: Building the ‘Data Commons’

- urgent need for new policies and incentives for data sharing and open infrastructure (international?)
- how to integrate proprietary databases into an open infrastructure
- privacy and security: is individual de-identification illusory?

Computational- and Data-Enabled Science

Bigger Data and Better Questions

Data Science: Thinking More Deeply About Data and Knowledge Generation

Big Data and Data Science Will Generate Destabilizing and Disruptive Knowledge

The Pending Era of Machine Intelligence and Cognitive Systems: Overcoming the "Bandwidth" Limits of Humans

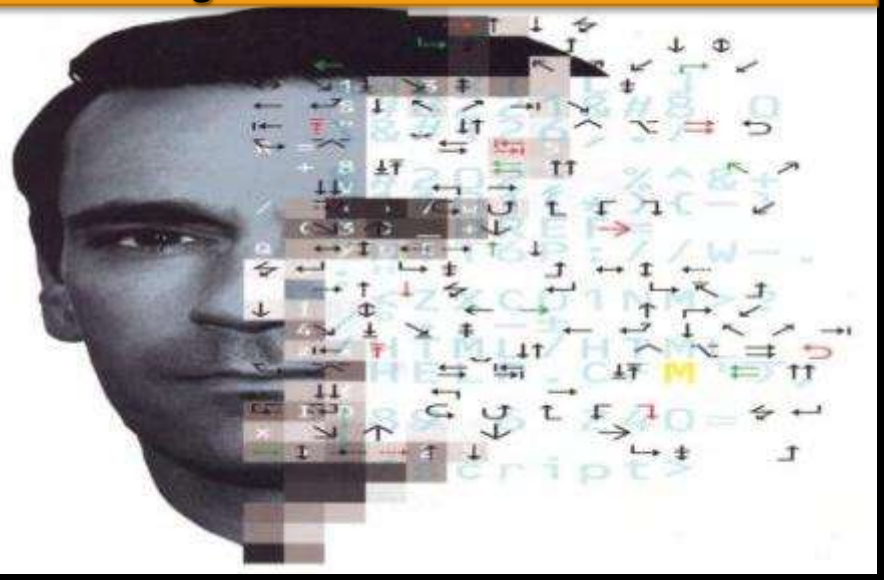
- limits to individual expertise
- limits to our multi-dimensionality
- limits to our sensory systems
- limits to our experiences and perceptions
- limits to our objective decision-making

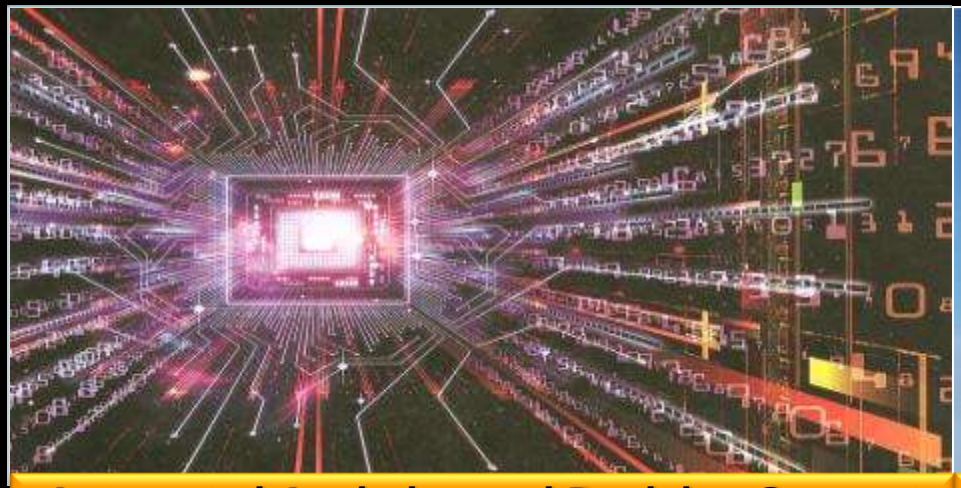
"helping the slow brain catch up with the fast machine"

Technology Acceleration and Convergence: The Escalating Challenge for Professional Competency, Decision-Support and Future Medical Education Curricula

