Future Perspective of Biotech:

Precision Medicine & Digital Health

Chung-Liang Chien, PhD

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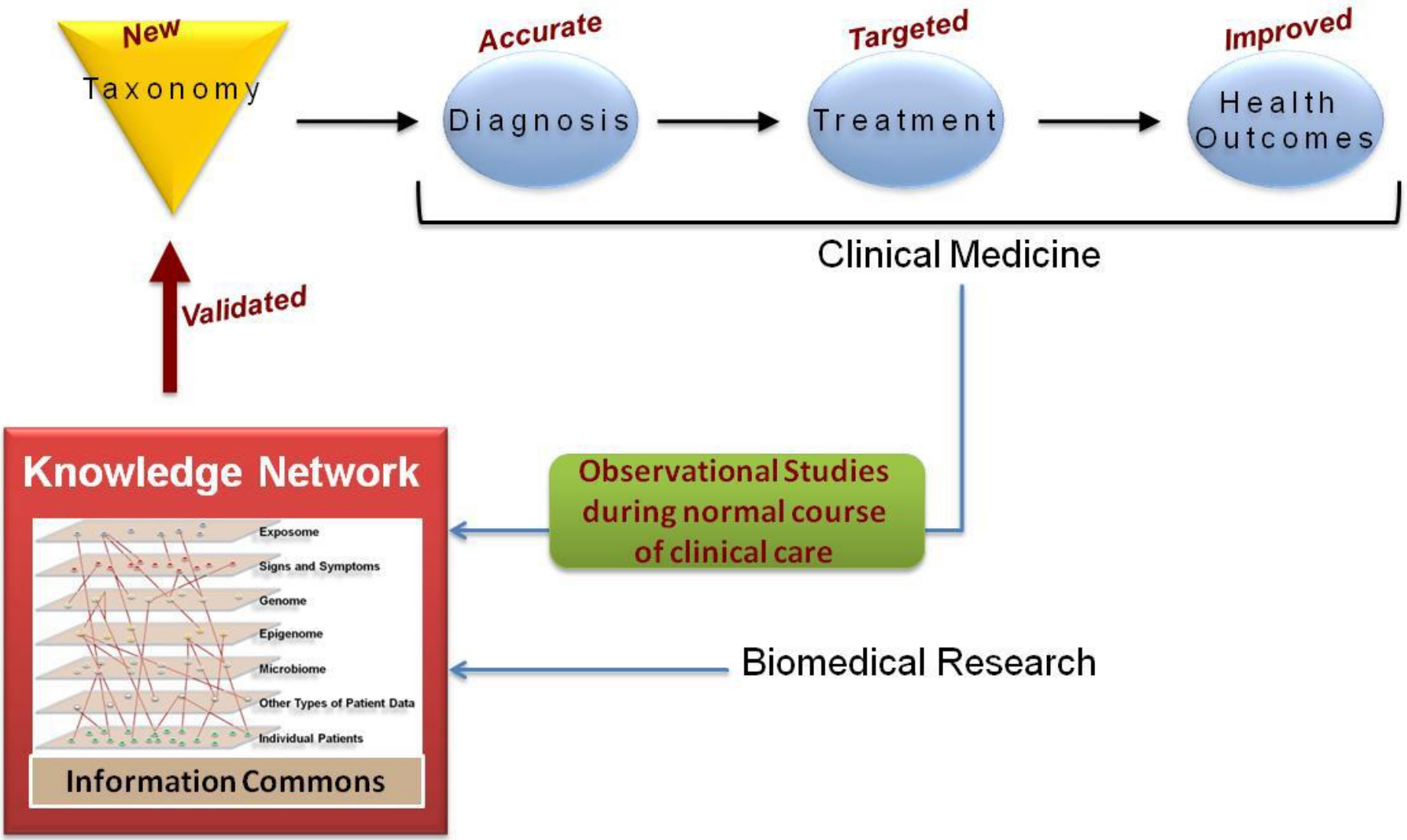
National Taiwan University

Creation of a New Taxonomy first requires an "Information Commons"



A

Community	Goals	Taxonomic Needs
Biomedical Researchers Drug development industry	Elucidate disease mechanisms Discover new therapies	Dynamic Increasing complexity Greater precision
Public Health Officials Medical Practitioners Health Care Industry	Track disease incidence Deliver/administer health care	Scalable Accurate Robust Simple

B

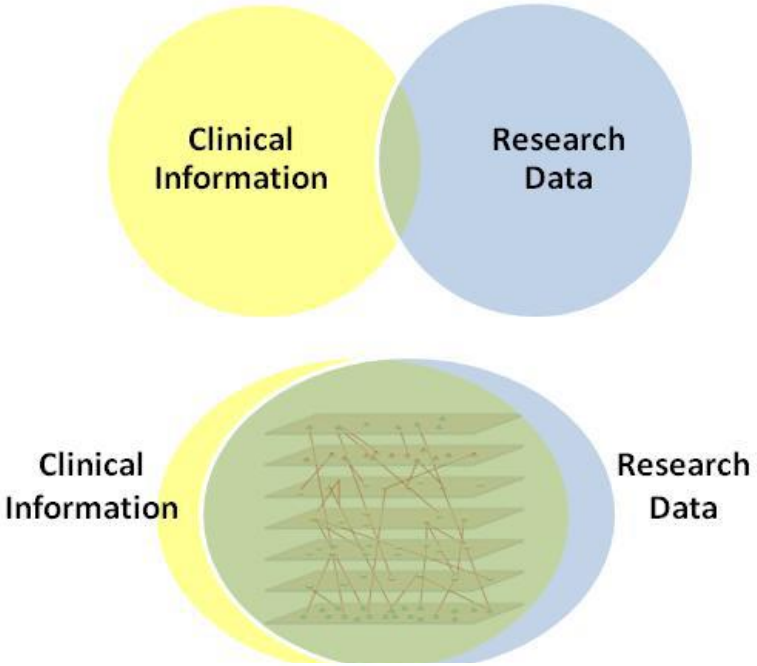


Figure 1-1: A) Different stakeholder communities are perceived to have distinct taxonomic and informational needs. B) Integration of information and a consolidation of needs could better serve all stakeholders.

