Department of Electrical Engineering (ESAT)

Faculty of Engineering
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From Bioinformatics to Health Decision Support

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IBBT

Content

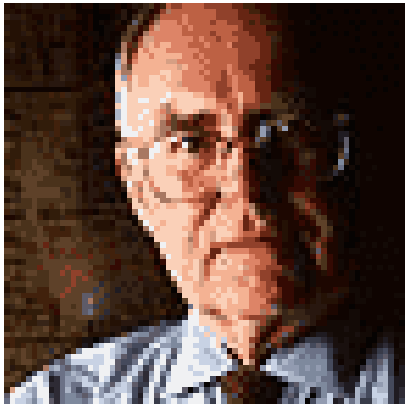
I. Exponential evolution of technology
   a. Computers
   b. Communication
   c. Data
   d. Bio-Technology and Bioinformatics

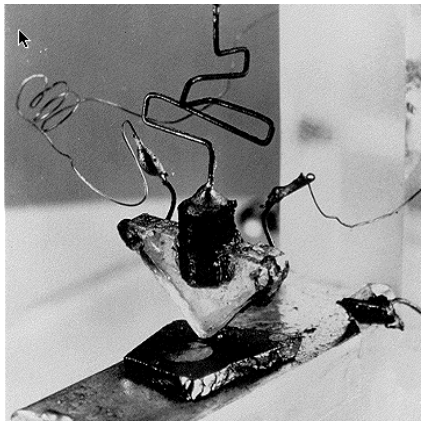
II. Multi-, cross- and interdisciplinarity: integration

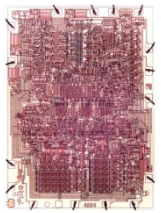
III. Societal demands
   a. Translational gap
   b. Clinical decision support systems

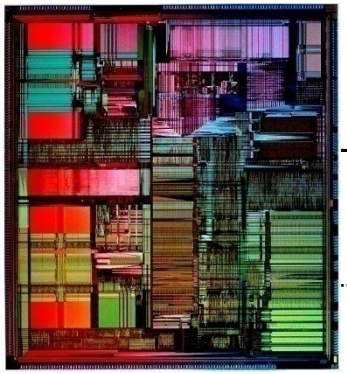
IV. Health Decision Support

Gordon Moore's law

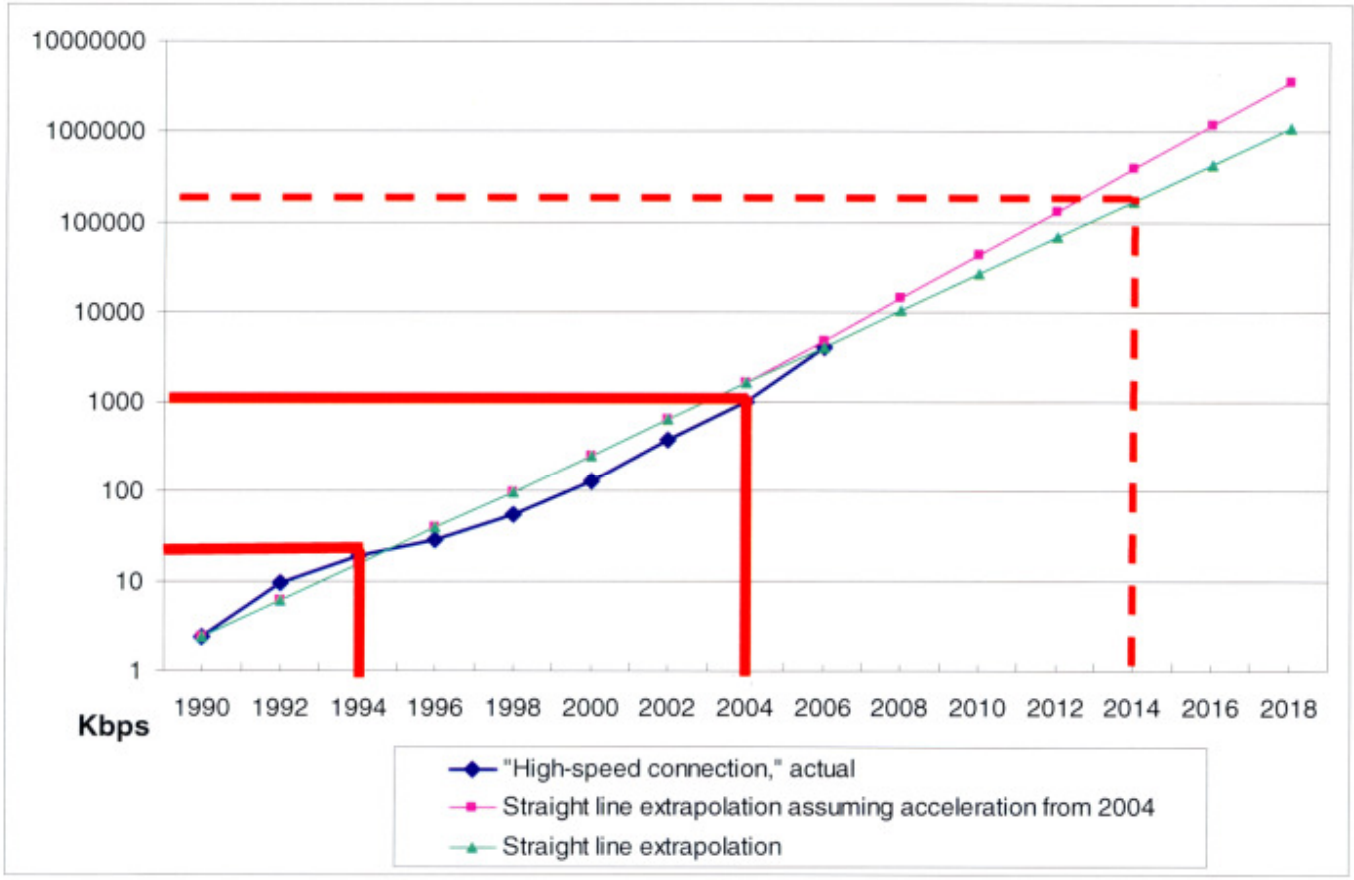








Broad band capacity



Source: Heavy Reading report "FTTH Worldwide Market & Technology Forecast, 2006-2011"

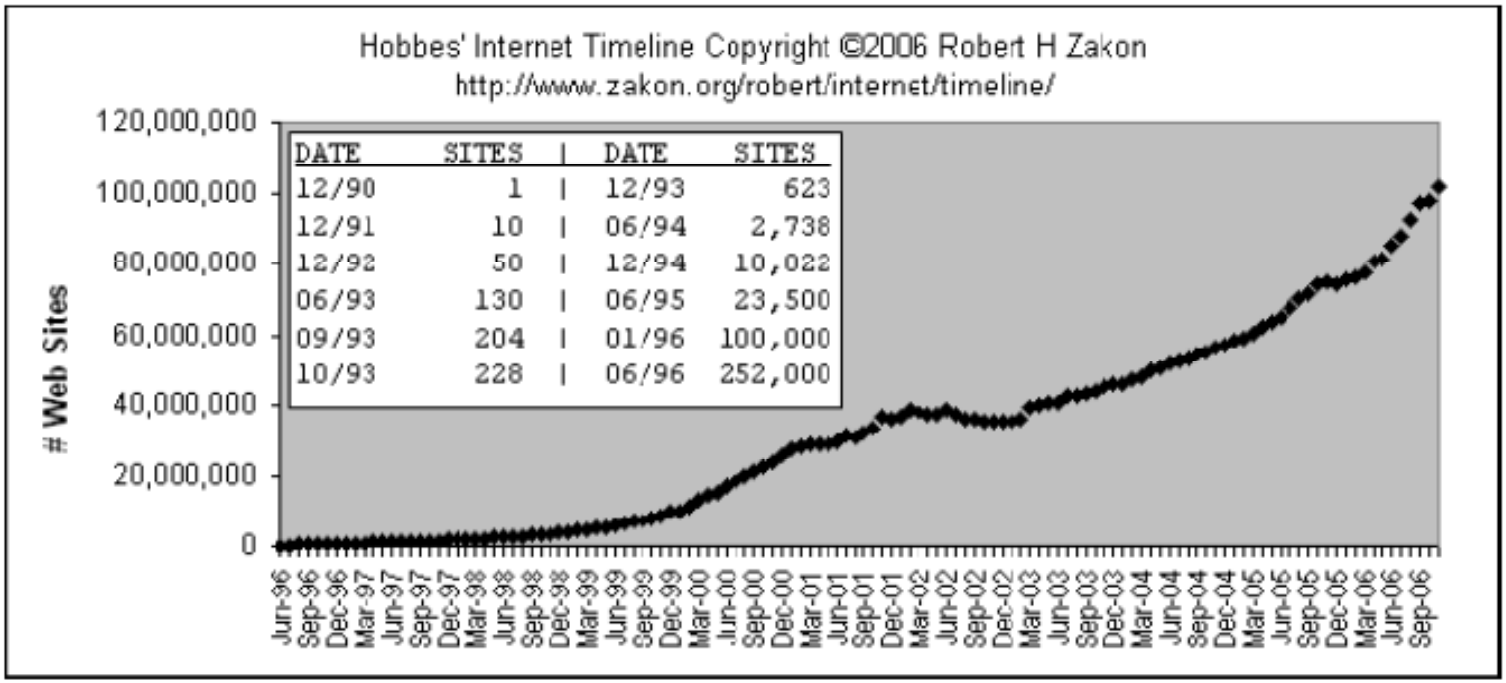
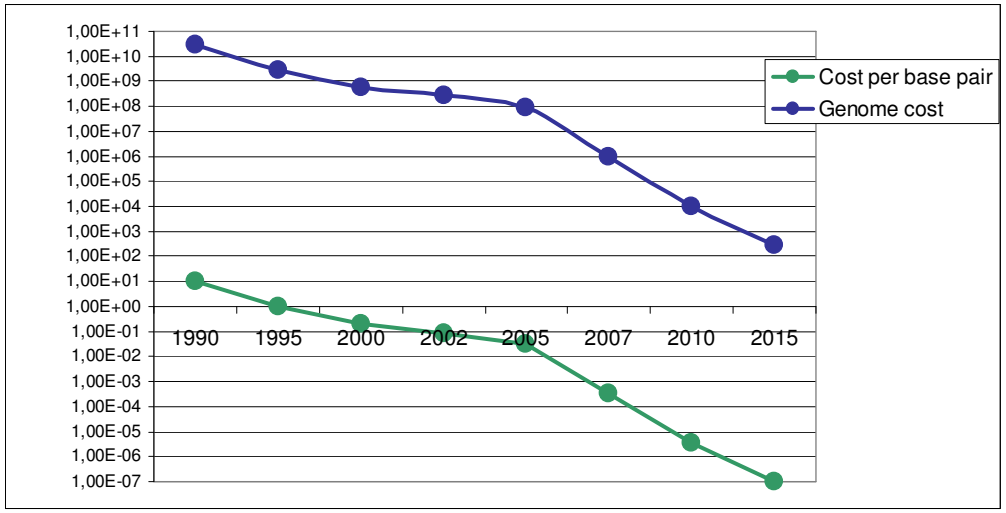


Figure 1.1: The estimated number of web sites on the World Wide Web. More precisely, the number of web servers is counted. Hence, the actual number of web sites will be larger since one server may host multiple sites. Moreover, most web sites contain a multitude of web pages or documents. *Google* currently indexes more than eight billion web pages! The total number of static and dynamic web pages is even many times larger and continuously increasing.

