Creative Destruction of Medicine: How the Digital Revolution Will Create Better Health Care

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The Creative Destruction of
MEDICINE
HOW THE DIGITAL REVOLUTION WILL CREATE BETTER HEALTH CARE
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Eric Topol, MD

- Director of Scripps Translational Science Institute
  - Practicing cardiologist at Scripps Clinic
  - Professor of genomics at Scripps Research Institute
- One of the top 10 most cited researchers in medicine
  - Founder of Cleveland Clinic Lerner College of Medicine
- Book published in 2012

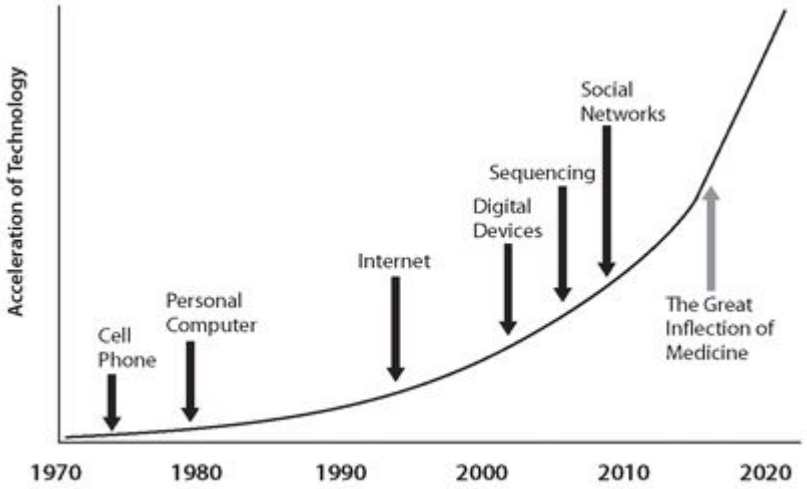
The Digital Landscape: Cultivating a Data-Driven Participatory Culture

Increased Bandwidth

Increased ability of mobile devices

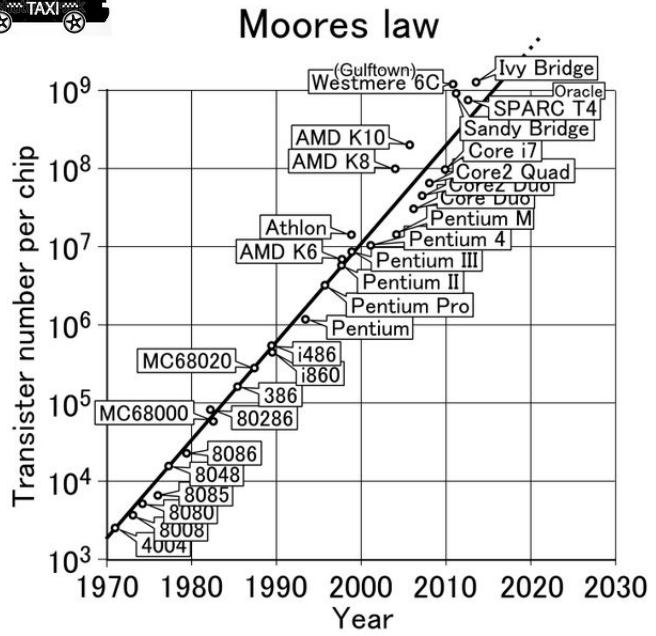
The ways we have changed (the C's):

1. Constant connectivity: ADHD
2. Collaboration and Crowdsourcing
3. Customized Consumption
4. Cloud Computing



Effects of the Six C's:

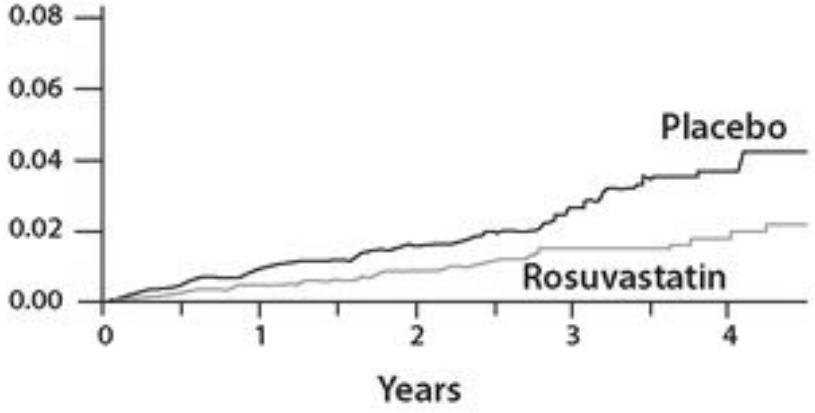
1. Disruption and Destruction
   a. Blockbuster → Netflix
   b. On demand TV shows
   c. Free online news
2. Dealing with Data Deluge
   a. Crazy amounts of data being generated
   b. Moore's Law
   c. 5 exabytes generated up until 2003 → Every 2 days
3. Data Driven Culture
   a. Ubiquity of Information
   b. Shop, Travel, Invest, Consume Info
4. Big Picture Super Convergence
   a. Medicine needs to be updated
   b. Currently anchored to medium
   c. Needs to be anchored to individual



The Orientation of Medicine Today: Population versus Individual

Evidence-based medicine:

- Lipitor/Crestor
  - 4% → 2%
  - Mass Medicalization
  - Don’t Identify 1-2 people
- Plavix
  - Significant population couldn’t metabolize
  - Potential Heart Attacks based on genes
- Variety of other examples

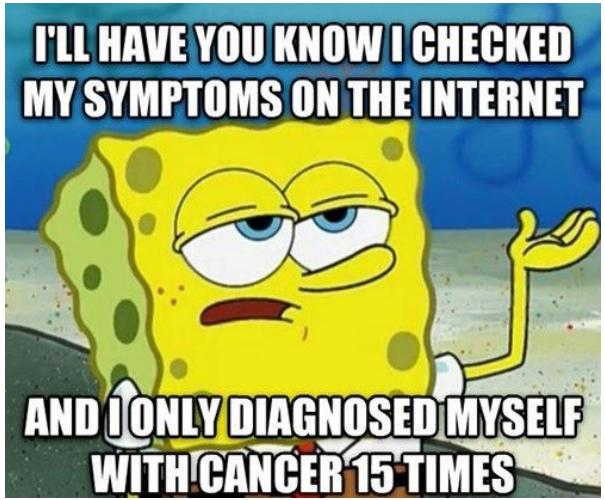


How do we solve this?

→ Evidence based on individuals, not populations

To What Extent Are Consumers Empowered? Clicks and Tricks

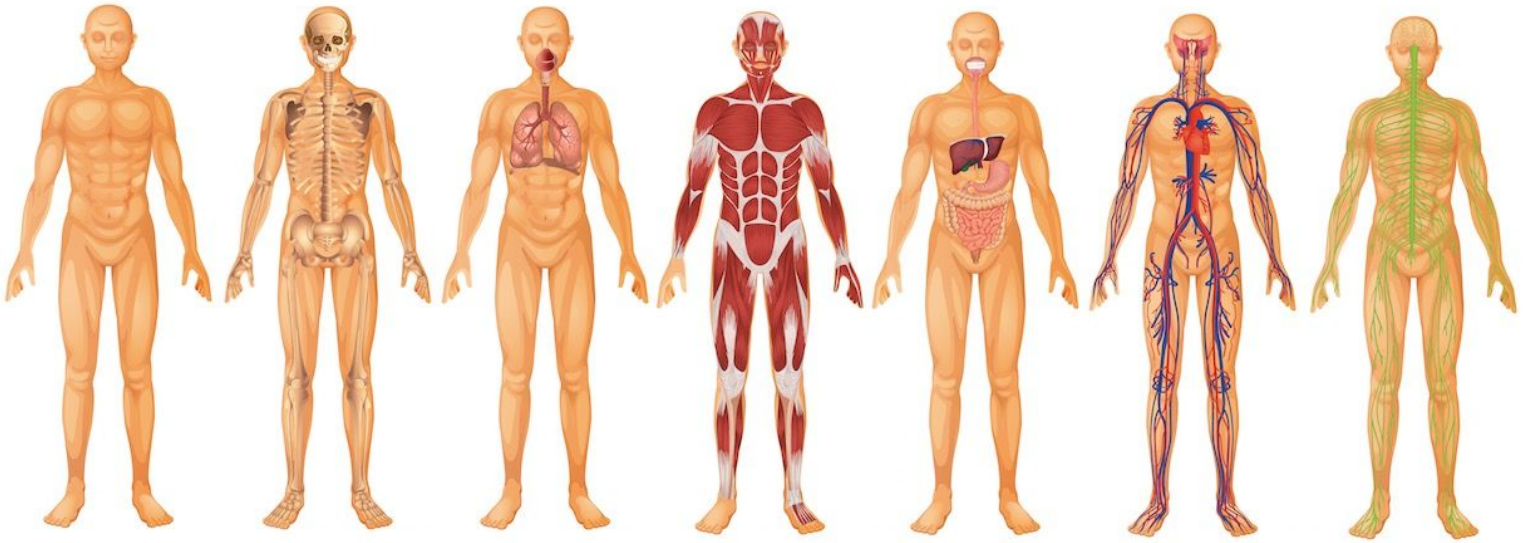
- Hyper-informed patients try to make informed decisions, but can sometimes backfire
- Disease Mongering
- Vitamin/Supplement Tablets often cause more issues than they solve
- Self-diagnosis as a result of DTC marketing
- Dr. Oz → Self-empowerment
- Procedures/Products promoted by creators (even when lacking validation)
- WebMD