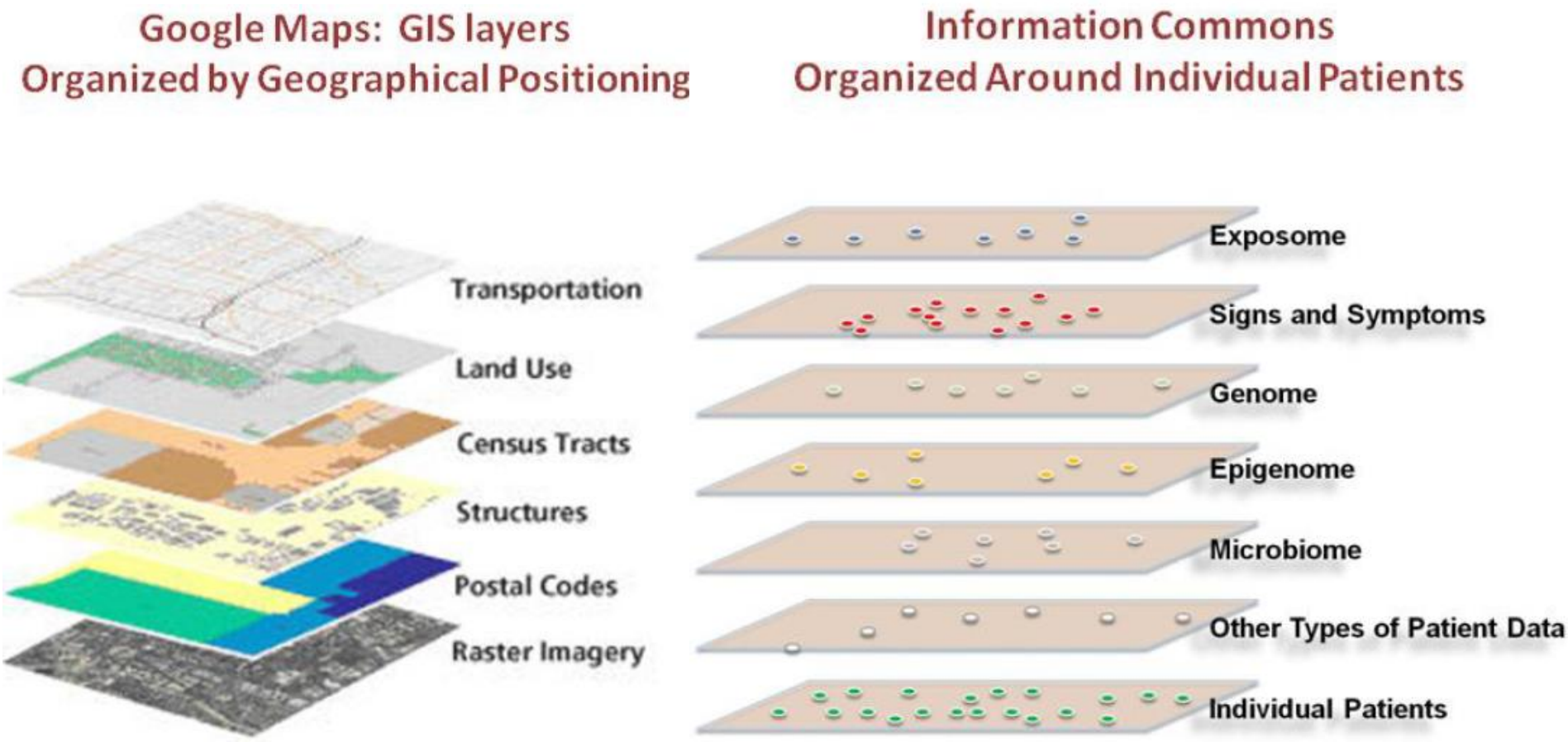


Figure 1-2: The proposed, individual-centric Information Commons (right panel) is somewhat analogous to a layered Geographical Information System (left panel). In both cases, the bottom layer defines the organization of all the overlays. However, in a GIS, any vertical line through the layers connects related snippets of information since all the layers are organized by geographical position. In contrast, data in each of the higher layers of the Information Commons will overlay on the patient layer in complex ways (e.g., patients with similar microbiomes and symptoms may have very different genome sequences). Source: FPA 2011 (left panel).

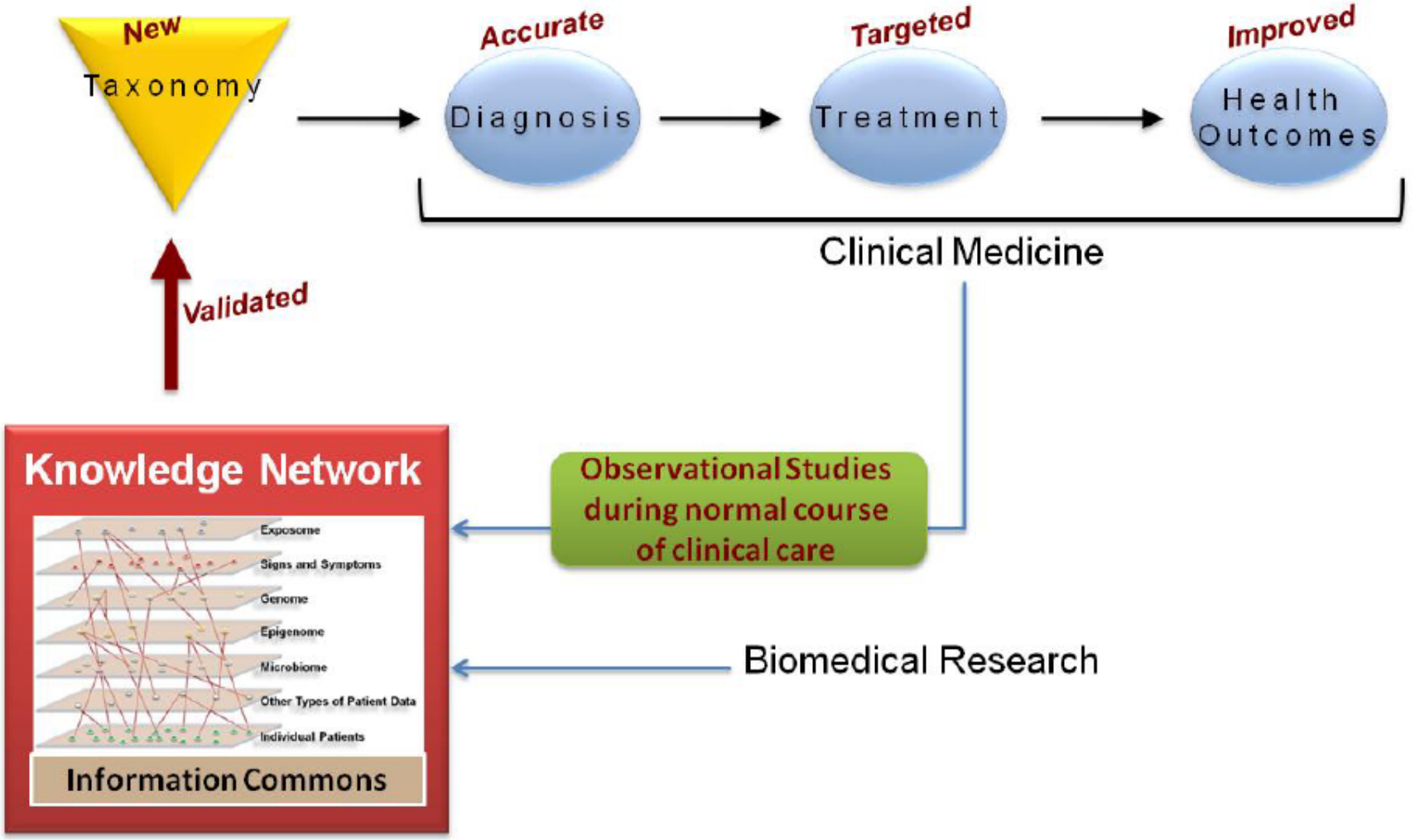


Figure 1-3: An individual-centric Information Commons, in combination with all extant biological knowledge, will inform a Knowledge Network of Disease, which will capture the exceedingly complex causal influences and pathogenic mechanisms that determine an individual's health. The Knowledge Network of Disease would allow researchers hypothesize new intralayer cluster and interlayer connections. Validated findings that emerge from the Knowledge Network, such as those which define new diseases or subtypes of diseases that are clinically relevant (e.g., which have implications for patient prognosis or therapy) would be incorporated into the New Taxonomy to improve diagnosis and treatment.