By 2010, 1/3 of all world data bases will consist of biomedical data

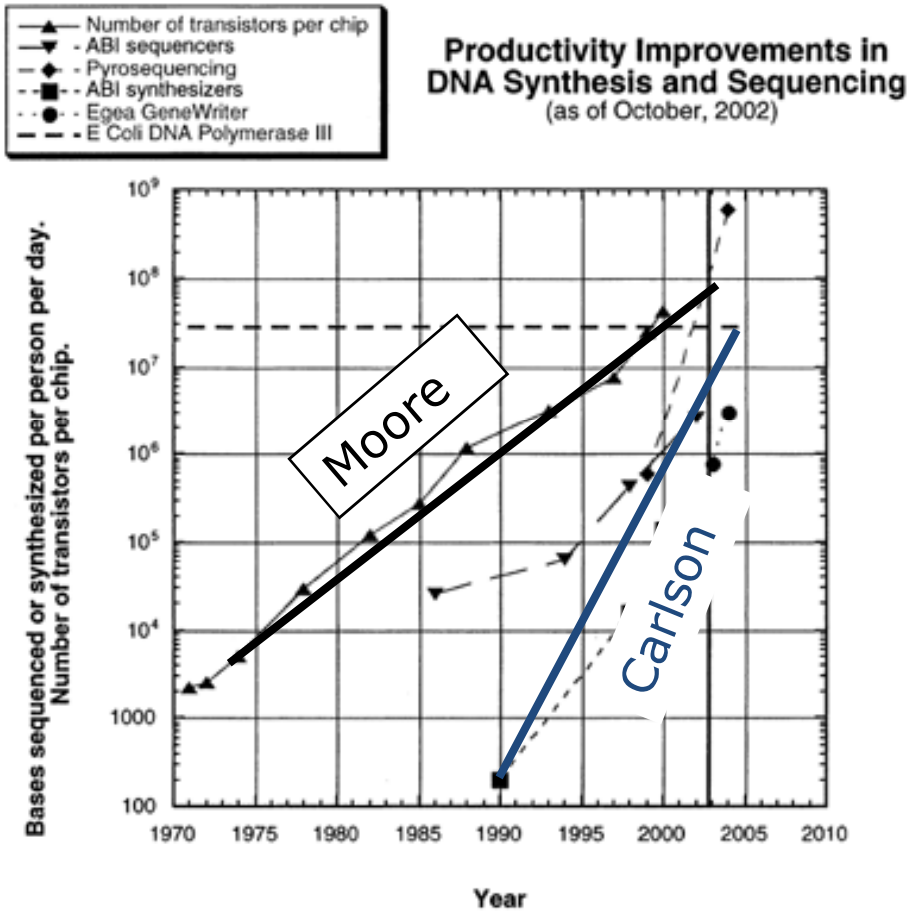
Making sense of the 1000 $ genome ?

- Human genome project
  - Initial draft: June 2000
  - Final draft: April 2003
  - 13 year project
  - $300 million value with 2002 technology
- Personal genome
  - June 1, 2007
  - Genome of James Watson, co-discoverer of DNA double helix, is sequenced
    - $1.000.000
    - Two months
- €1000-genome
  - Expected 2012-2020



Year	Cost per base pair	Genome cost
1990	10	3E+10
1995	1	3.000.000.000
2000	0.2	600.000.000
2002	0.09	270.000.000
2005	0.03	90.000.000
2007	0.000333333	1.000.000
2010	3.33333E-06	10000
2015	0.0000001	300

Moore versus Carlson



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GGGATGTTTATAACCATCTT
TGAGATTATTGATGCATGGT
TATTGGTTAGAAAAAATATA
CGCTTGTTTTTCTTTCCTAG
GTTGATTGACTCATACATGT
GTTTCATTGAGGAAGGAAC
TTAACAAAACTGCACTTTTT
TCAACGTCACAGCTACTTTA
AAAGTGATCAAAGTATATCA
AGAAAGCTTAATATAAAGAC
ATTTGTTTCAAGGTTTCGTA
AGTGCACAATATCAAGAAG
ACAAAAATGACTAATTTTGT
TTTCAGGAAGCATATATATT
ACACGAACACAAATCTATTT
TTGTAATCAACACCGACCAT
GGTTCGATTACACACATTAA
ATCTTATATGCTAAAACTAG
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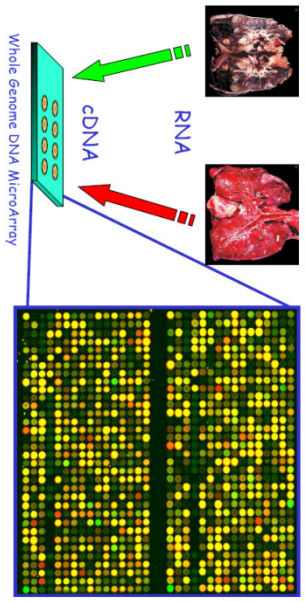
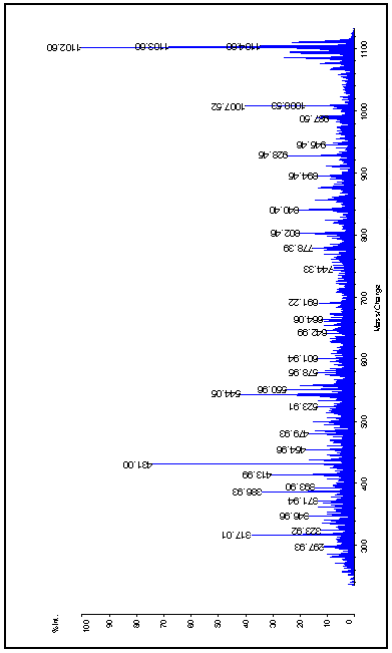
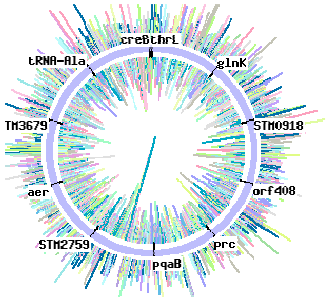
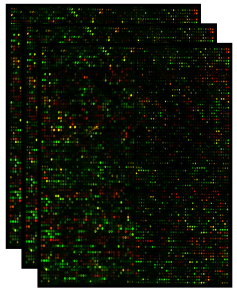
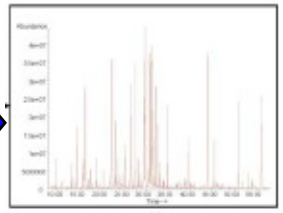
ATAACCATCTTTGAGATTAT
TGATGCATGGTTATTGGTTA
GAAAAAATATACGCTTGTTT
TTCTTTCCTAGGTTGATTGA

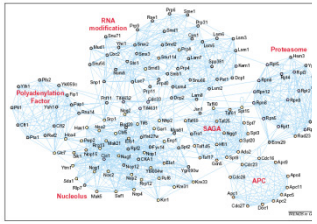












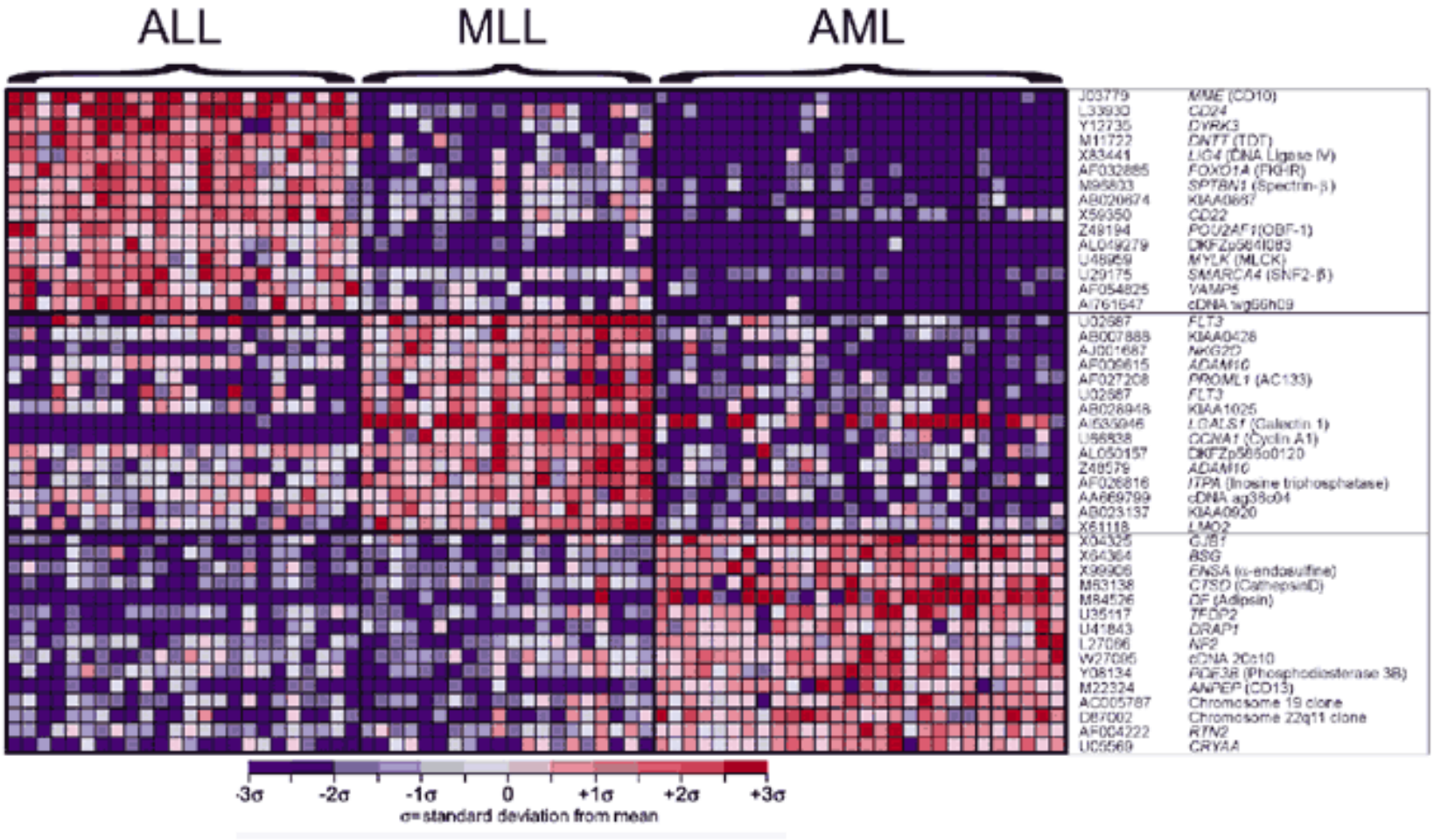
genome **transcriptome** **proteome** **metabolome** **interactome**