Data Deluge

Cognitive Bandwidth Limits





Automated Analytics and Decision Support

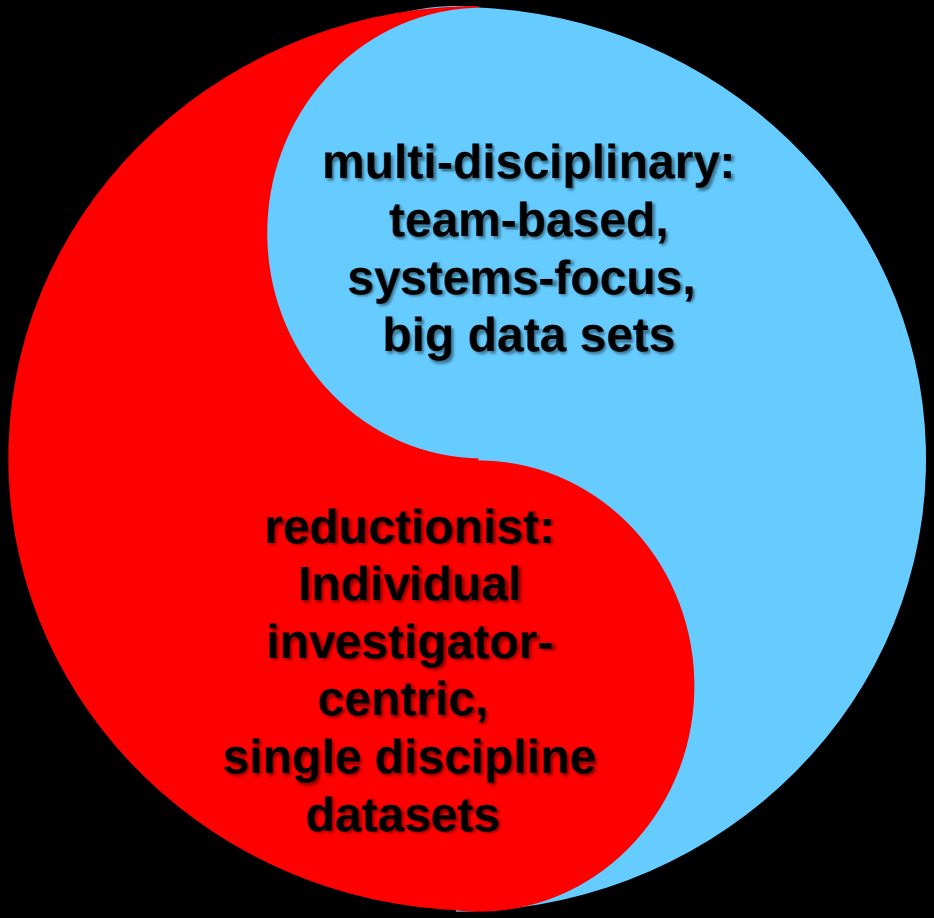
Facile Formats for Actionable Decisions

Living in a World Where the Data Analytics and Interpretation Algorithms Are Obscure to the End User

- ceding decision authority to computerized support systems
- resistance and push back in a MD-centric culture
- culturally alien to professionals in their expertise domains while they accept machine-based decision-support in many other aspects of their lives
- who will have the responsibility for validation and oversight of critical assumptions used in decision tree analytics for big data?
  - regulatory agencies and professional societies (humans)?
  - machines?

Big Data:
Changing the Intellectual Framework for Discovery and Knowledge Acquisition