Biology Has Become a Data-Intensive Science

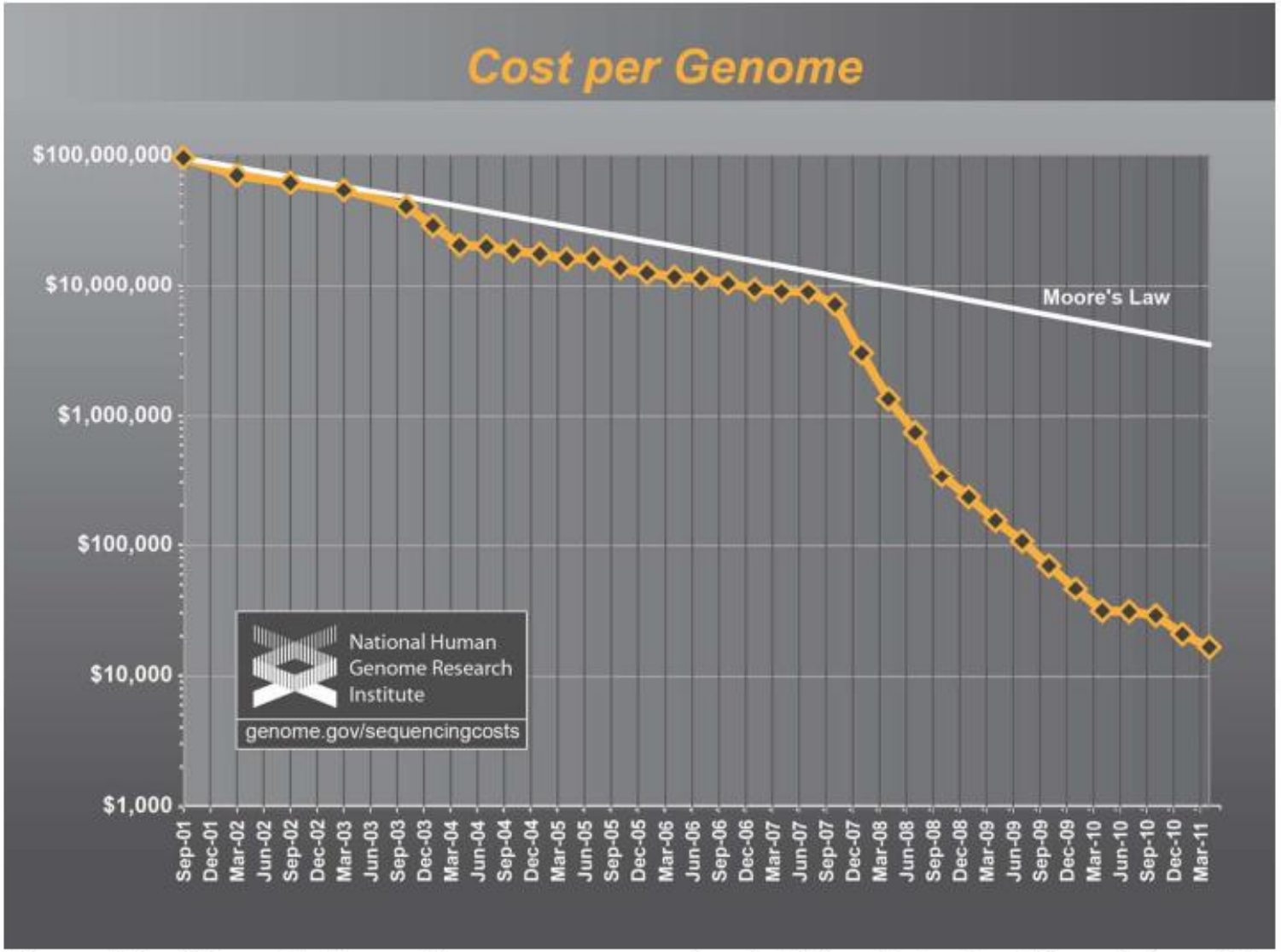


Figure 2-1: The cost of complete genome sequencing is falling faster than Moore's Law. The cost is still dropping rapidly, with a "$1000 genome" becoming a realistic target within a few years. Source: Wetterstrand 2011.

Cancer Research: Lung Cancer

at NTU Center of Genomic Medicine

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JANUARY 4, 2007 VOL. 356 NO. 1

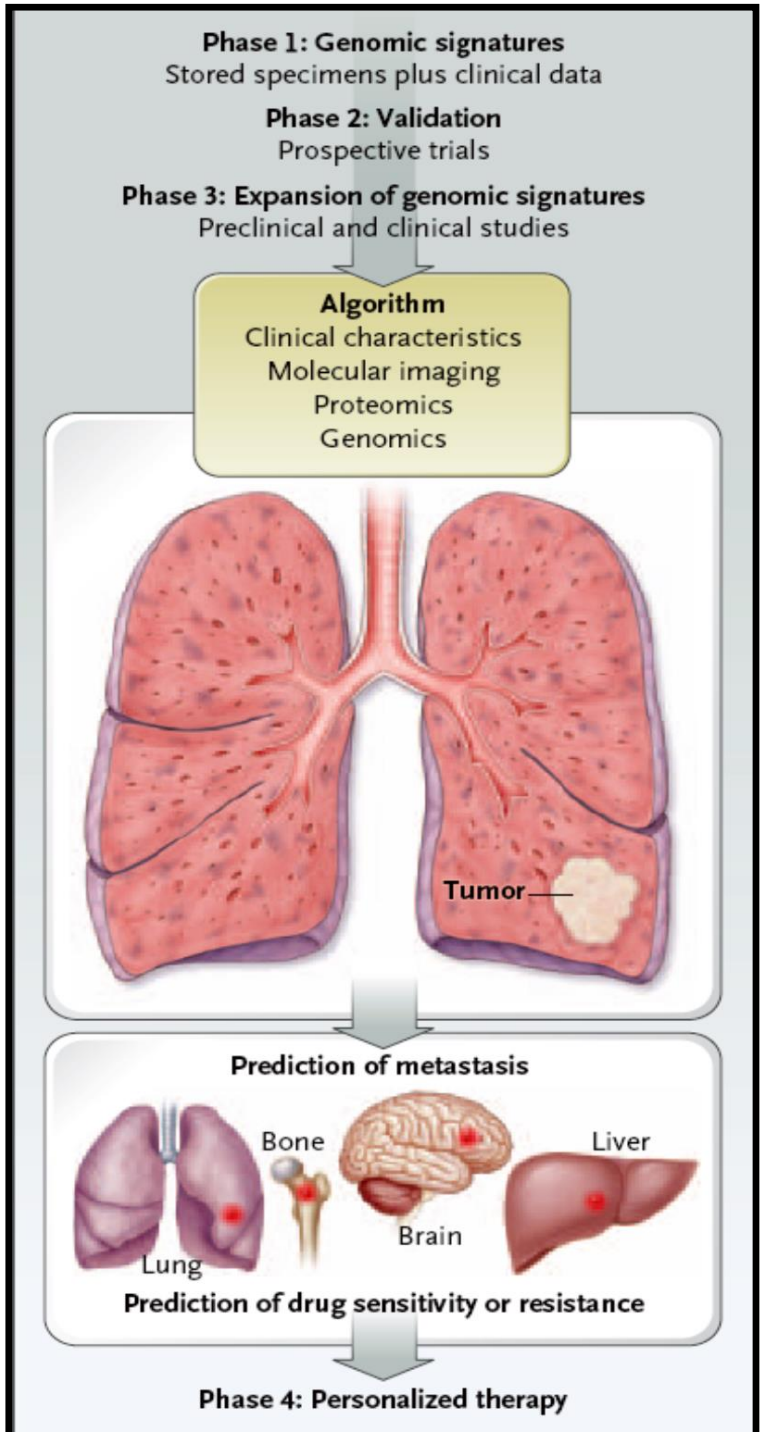
A Five-Gene Signature and Clinical Outcome in Non–Small-Cell Lung Cancer