GS-FLX Roche
Applied Science 454

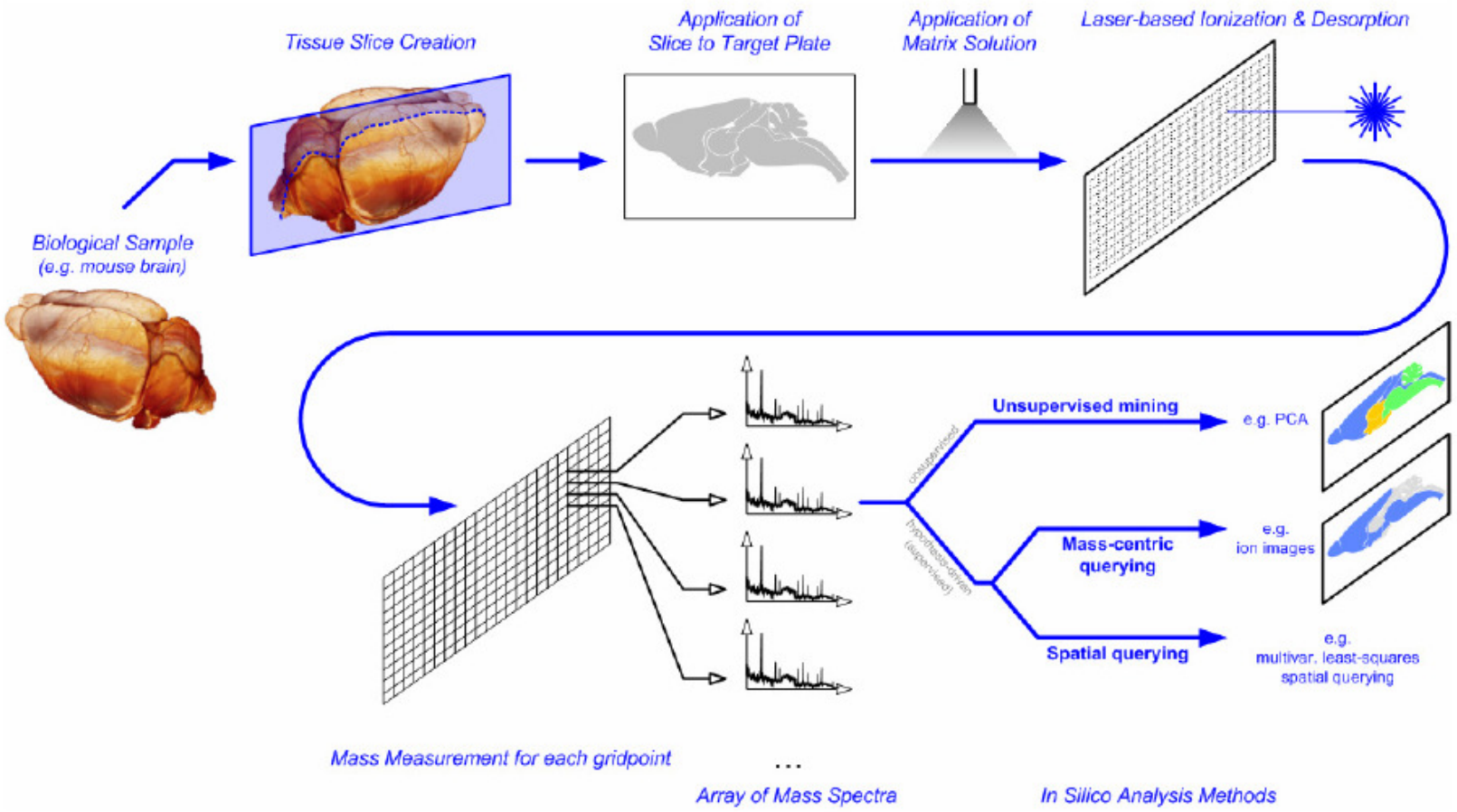
maf VIB
MicroArray Facility

Prometa

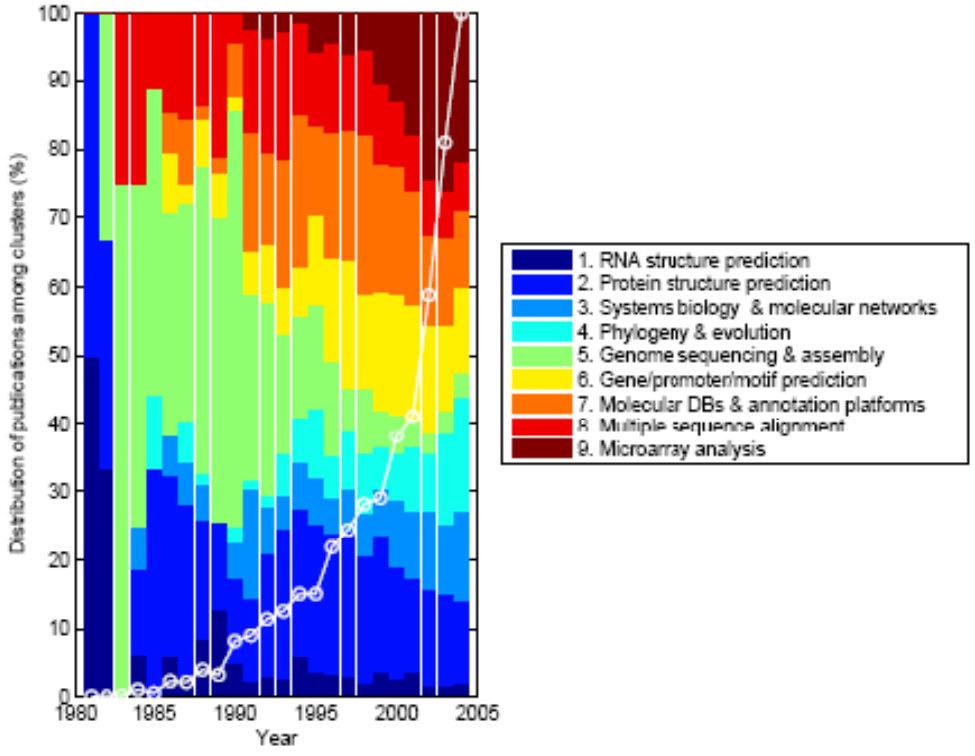
Microarray data: genetic fingerprints

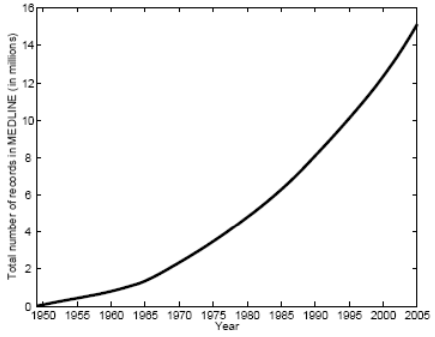


Imaging mass spectrometry



Text mining





1.2: Growth of MEDLINE, the U.S. National Library of Medicine (NLM) bibliographic database covering the fields of medicine, nursing, dentistry, veterinary medicine, the health care system and preclinical sciences. The number of scientific publications (in millions) is indicated for each year. MEDLINE contains approximately 15 million unique records about journals in life sciences. This figure was constructed using data published by [61].

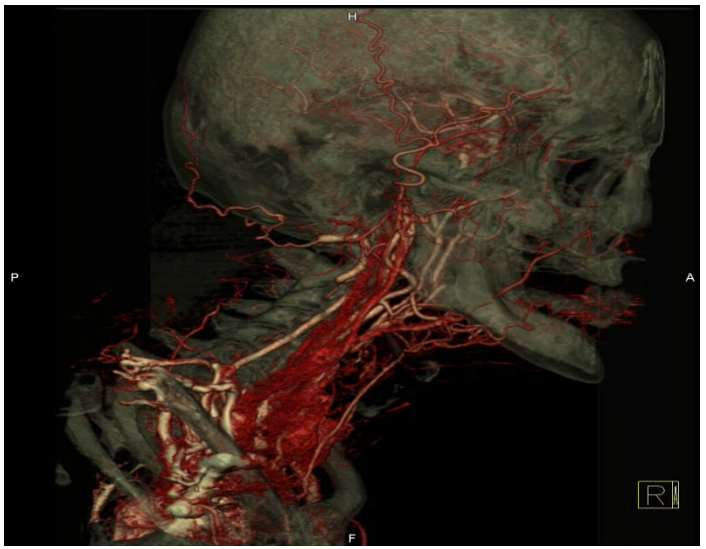
Medical images

-New technologies generate more data

-Increased spatial and temporal resolution

-More studies per patient, more datasets per study

Virtual colonoscopy from CT images
with automatically detected polyps



subtraction CT angiography

Medical image processing

Radiography and Computed tomography

Dose reduction, increased volume coverage, higher contrast-to- noise ratio, improved spatial and temporal resolution for tissue characterization, automatic segmentation, monochromatic imaging and improved beam hardening correction (e.g., blooming).