Potential solution: Individualized Medicine

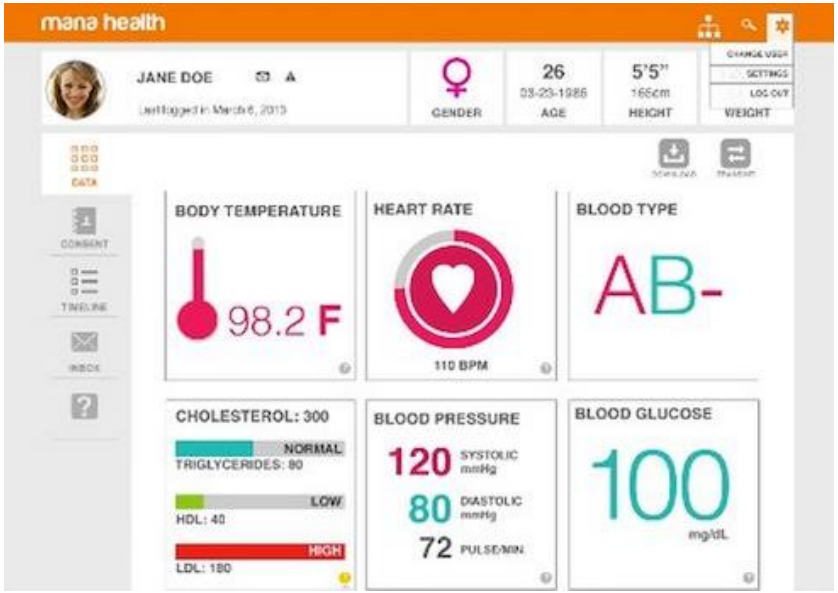
Physiology: Wireless Sensors

- Limited insight into the body- keyhole view
    - Snapshots of body system health: blood pressure, glucose, heart rhythm



Physiology: Wireless Sensors

- Targeted application - better data, lower costs
  - Diabetes
  - Arrhythmia
  - Vitals
- Emerging countries
  - "Mobile Phone Laboratory"
    - Complete blood counts
    - Melanomas and lung cancer



Physiology: Wireless Sensors

- Virtual Doctor's Visits

- Challenges of Wireless Medicine
  - Data flooding
  - Privacy
  - Cost
  - Difficult integration - different sensors, different data

Biology: Sequencing the Genome

- Genome vs Exome
  - Protein coding
  - Regulation
- 23 pairs of chromosomes
- 6 billion bases

Biology: Sequencing the Genome

- Pharmacogenomics
  - Hepatitis C: Conventional treatment works in 50% of patients
  - Stents and blood clots

- 25% of common drugs have some genetic information that can be used to guide patients

- Predicting drug reactions VS Predicting disease susceptibility

Biology: Sequencing the Genome

- Rare variants
  - Some cancers, and Mendelian diseases (e.g., sickle cell anemia)

- Exome sequencing
  - Cheap and quick

- Full genome sequencing
  - Accuracy

Biology: Sequencing the Genome

- Consumer Genomics
  - Genome wide scans for the public
  - Readout of risk for diseases
  - Make people seek testing before they 'need' to - good!
    - Changing lifestyle
  - Government regulation issues
    - FDA investigations
- Consumers will be the drivers of genetics in clinical practice
  - Not many medical geneticists or push from the clinical side
- One day it will be widely adopted, cheap, and insightful