Hsuan-Yu Chen, M.Sc., Sung-Liang Yu, Ph.D., Chun-Houh Chen, Ph.D., Gee-Chen Chang, M.D., Ph.D., Chih-Yi Chen, M.D., Ang Yuan, M.D., Ph.D., Chiou-Ling Cheng, M.Sc., Chien-Hsun Wang, M.Sc., Harn-Jing Terng, Ph.D., Shu-Fang Kao, M.Sc., Wing-Kai Chan, M.D., Han-Ni Li, M.Sc., Chun-Chi Liu, M.Sc., Sher Singh, Ph.D., Wei J. Chen, M.D., Sc.D., Jeremy J.W. Chen, Ph.D., and Pan-Chyr Yang, M.D., Ph.D.

EDITORIAL

Molecular Signatures of Lung Cancer — Toward Personalized Therapy

Roy S. Herbst, M.D., Ph.D., and Scott M. Lippman, M.D.



The Opportunity to Integrate Data-Intensive Biology with Medicine

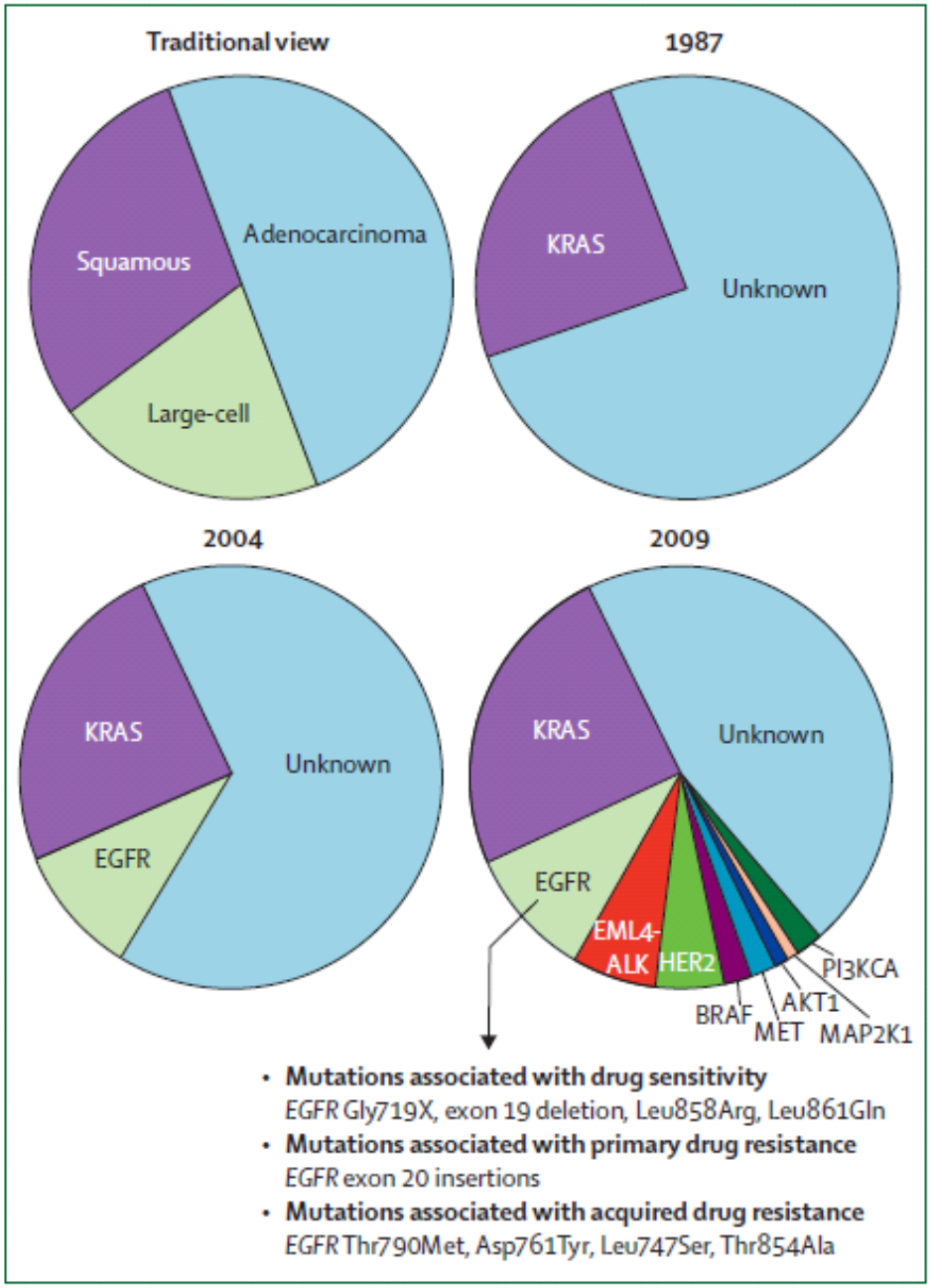
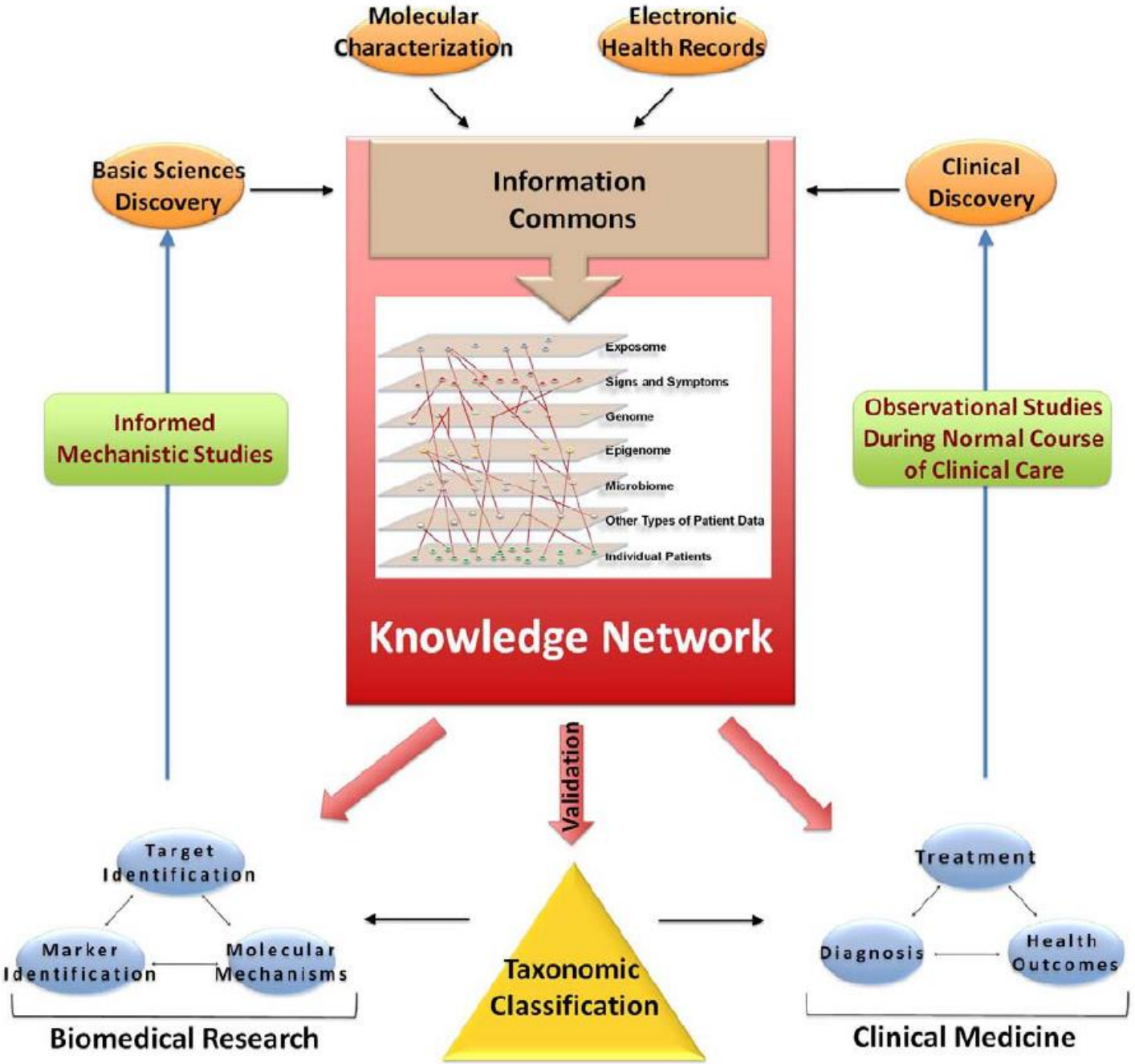