Magnetic resonance imaging

Diffusion-weighted imaging for detection, quantification and therapy response in oncology; New contrast agents; better image quality (higher resolution, better SNR) and shorter acquisition times; higher external magnetic fields, higher gradients (e.g., gradient head insert coils to avoid cardiac stimulation) in each direction, multiple coils, and reconstruction algorithms that are not based on Fourier theory;

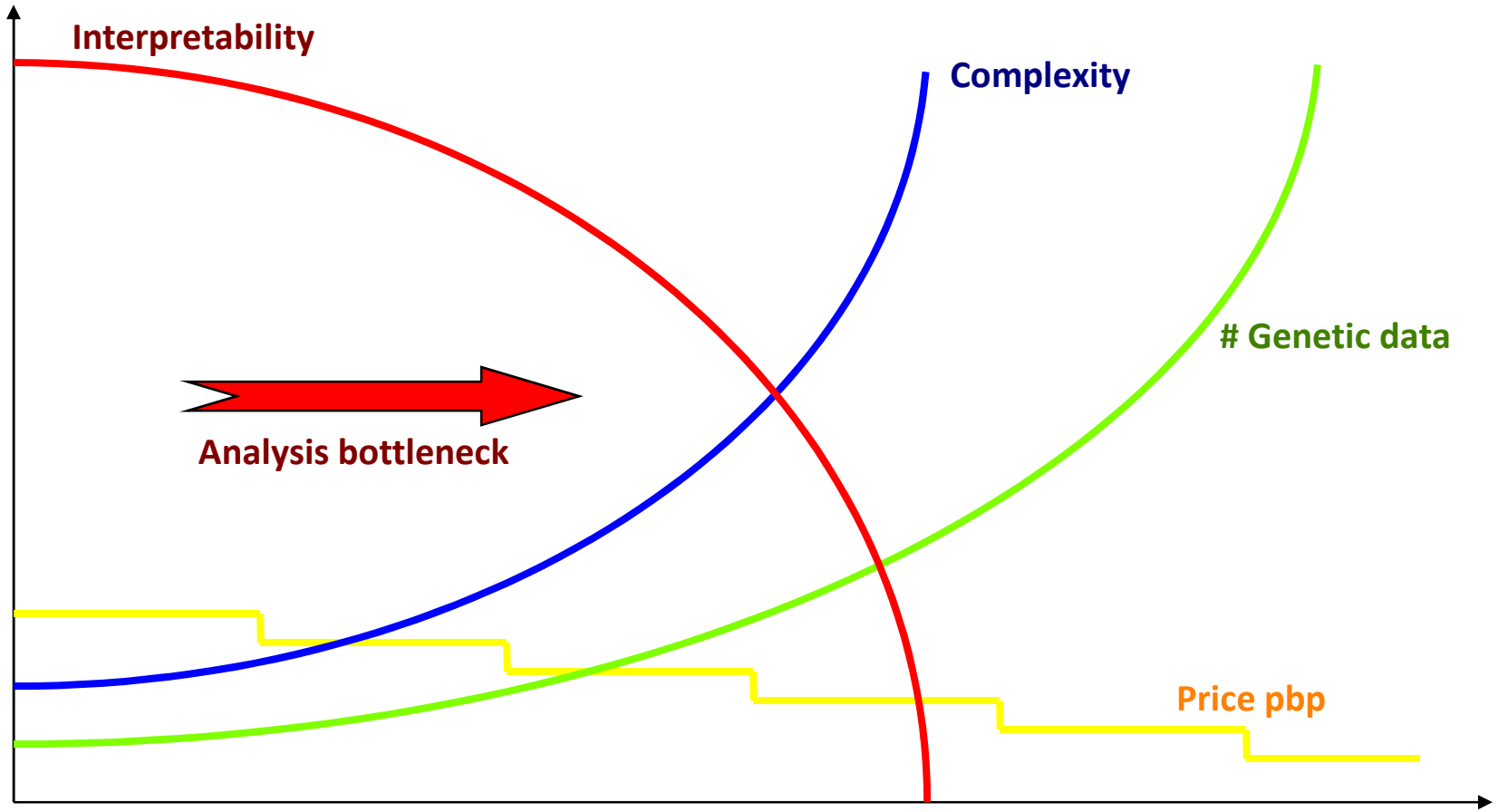
Nuclear medicine imaging

Improved TOF and hybrid systems, new detectors, removal of motion artifacts; development of new generations of tracers; more specific biomarkers that bind to specific receptors; molecular imaging: towards the visualization of biological processes at the cell level; imaging small animals;

Ultrasound

Increased resolution and contrast-to-noise ratio; tissue characterization based on backscatter ; contrast echography and its therapeutic application; targeted contrast-enhanced ultrasound;

Analysis bottlenecks



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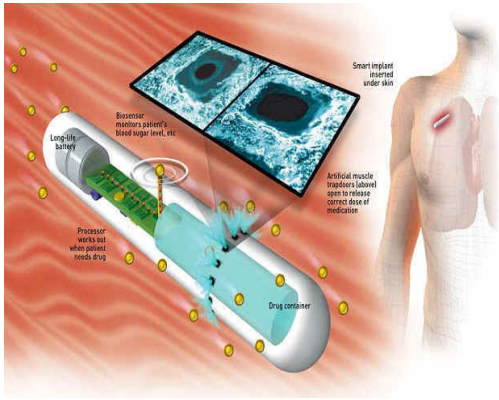
Transdisciplinary integration