Anatomy: From Imaging to Printing Organs

Current Imaging Technologies

- Radiation Imaging
  - X-rays, CT scans, mammograms
  - Pro: can uncover “incidental findings” - abnormalities that lead to further testing
  - Pro: provides accurate and high resolution imagery
  - Cons: radiation exposure
- Ultrasound
  - No radiation
  - Cons: not as accurate, can’t image through bone or extensive fat tissue
- MRIs
  - Pros: no radiation, highly detailed
  - Cons: large, unpleasant, expensive machines

MRI Machine

Anatomy: From Imaging to Printing Organs

Recent Technological Developments

- Pocket sized ultrasound
- Molecular diagnostics to detect potential heart problems
  - Will not require radiation exposure like CT scans
- Special PET scans for Alzheimer's
  - Can light up part of brain that is damaged
- Gene-targeted Cancer Drugs
- Printing organs
  - Early successes
    - Growing a bladder in culture with tissue from biopsy
    - Synthetic retina from stem cells
    - 3D printed plastic trachea combined with stem cells

Electronic Health Records and Health Information Technology

1999 NYT Report:

- 44,000-98,000+ people die in hospitals due to medical errors
- $17-29 billion in errors
- More than highway accidents and breast cancer combined

2001 Institute of Medicine Report:

- Notes health care organizations work as silos
- Physicians often act without complete information about patient's condition
- Medication errors are the leading cause of hospital related deaths
- Calls for elimination of handwritten clinical data by end of the decade

2002 Study on US Hospital Deaths:

- 113,000 by medication error
- 80,000 by hospital injections

Electronic Health Records and Health Information Technology

Solution

- EHR: Electronic Health Records
  - Electronic record of patient's medical data
- PHR: Personal Health Records
  - Similar to EHR, but patient collects and maintains the data
- HIT: Health Information Technologies
  - Examples
    - Alerting physician of prescription for a medication allergy
    - Alerting physician of need for vaccination
    - Medication tracking
    - Enabling patients to check their own lab/test results
    - Detecting signs of impending epidemic or adverse affects of new medication

Electronic Health Records and Health Information Technology

Outcomes

- Conflicting reports on success
  - 2006 Study: HIT shown to reduce medication errors, increase compliance to guidelines
  - Veterans Health Administration: medication error rate of 7 / 1 million
    - Overall US rate is 7,000 times higher
  - Other studied showed less of an impact

Challenges

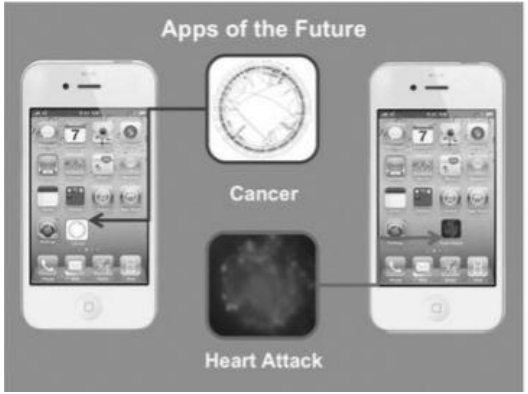
- Isolated and proprietary systems
  - Transferring data between different medical systems can be difficult
  - Average 65+ American receives care from 7 physicians in 4 different organizations
- Forces doctors to focus on screen instead of patient
- Security concerns
- Expensive to setup

The Convergence of Human Data Capture

- Previous chapters have focused on the “four modalities”
  - Wireless Physiological monitoring
  - Genomics
  - Anatomical imaging
  - Electronic Data storage
- Combining these four fields can create solutions to a variety of medical problems