Figure 2-2: Knowledge of non-small-cell lung cancer has evolved substantially in recent decades.

The traditional characterization of lung cancers based on histology has been replaced over the past 20 years by classifications based on driver mutations. In 1987, this classification was rudimentary as only one driver mutation had been identified, KRAS. However, the sophistication of this system for molecular classification has improved with the advent of more genetic information and the identification of many more driver mutations. Similar approaches could improve the diagnosis, classification, and treatment of many other diseases.

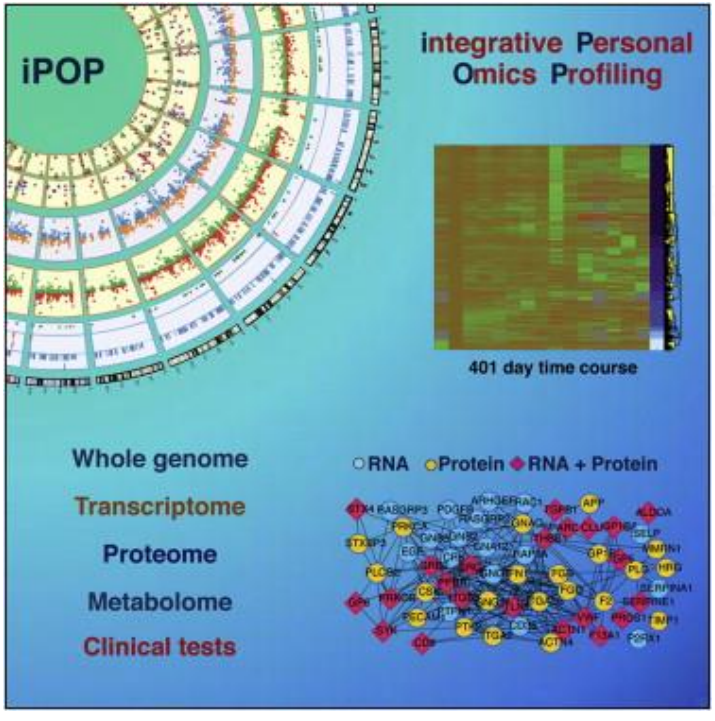
Source: Pao and Girard 2011

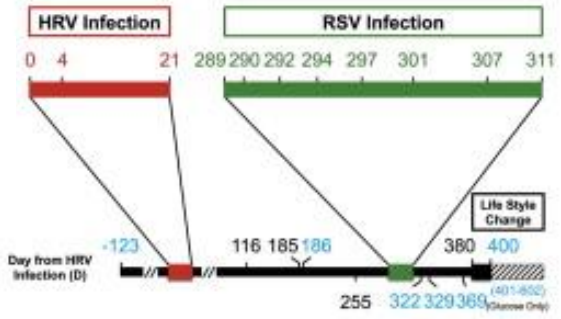
Figure 3-1: Building a Biomedical Knowledge Network for Basic Discovery and Medicine.