hypothesis driven research



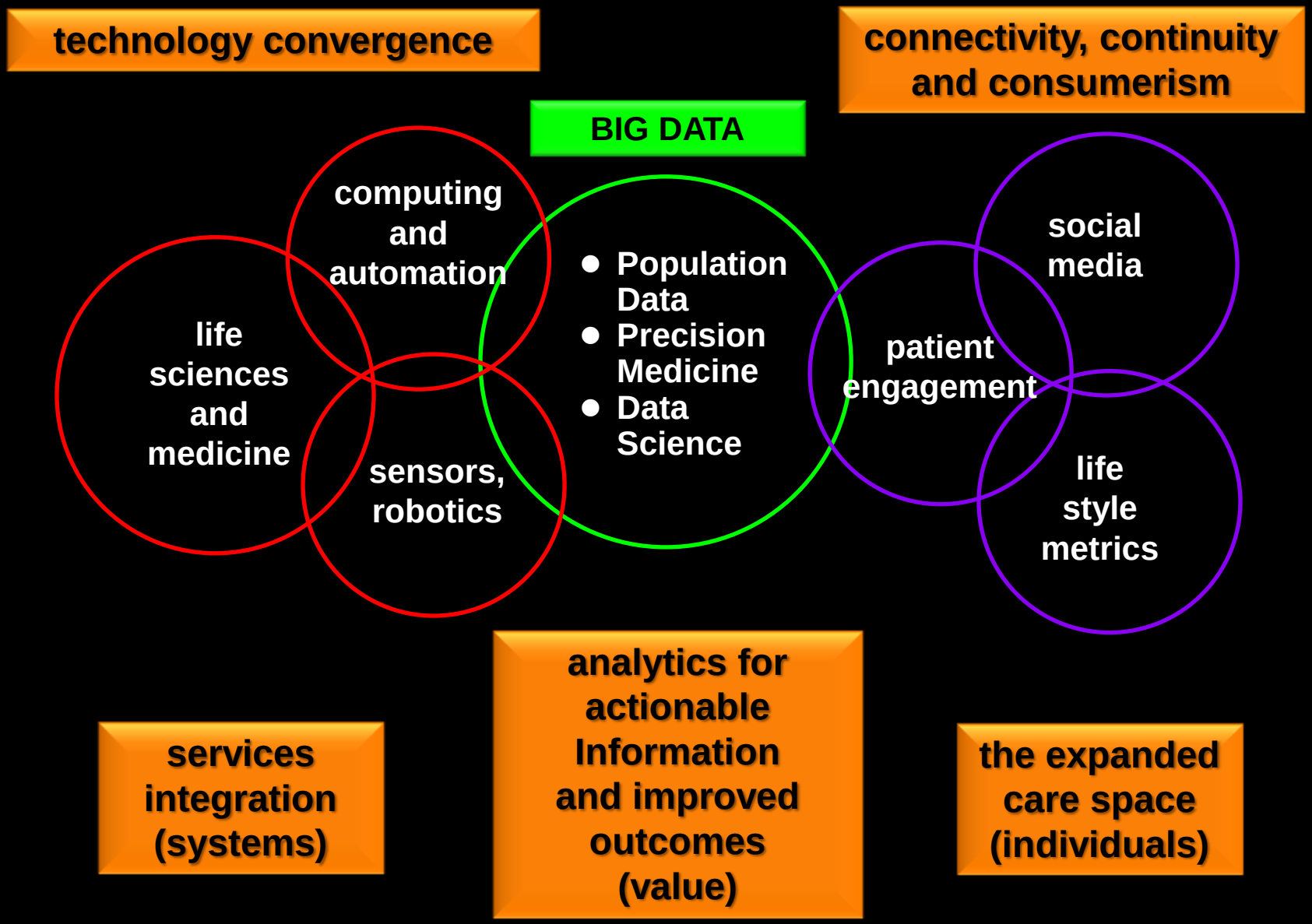
unbiased datasets and new analytics for pattern mining