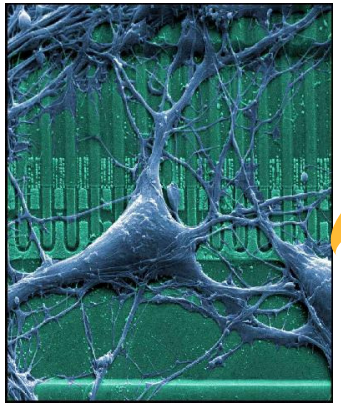
Materials, energy, IT

Ubiquitous computing

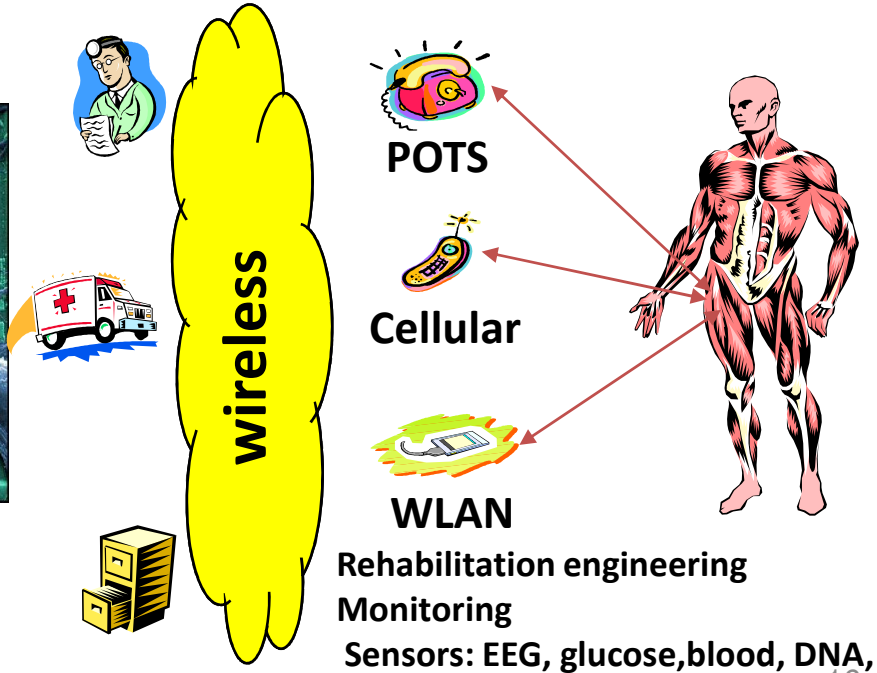
Ambient intelligence



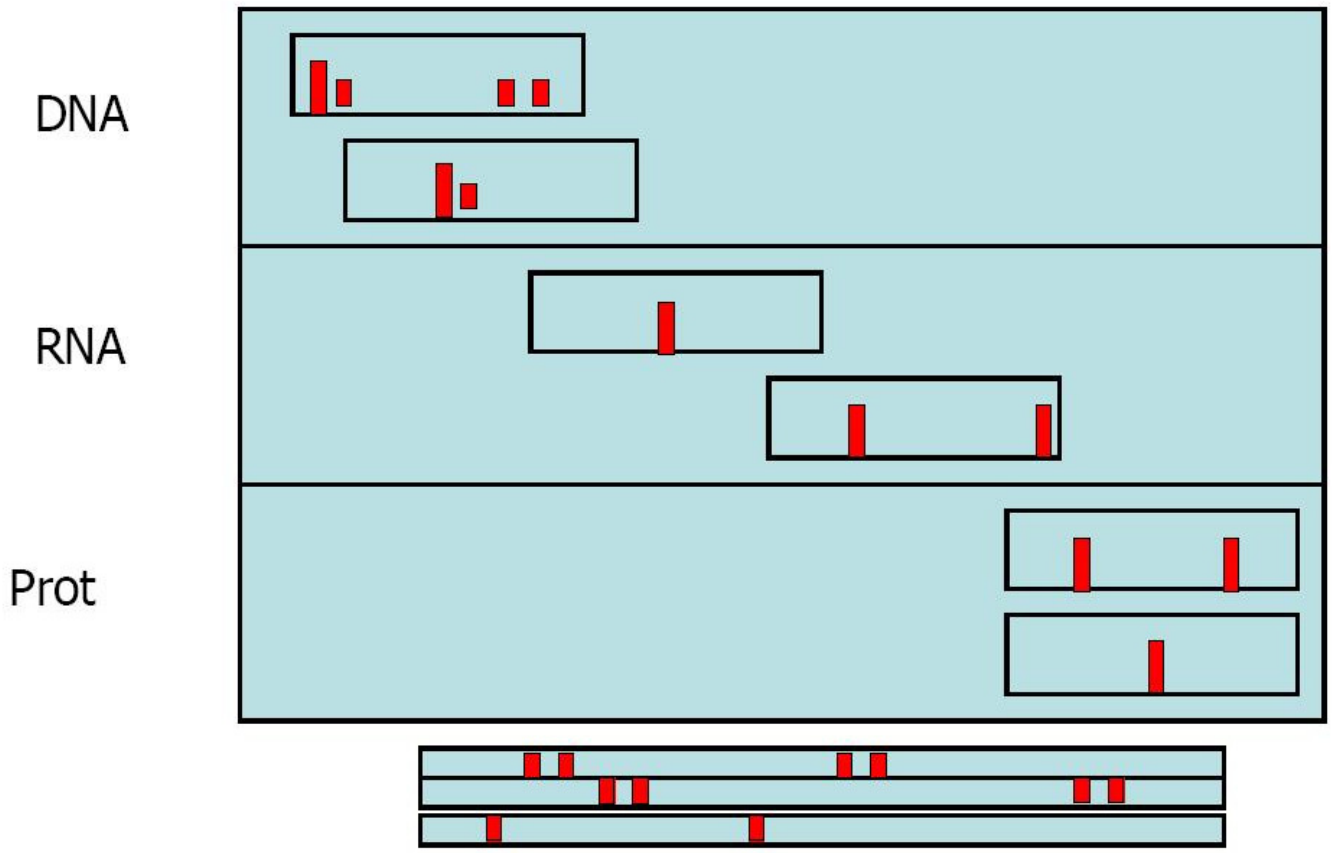
Embedded intelligence
Smart pills



Neuron on chip

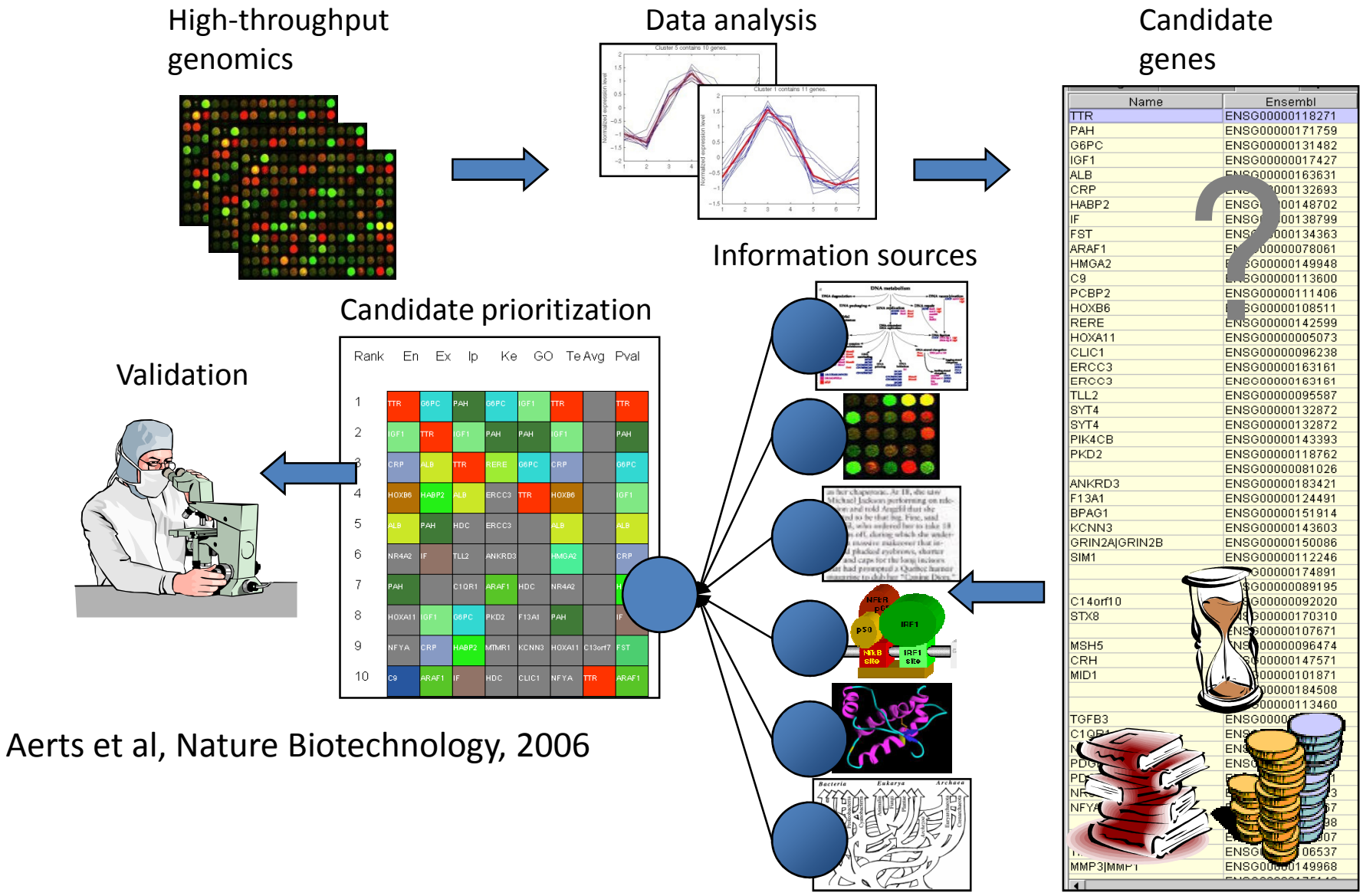


Rehabilitation engineering
Monitoring
Sensors: EEG, glucose,blood, DNA, …
Add-ons: vision, hearing, implants, …



An integrated molecular profile derived from high-throughput genetic, transcriptional and proteomics data.

Heterogenous data source gene prioritization



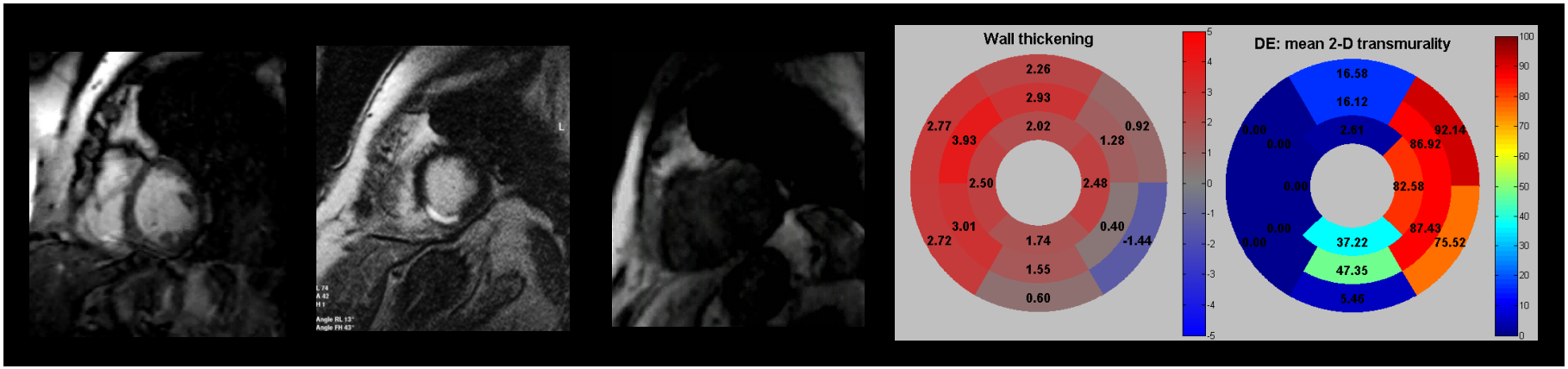
Aerts et al, Nature Biotechnology, 2006

Multimodal image data integration

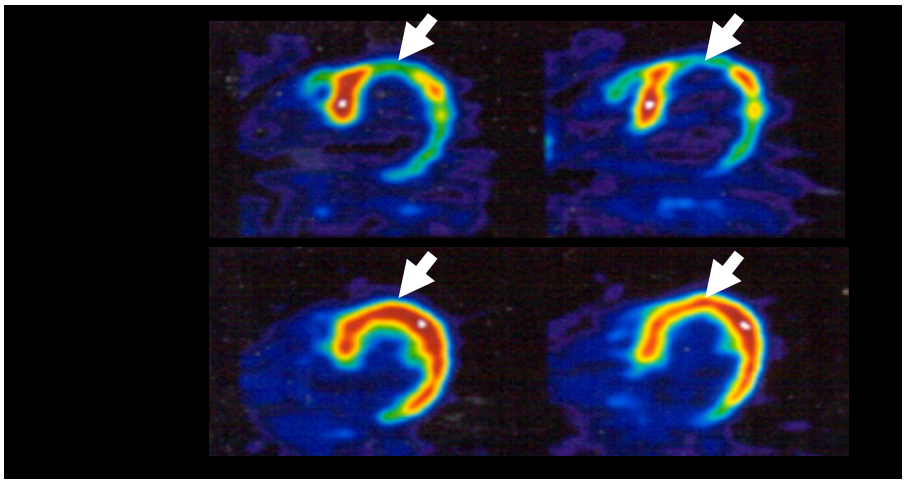
Assessment of myocardial infarction and residual viability:

multimodal characterization of function, perfusion and metabolism

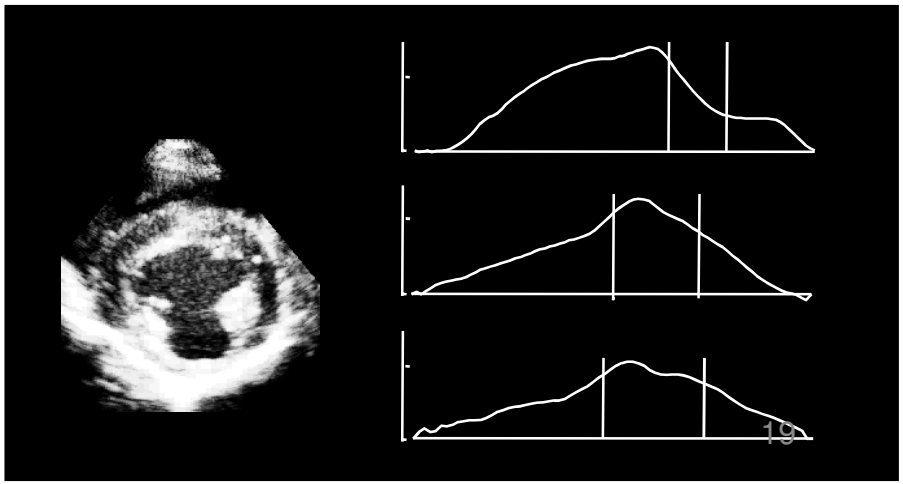
MR



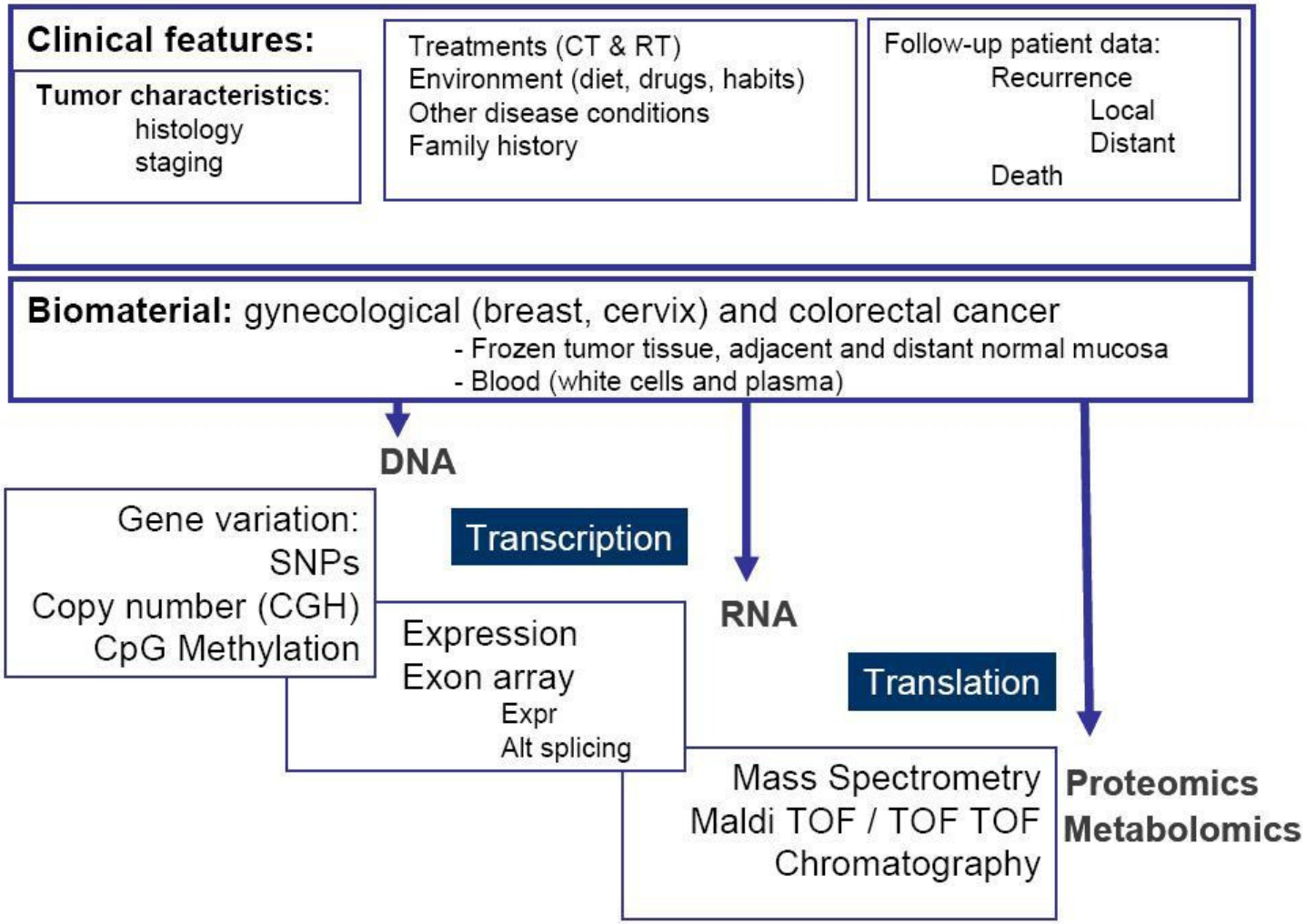
PET



US



Clinical decision support



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Societal demands

- **Improve quality performance of health decision/diagnosis systems**
  - Support individual medical doctor
    - Avoid/decrease number of medicial errors
    - Web portal for Evidence Based Medicine
      - Organised access to literature
      - Examples: UK, Norway, Sweden, Finland
  - Information sharing among doctors
    - avoid/monitor patient (s)hopping behavior
    - Global Medical File per patient
    - Interoperability
- **Deal with 'empowerment of the patient': Patient-centric health care**
  - Medical care in 4P: personalized, preventive, predictive, participatory
  - Increasing trend for 'customized''personalized' medicine
  - Improve transparancy and consistency
  - Deal/cope with 'professional' (chronical) patients (heart, diabetes, cancer,…)
  - Improve patient mobility
- **Cost effectiveness of the health care system**
  - Ageing population:
    - EU 2050: 65+ → +70%; 80+ → +180%
    - Vl. 2012: 60+ → 25 % of Vl.
  - Monitor overconsumption
  - Improve transparancy
  - Detect abnormalities in diagnosis/therapy/…
- **Cope with tsunami of available information and data (clinical, population, ….)**

Obama

But in order to lead in the global economy and to ensure that our businesses can grow and innovate, and our families can thrive, we're also going to have to address the shortcomings of our health care system.

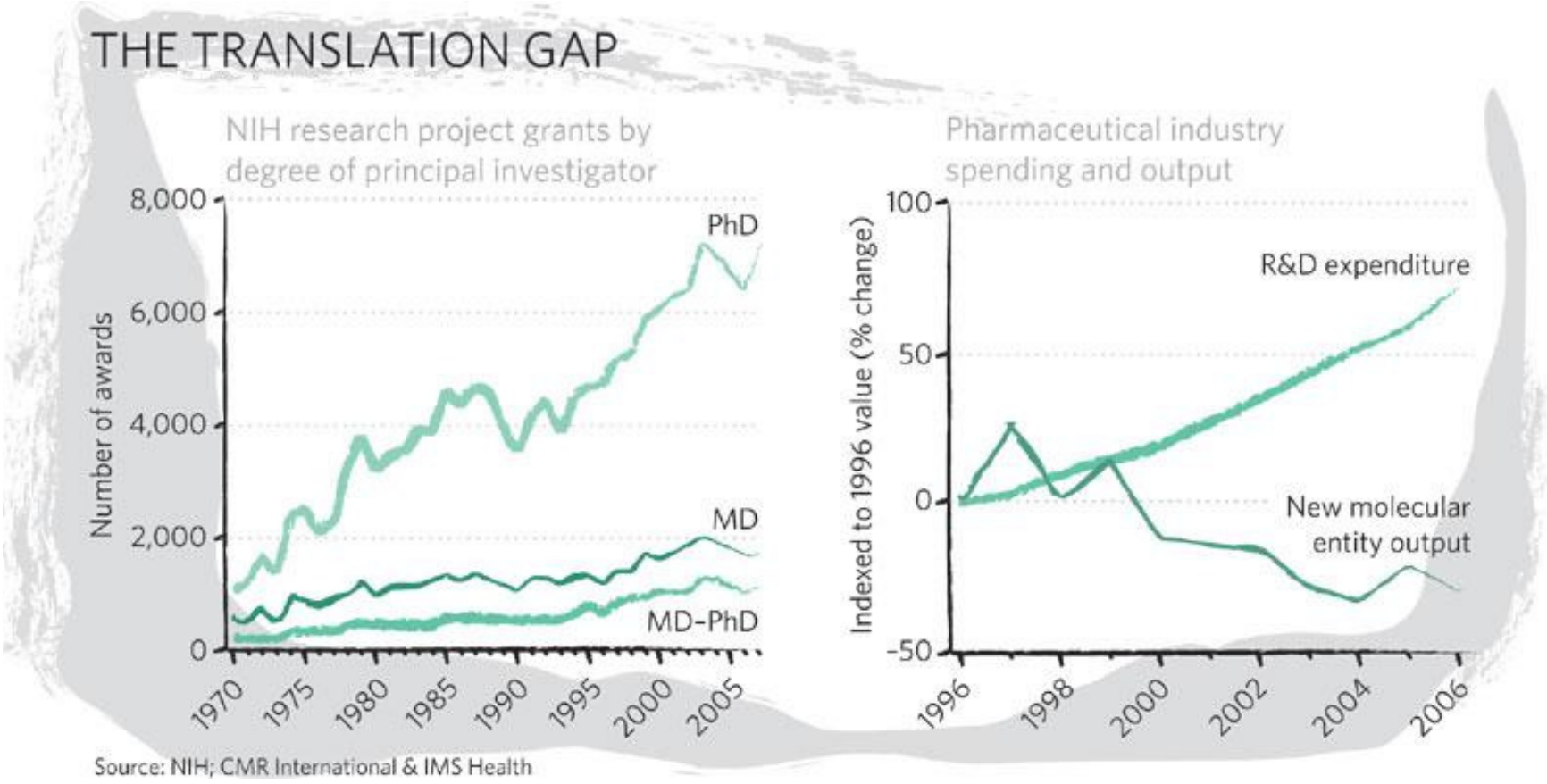
The Recovery Act will support the long overdue step of ***computerizing America's medical records***, to reduce the duplication, waste and errors that cost billions of dollars and thousands of lives. But it's important to note, ***these records also hold the potential of offering patients the chance to be more active participants in the prevention and treatment of their diseases***. We must maintain patient control over these records and respect their privacy. At the same time, we have the opportunity to offer billions and ***billions of anonymous data points to medical researchers who may find in this information evidence that can help us better understand disease***.

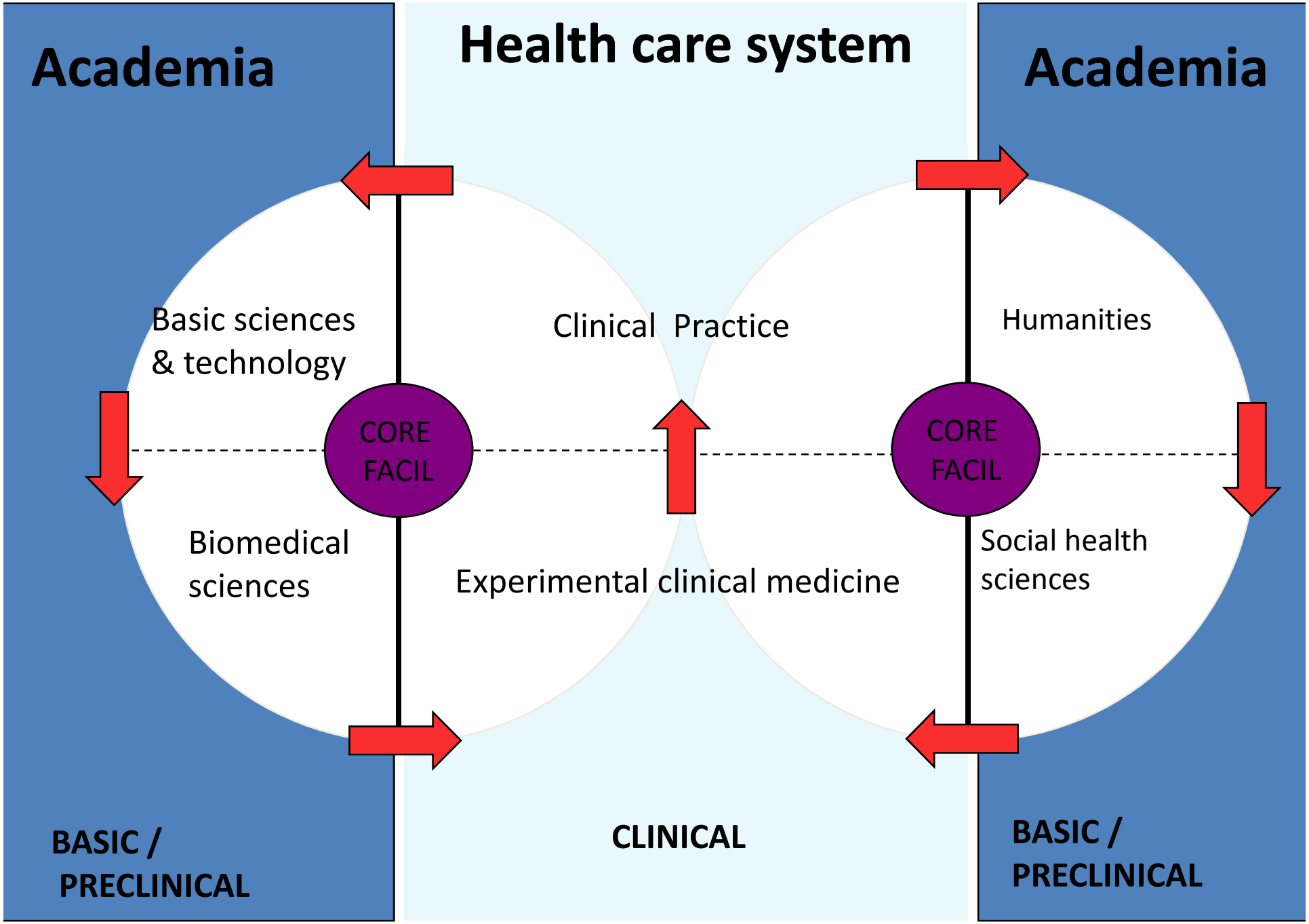
History also teaches us the greatest advances in medicine have come from scientific breakthroughs, whether the discovery of antibiotics, or improved public health practices, vaccines for smallpox and polio and many other infectious diseases, antiretroviral drugs that can return AIDS patients to productive lives,
pills that can control certain types of blood cancers, so many others.