The Convergence of Human Data Capture

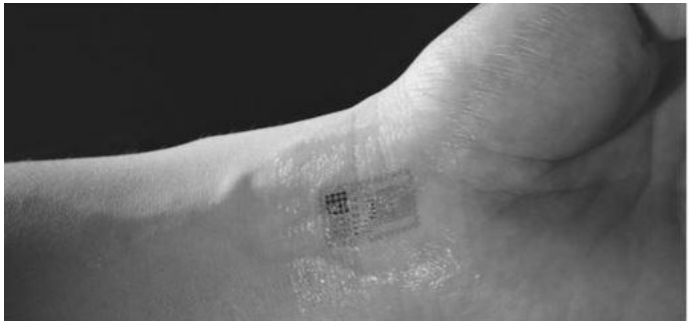
- Heart Attack
  - Using technology to detect problems that can lead to a heart attack
  - Mapping human genome
  - Using Nanosensor to detect molecular signature in blood
- Cancer
  - Current methods of detection are expensive and can lead to false positives.
  - New Technologies can detect one tumor cell out of millions and use DNA fusion tracking to detect cancer
- Transplant Rejection
  - Use DNA to determine how likely a patient is of rejecting a transplant
- Type 1 Diabetes
  - Gene Sequencing has determined that the disease is caused by problems in the immune system
- Asthma
  - We now know common gene sequences used with Asthma

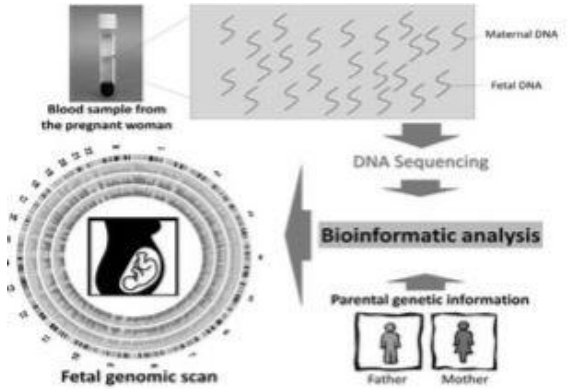


Prototype handheld genome sequencer

The Convergence of Human Data Capture

- Genomics and Drug Development
  - Disease in a dish
    - Can create stem cells out of regular cells
  - Electronic Skin
    - Chips that can detect heart rhythm, muscle activity, and brain waves
  - Fetal Whole Genome Sequencing and Wireless Sensors
    - DNA of unborn baby can be sequenced through mother's blood sample
    - Avoids methods that can cause miscarriages
  - Genomics and Social Networking
    - Using the human genome instead of specific markers for diseases has lead to more accurate outbreak results





Doctors with Plasticity?

- Education
  - Medical schools can use reform
  - Follow more cutting-edge models such as collaboration and resources like Khan Academy
- Accountability
  - Currently not enough data to hold Physicians accountable in many cases
- Physician Demographics
  - Shortage of Physicians in the country
  - Even though there is a shortage, doctors are being paid less
- Doctors and Email
  - Despite low usage, Email can help make doctors more efficient and save time with face-to-face meetings

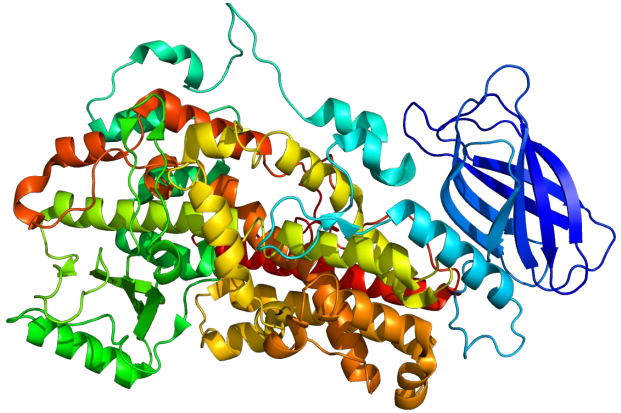
Doctors with Plasticity?

- Doctors and Social Networking
  - Doctors can use more social media
  - Comes at risk of violating patient privacy if not careful
- Telemedicine
  - Using video calls to allow patients and doctors to communicate face-to-face
- New Models
  - Some doctors have tried setting up moden practices that use email, video chatting and other modern methods
- Digital Doctors of the Future?
  - For these technologies to revolutionize medicine, doctors actually need to adapt
  - Young doctors are more likely to adapt technologies, but this can take time