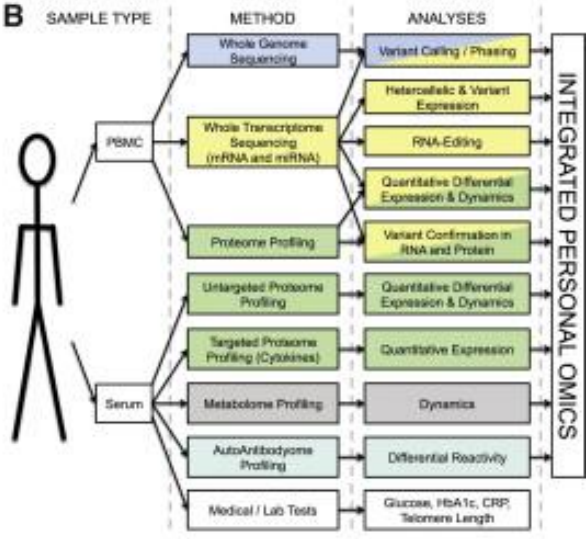


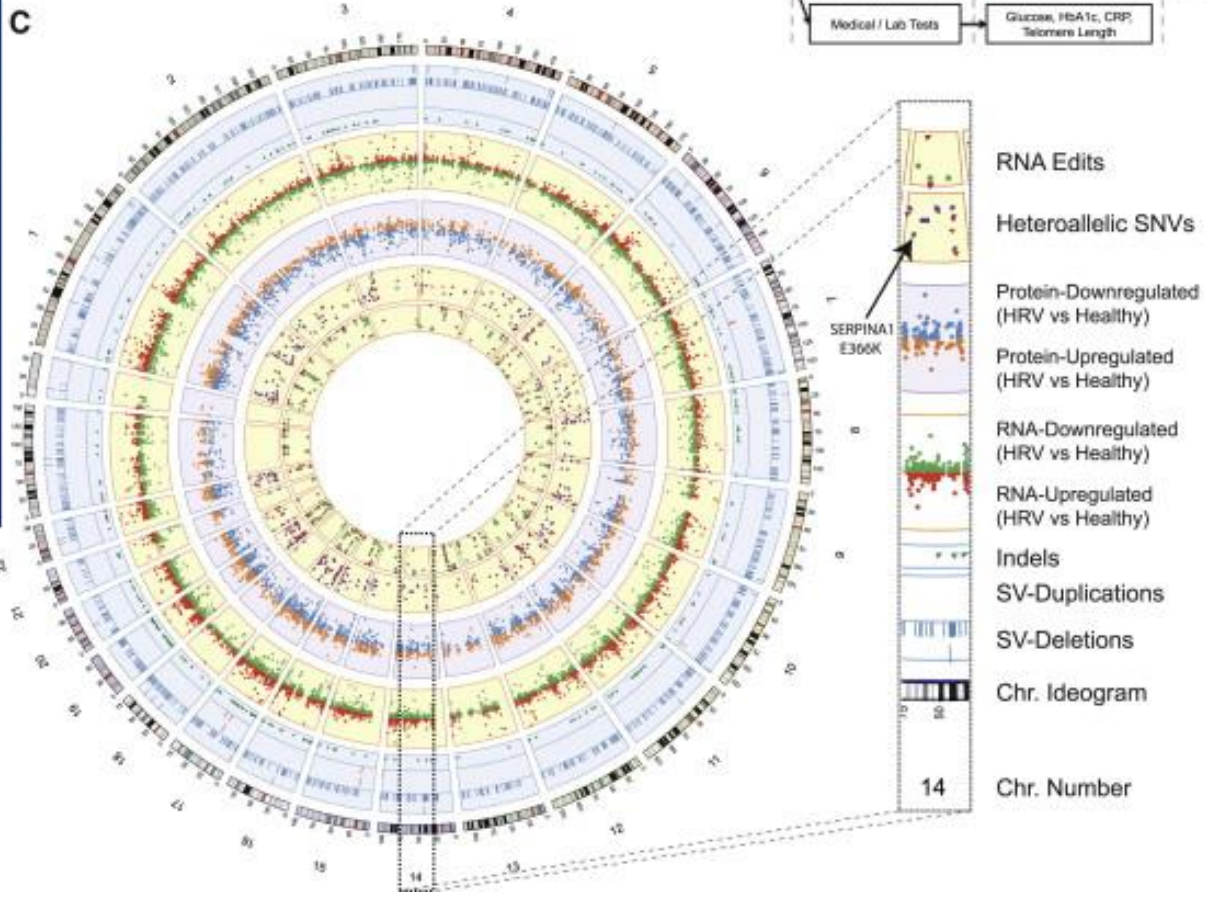
Cell *148*, 1293–1307, March 16, 2012

Personal Omics Profiling Reveals Dynamic Molecular and Medical Phenotypes









NATURE BIOTECHNOLOGY | NEWS AND VIEWS

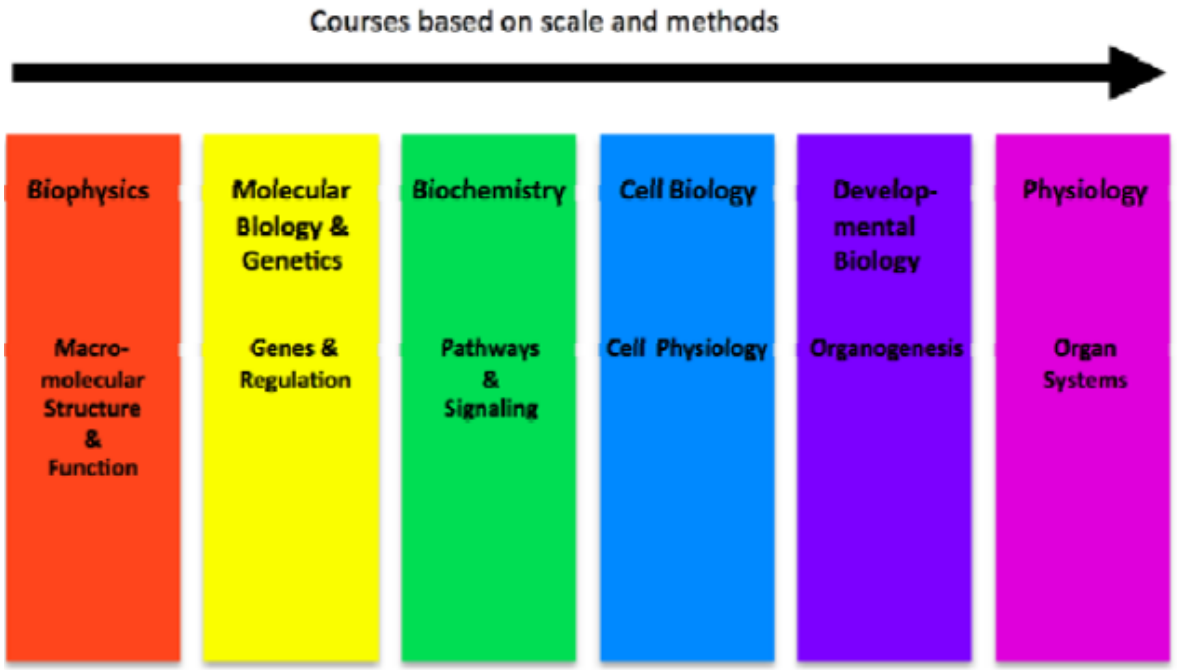
Omics gets personal

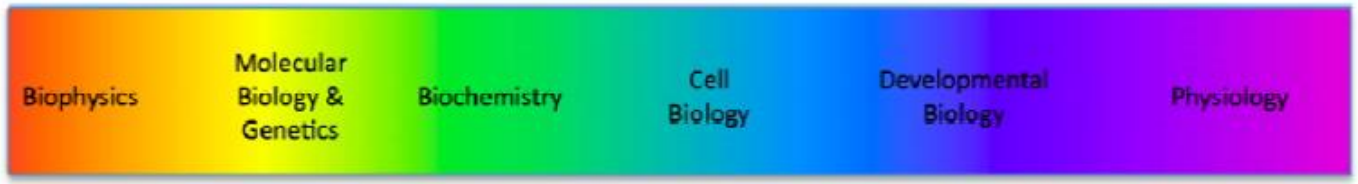
Laura DeFrancesco

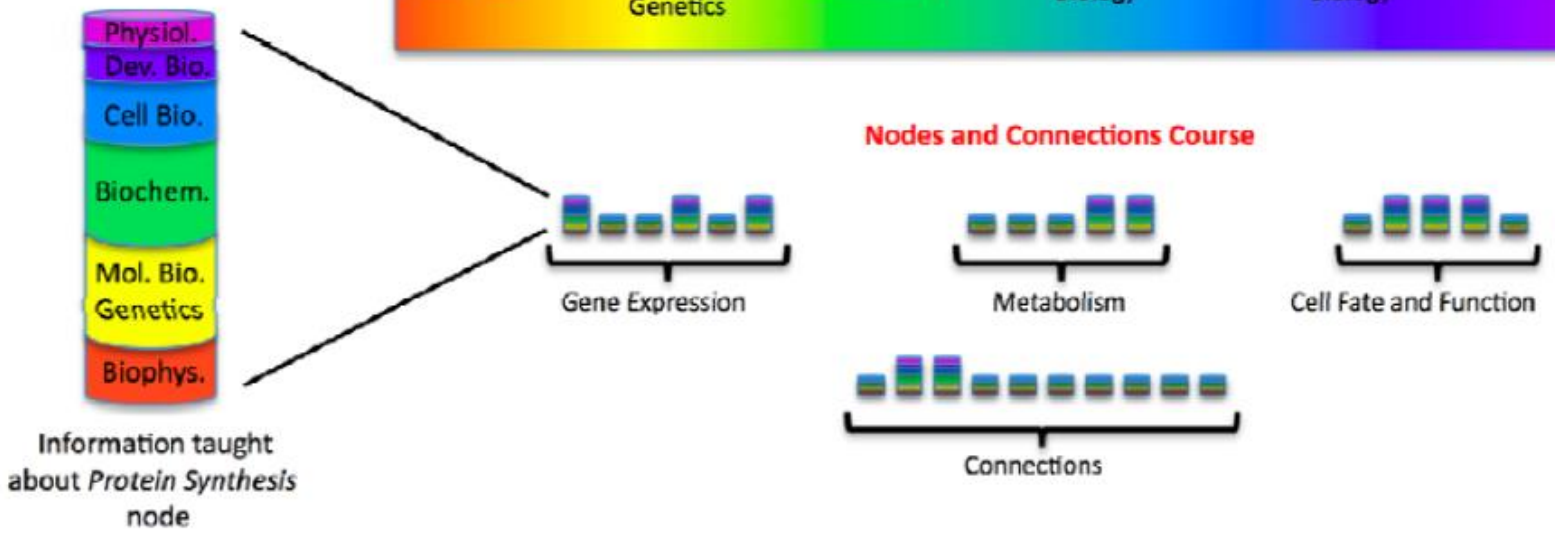
Nature Biotechnology **30**, 332 (2012)
Published online 10 April 2012

Figure 4-1 The current model of the first year curriculum in a typical biomedical graduate program (top) and an alternative model (bottom).

The multicolored bars in the nodes and connections course represent fundamental principles and essential facts about each key process integrated across scales.







臺大基因體醫學研究中心
NTU Center of Genomic Medicine

主持人：楊泮池 院長　陳明豐 院長　陳為堅 院長

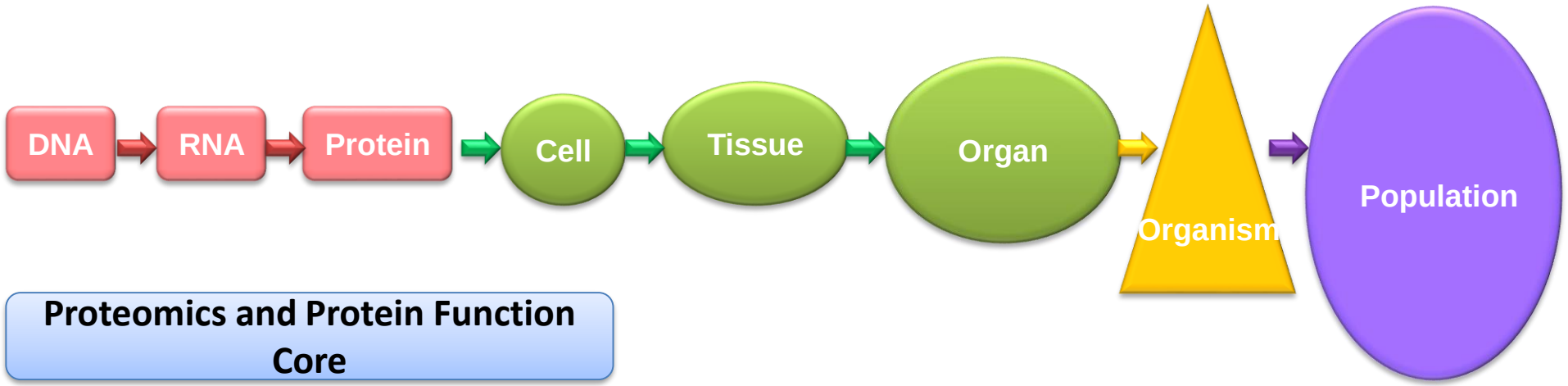
Genomic Medicine Cores
執行長：錢宗良教授

Cancer Division
楊泮池教授

Infectious Disease Division
陳培哲教授

Administration Office & Teaching Resource Center

- **Proteomics** 周綠蘋
- **Microbial Genomics** 陳培哲、王錦堂等
- **Microarray** 楊泮池、俞松良等
- **Tissue Bank** 林中梧
- **Transgenic & Knockout Mouse** 蘇銘嘉、林淑華