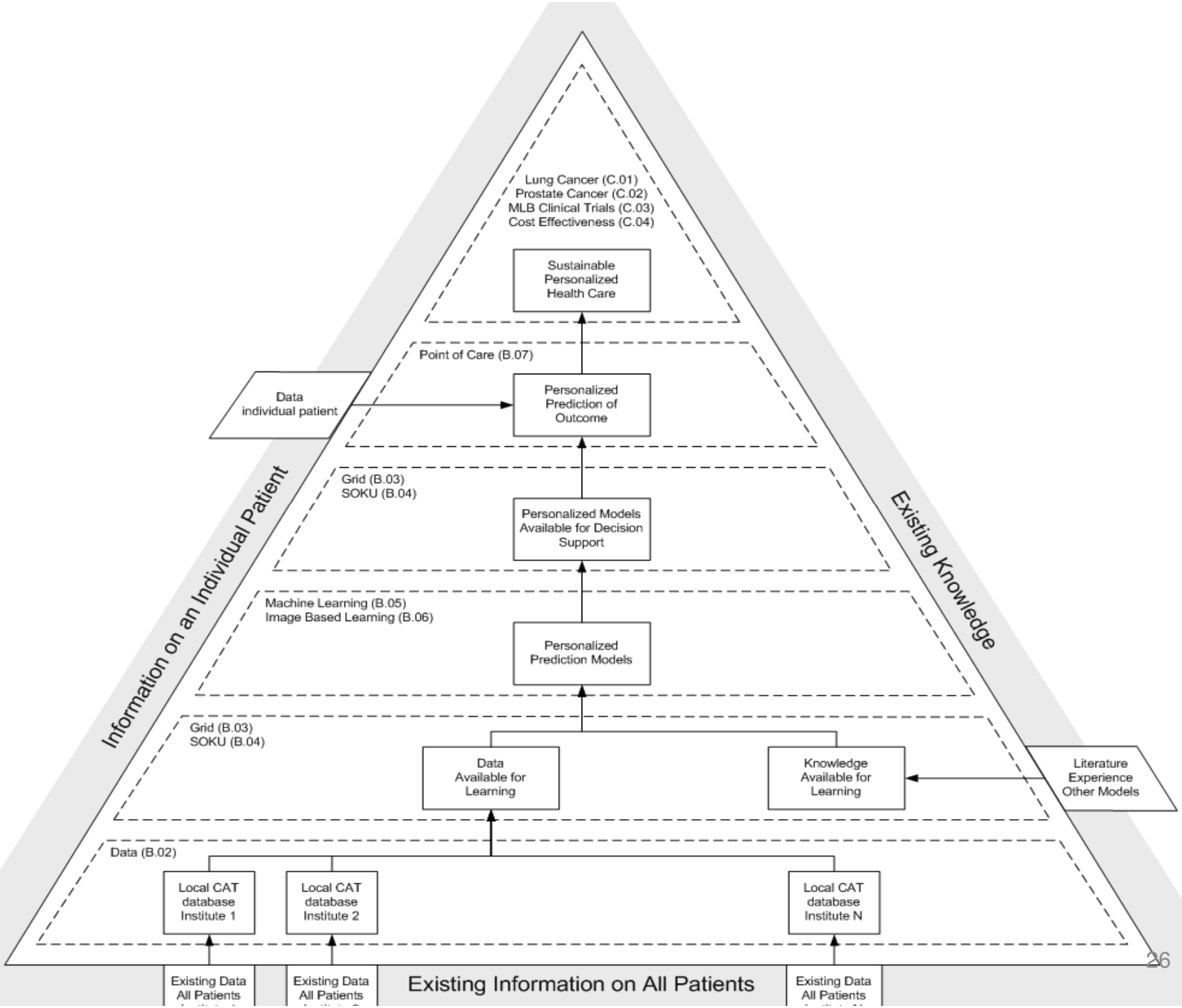
Because of recent progress –- ***not just in biology, genetics and medicine, but also in physics, chemistry, computer science, and engineering –- we have the potential to make enormous progress against diseases in the coming decades***. And that's why my administration is committed to increasing funding for the National Institutes of Health, including $6 billion to support cancer research -- part of a sustained, multi-year plan to double cancer research in our country. (Applause.)

http://www.whitehouse.gov/blog/09/04/27/The-Necessity-of-Science/

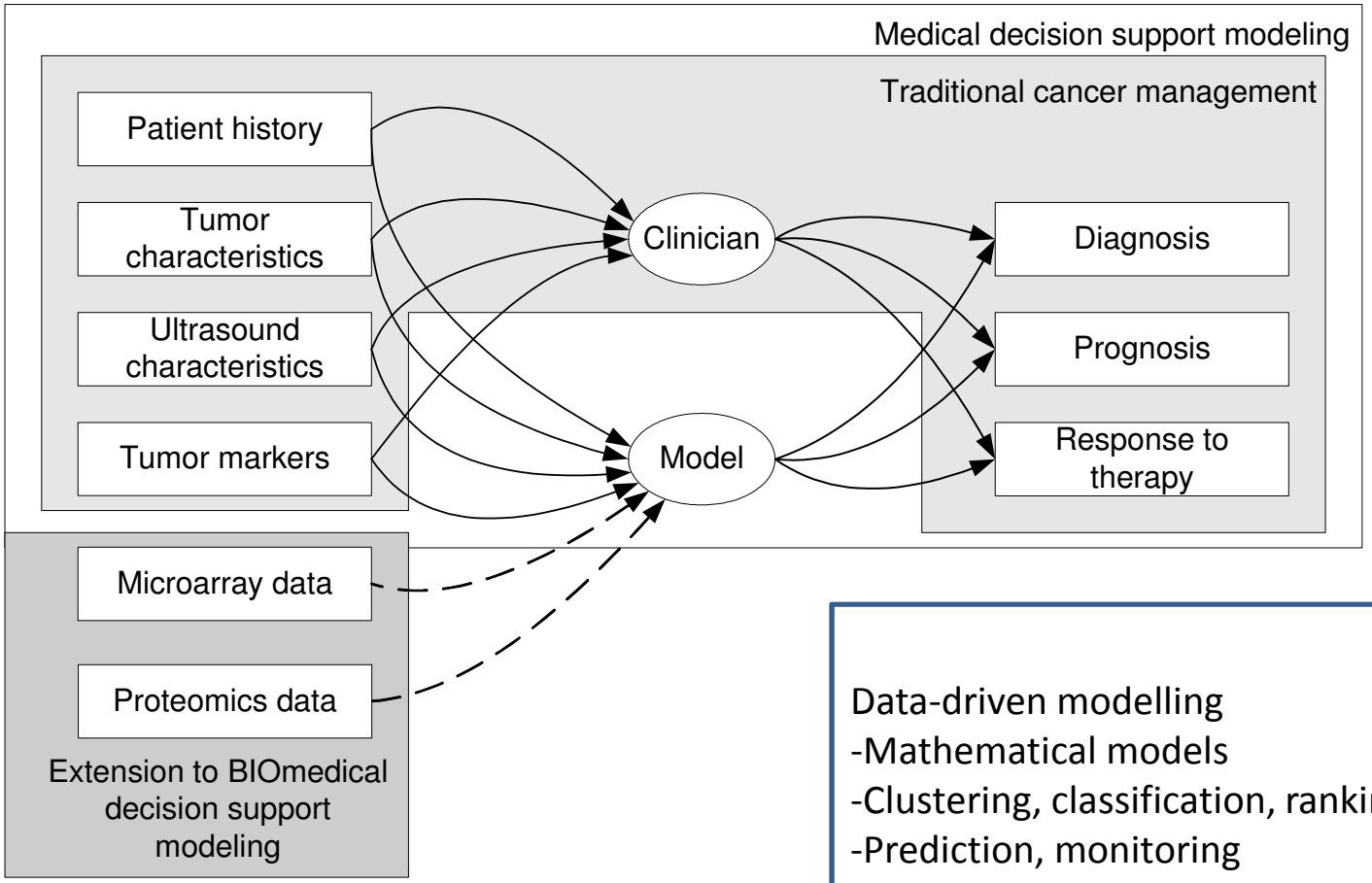
Translational medicine: bed ←→bench




Academia
Health care system
Academia
Basic sciences
& technology
Clinical Practice
Humanities
CORE
FACIL
CORE
FACIL
Biomedical
sciences
Experimental clinical medicine
Social health
sciences
BASIC /
PRECLINICAL
CLINICAL
BASIC /
PRECLINICAL


Lung Cancer (C.01)
Prostate Cancer (C.02)
MLB Clinical Trials (C.03)
Cost Effectiveness (C.04)
Sustainable Personalized Health Care
Point of Care (B.07)
Data individual patient
Personalized Prediction of Outcome
Grid (B.03)
SOKU (B.04)
Personalized Models Available for Decision Support
Machine Learning (B.05)
Image Based Learning (B.06)
Personalized Prediction Models
Grid (B.03)
SOKU (B.04)
Data Available for Learning
Knowledge Available for Learning
Literature Experience Other Models
Data (B.02)
Local CAT database Institute 1
Local CAT database Institute 2
Local CAT database Institute N
Existing Data All Patients
Existing Data All Patients
Existing Information on All Patients
Existing Data All Patients
Information on an Individual Patient
Existing Knowledge