Defining An Optimum Balance

Data Science, Machine Intelligence and Decision Science

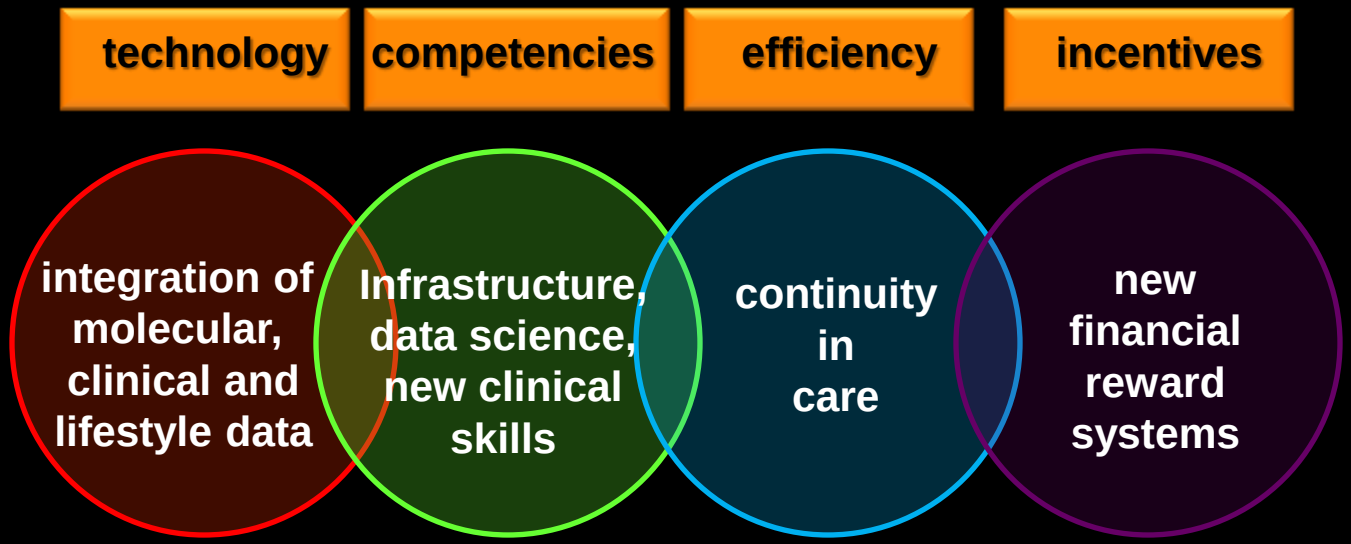
- changing the nature of discovery
  - hypothesis-driven versus unbiased analytics of large datasets (patterns, rules)
- changing the cultural process of knowledge acquisition
  - large scale collaboration networks, open systems versus individual investigators and siloed data
- changing knowledge content
  - increased quantification and complexity
  - integration of diverse data streams
- changing the cognitive and intellectual competencies for knowledge-intensive competitiveness in multiple domains
- changing education, training and research

The Evolving Data-Intensive Healthcare Ecosystem



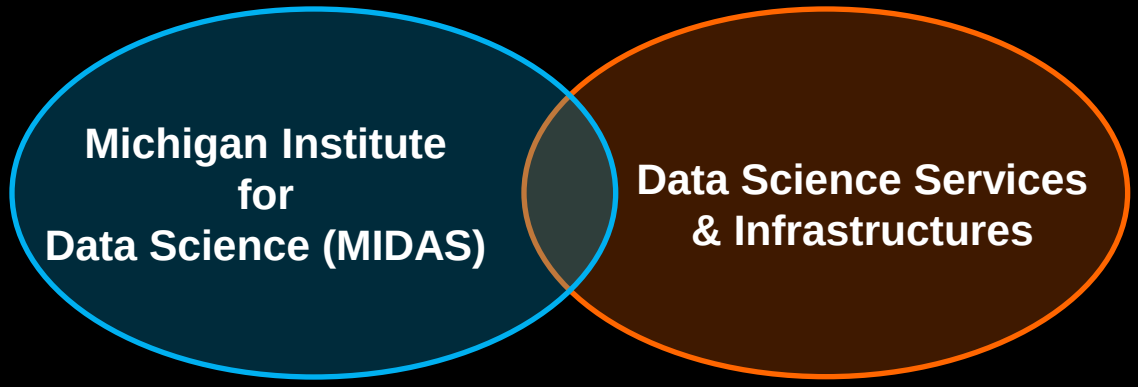

CHANGE
is good
you go first

Leveraging the Potential of Precision Medicine Will Require PROFOUND CHANGES in the Organization and Proficiency of Healthcare Services



- seamless integration of complex, diverse and dynamic data for real-time monitoring of health status and risk management
- shift from reactive episodic care encounters to increasingly proactive risk mitigation
- progressive shift from management of overt disease to sustained wellness and continuity in care

Data Science at the University of Michigan



Health System
Data and Analytics
Integration

Department of
Computational Medicine
and Bioinformatics

UMHS-IT

UMMS Disruptive
Care at Home Program

Michigan Center
for Critical Care

Michigan Metabolomics
and Obesity Center

Institute for Health
Policy and Innovation

UMMS Dept.
Learning Health Systems

SNRE Geospatial
Health Informatics Center

School of Public Health
FUSION Project

MIDAS:
Transportation Science, Social Media,
Personalized Health, Personalized Education

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Slides available @ http://casi.asu.edu/