- **Genetic Epidemiology** 陳為堅、簡國龍等
- **Bioinformatics Biostatistics** 莊曜宇、蕭朱杏等
- **Stem Cell** 何弘能 錢宗良
- **Metabolomics** 郭明良、曾宇鳳、郭錦樺



Proteomics and Protein Function Core

Microarray Core

Microbial Genomics Core

Biomedical Molecular Imaging Core

Tissue Bank Core

Transgenic and Gene Knockout Mouse Core

Genetic Epidemiology Core

Bioinformatics and Biostatistics Core

Stem Cell Core

Metabolomics Core

Taiwan Biotech Take-off Action Plan

Basic R&D at Academic & Research Institutions → Pharmaceuticals/ Medical Devices Commercialization → Pharmaceuticals/ Medical Devices Clinical Trials → Product Reaches the Market

Industrialization R&D Center Builds on Upstream R&D (MOEA)

–Establishment of Biotech Pharmaceuticals Pre-clinical Core Platform
–Establishment of Medical Devices Rapid-Prototyping Center

Promotion of the SI²C to Provide an Integrated Service Platform (NSC)

– Provides legal, IPR, technical, and operations commercialization services
– Hardware resources for factory incubation: Hsinchu Biotech Park (medical devices), South Taiwan Science Industry Park (medical devices), National Biotechnology Research Park in Nangang (pharmaceuticals), experimental animal center