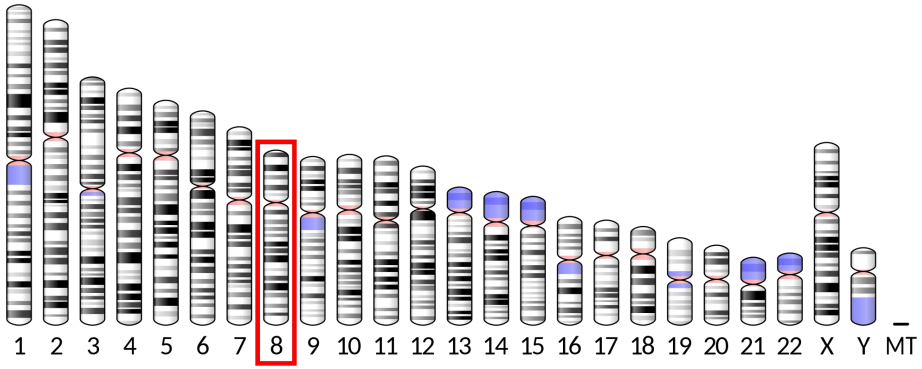
Rebooting the Life Science Industry

- Challenges to developing new drugs and addressing public health problems
  - The success of the life science industry is linked to the FDA and EMA
  - Difficulty finding therapies that work
  - Suppression of data from publications

> "The business model clearly worked -- and up until 2001, ironically at about the time of the human-genome breakthroughs, most would have expected this trend to continue. It has not. So now we are having to reinvent our industry" -- Andrew Witty, CEO, Glaxo



Finding new methods of drug discovery



1. Wikimedicine
2. Guaranteed-to-success Model
3. Digital Marketing, Tracking, and Sales

Homo Digitus

- Medical circle has been almost an exclusive supplier of healthcare information
  - Technology has eliminated the knowledge gap
  - Faster change with digital and mobile devices
- The creative destruction of medicine will result in an outgrowth of the science of individuality
  - The shift to “large *P*, small *n*”
  - Movement from reactive health care to preventative
- Replacement of hospitals and clinics

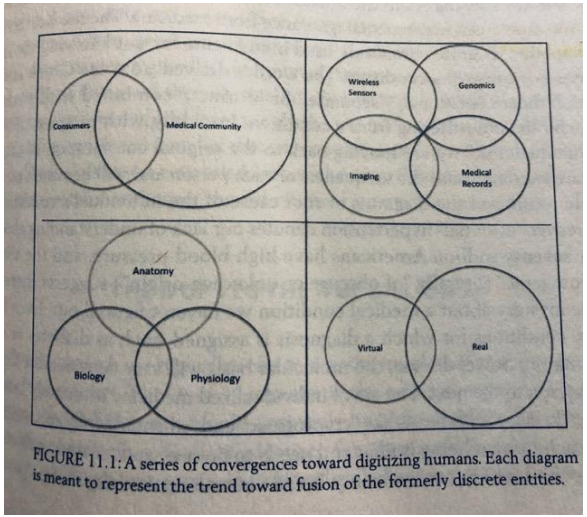


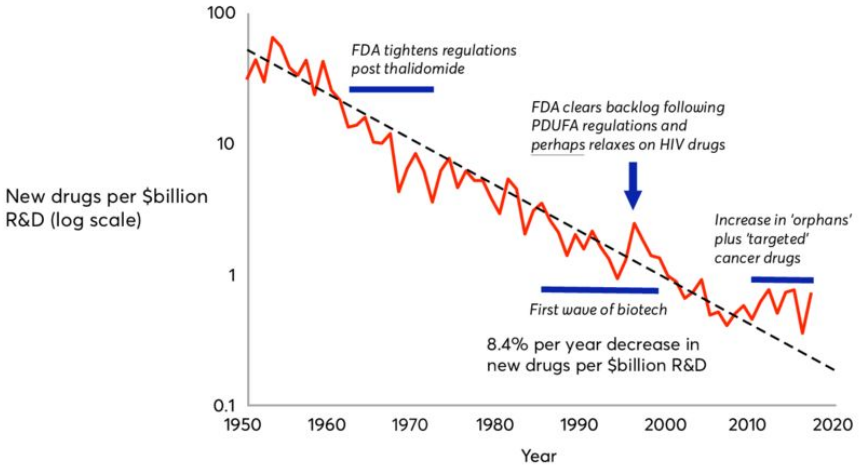
FIGURE 11.1: A series of convergences toward digitizing humans. Each diagram is meant to represent the trend toward fusion of the formerly discrete entities.

“There will be titanic changes ahead -- medicine can and will be rebooted and reinvented one individual at a time”

Post-Script

Areas that have evolved since the book's publishing

1. Population medicine
2. Digitization
3. The life science industry
4. Genomics zooms forward
5. A shift in doctor priorities



Questions?