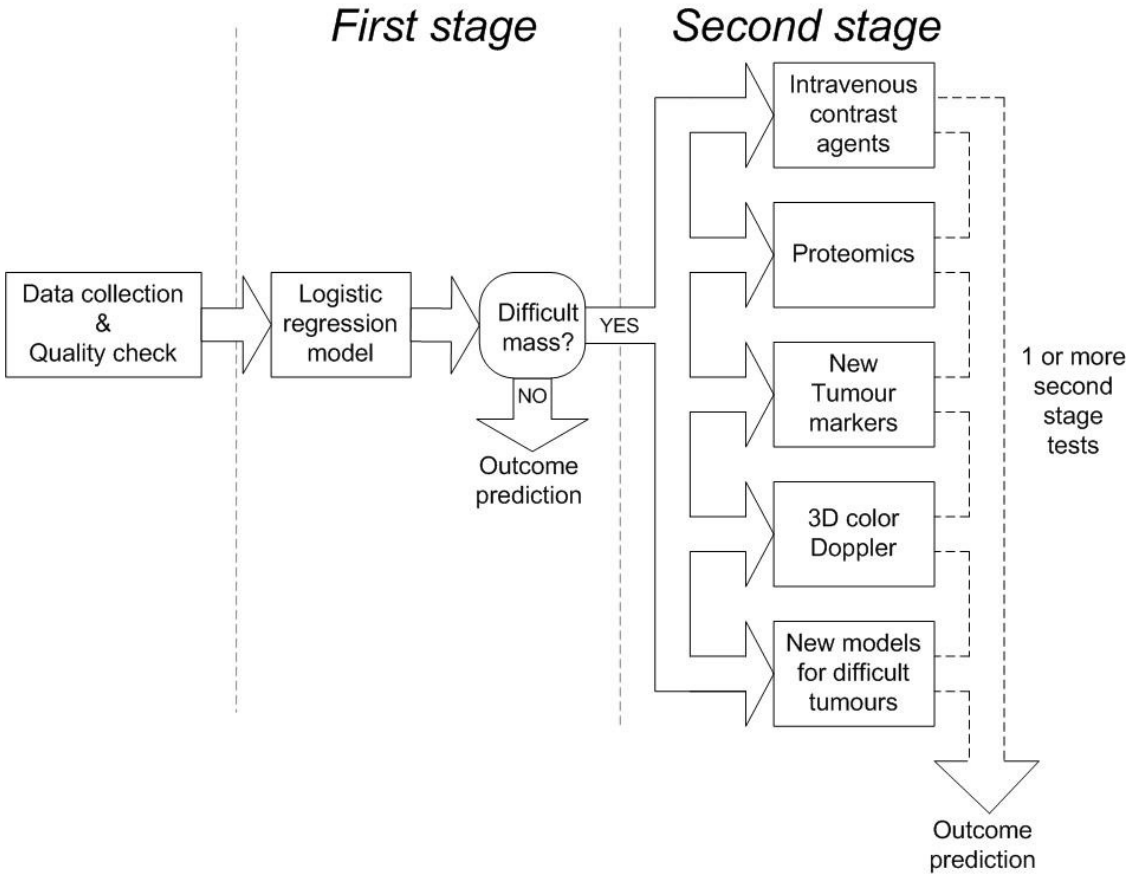
Clinical decision support: model + data integration



Data-driven modelling
-Mathematical models
-Clustering, classification, ranking, prioritization
-Prediction, monitoring
-Heterogeneous data source integration
-Algorithms/statistics/mathematical engineering
-Bayesian networks, kernel-based algorithm
-Software: proof-of-concept

IOTA (International Ovarian Tumour Analysis)

Phase I (1999-2002): 1066 patients, 9 European Centers
Phase II (2005-2007): 2093 patients, 20 European Centers
Phase III (to come): > 2000 patients, multicentre



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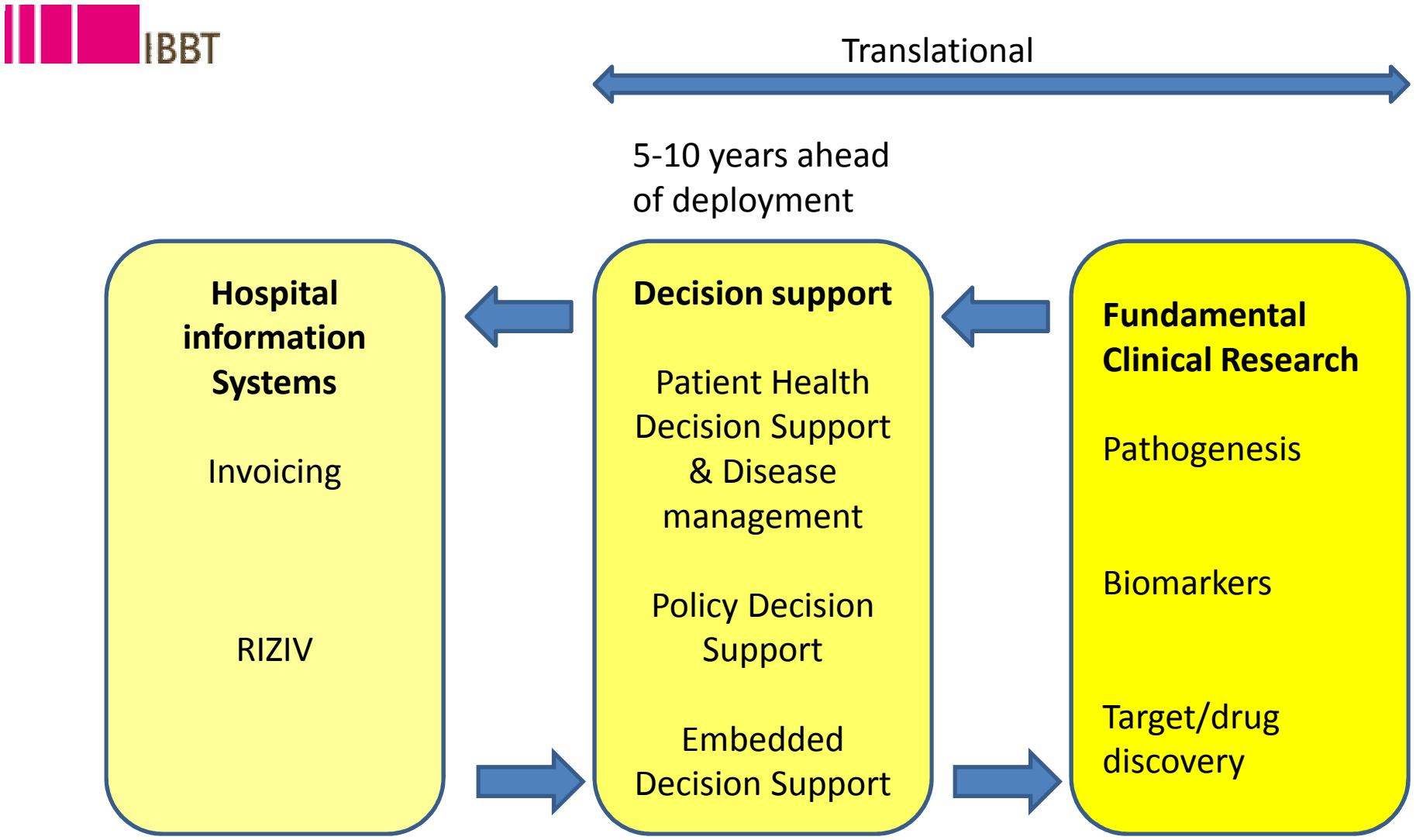
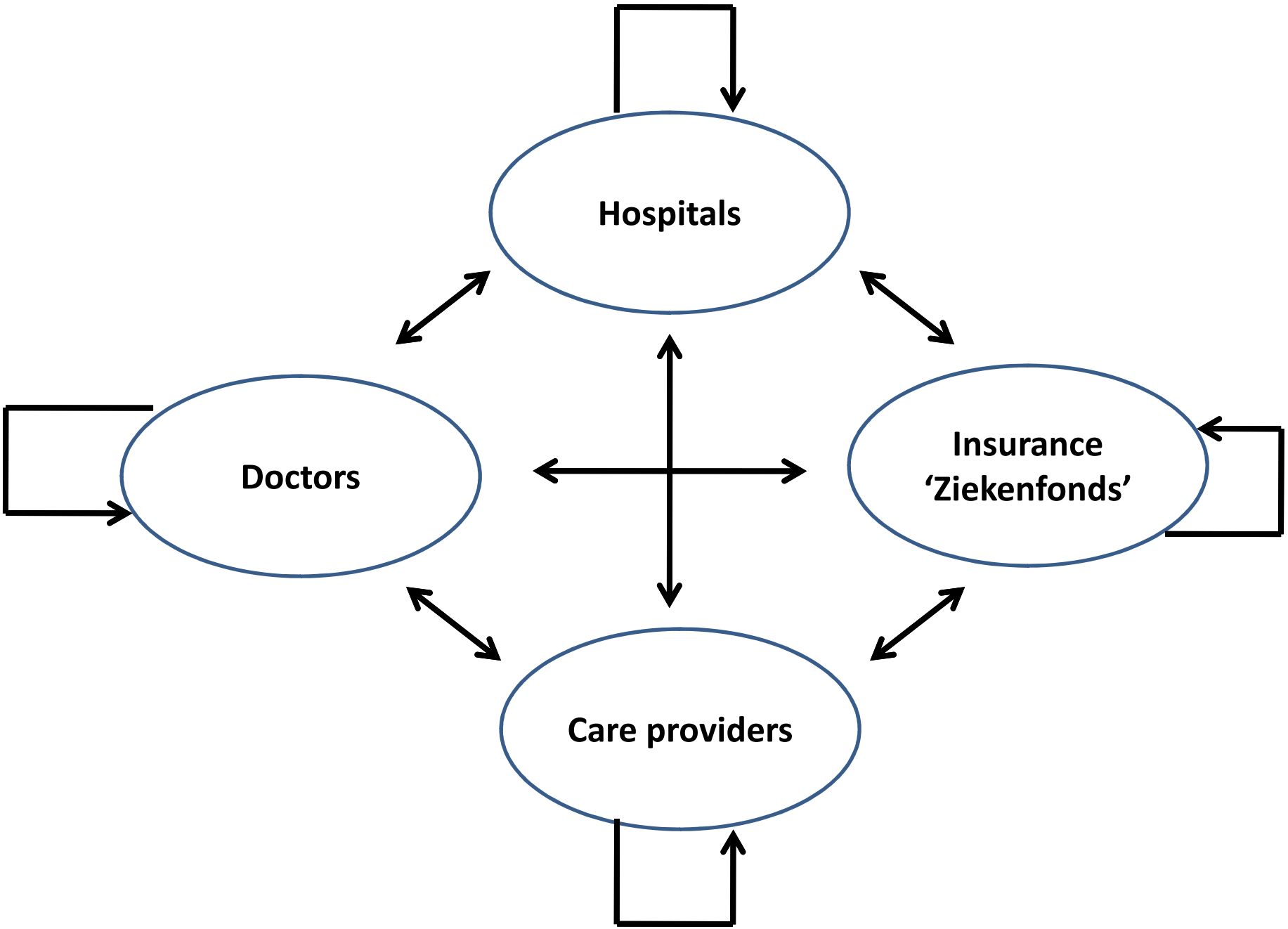

IBBT
Translational
5-10 years ahead
of deployment
Hospital information Systems
Invoicing
RIZIV
Decision support
Patient Health Decision Support & Disease management
Policy Decision Support
Embedded Decision Support
Fundamental Clinical Research
Pathogenesis
Biomarkers
Target/drug discovery


Hospitals
Doctors
Insurance
'Ziekenfonds'
Care providers

Health security aspects

-Multilateral security for community-centric healthcare IT platforms

-System and software security of critical community (e-health) infrastructures

-Enabling technologies for collaborative work in the e-health sector

-Policy negotiation, enforcement and compliance

-Privacy preserving data-mining and statistical databases

-Body Area Networks (implanted devices, wearable devices,…) and Personal Area Networks

- E-government : identity management, delegation, controlled data exchange

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