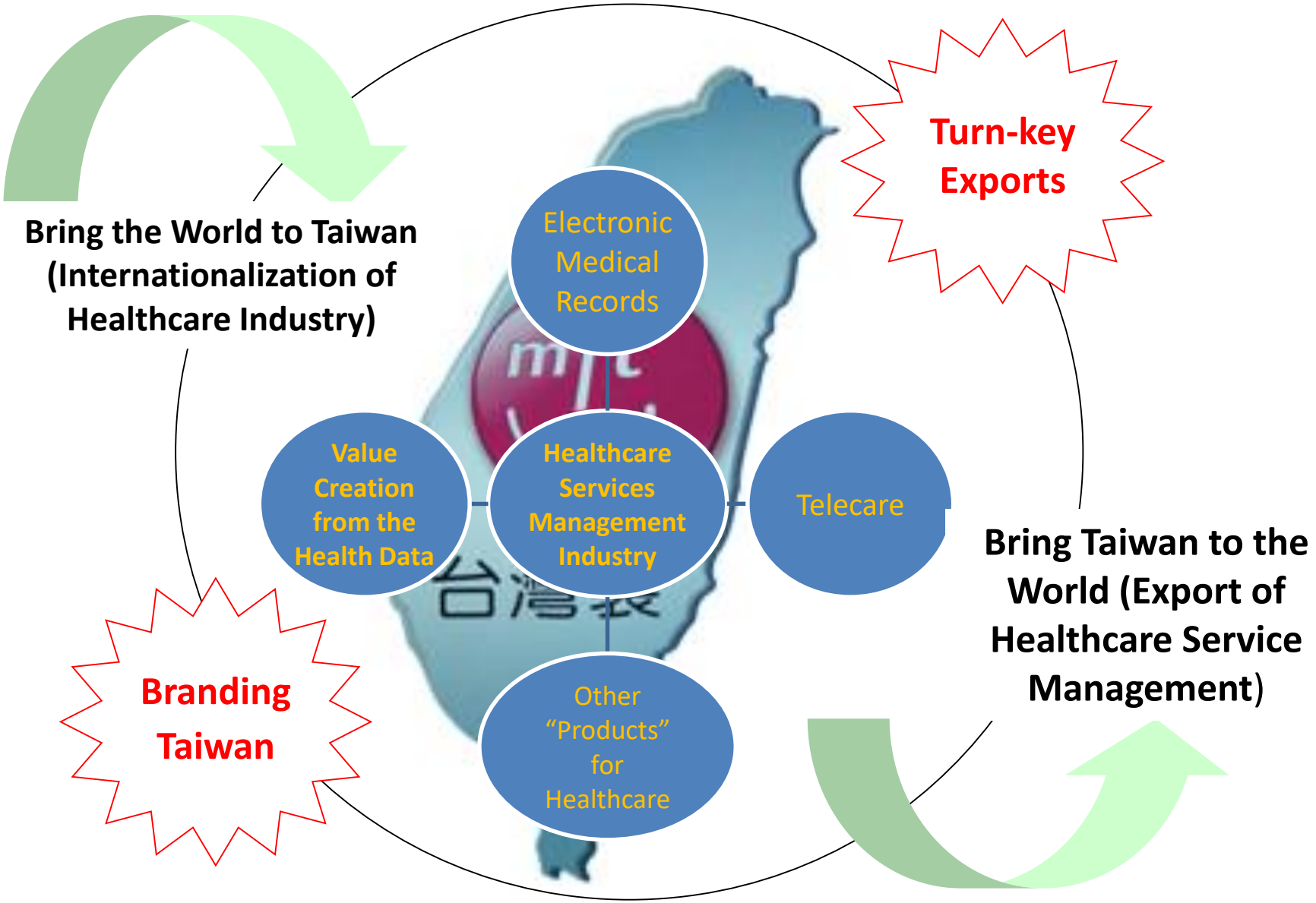
Foster International Harmonization (DOH)

– Establishment of an integrated and transparent evaluation process of medical products
– Greater efficiency in the evaluation process of medical products
– Promotion of regional regulatory harmonization
– Assistance in the industry's development

Establishment of BVC to Attract Private Funding matching with National Development Fund

–Capital will be introduced into the biotech industry, with the capital make-up of the BVC being on a 40:60 basis (government 40%, private sector 60%)

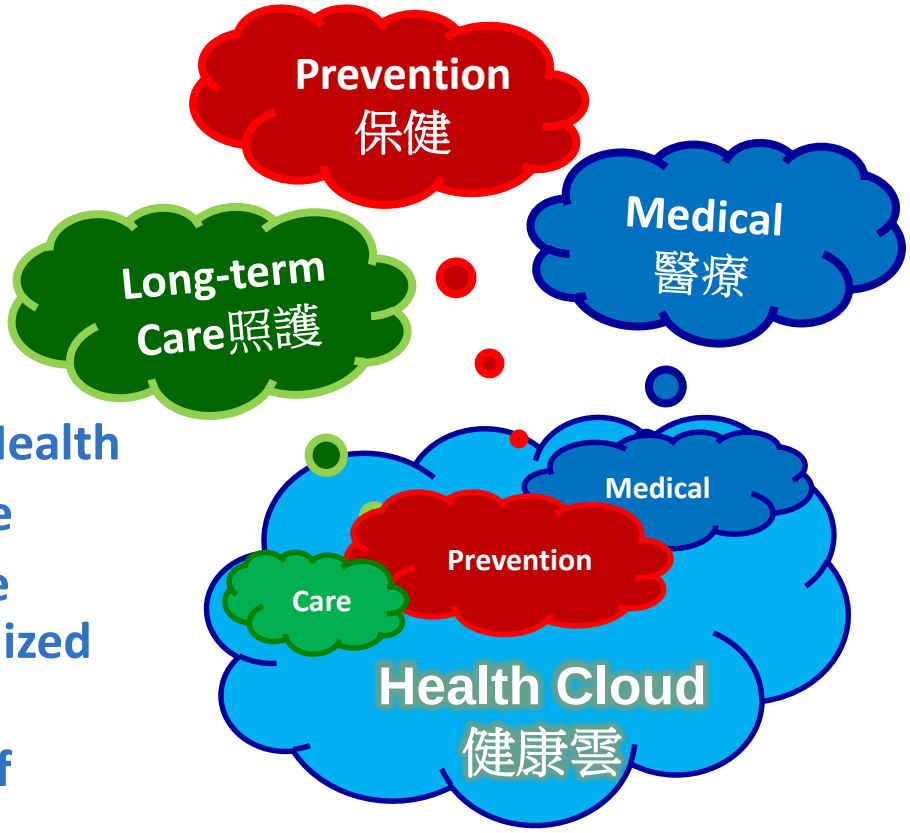
Taiwan Healthcare Management Service



Smart Living-Taiwan health cloud

Supporting Healthcare Management Services Industry and Promoting Smart Living

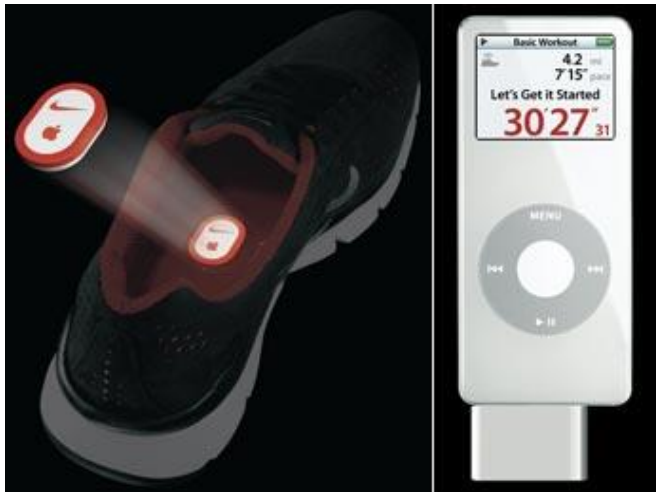
- ✓ ***Quality and Healthy Life***
  - Daily: Fitness at all time
  - Sick: Personalized Medicine
  - Elderly: Long-term Care
- ✓ ***ICT-enabled international model for Sustainable Health Cloud***
  - **Prevention Health Cloud** for Better Health
  - **Long-term Care Cloud** for Better Care
  - **Medical Cloud** for Efficient Resource Utilization (short term) and Personalized Medicine (long term)
  - **Health Cloud** for the Sustainability of Government Welfare and Industry Development



ICT-enabled Healthcare Applications

Personalized Preventive Health Care and Care Management

- Telecare
- Standards of technology and products
- Integration with social networking
  (gym, wellness, travel, sports and food industry）



Nike+ and iPhone, iPod

The **ingestible sensor** is technology you swallow. It's made entirely of ingredients found in food and activated upon ingestion. You take it alongside your medications, capturing the exact time of ingestion.

Your body powers the ingestible sensor. With no battery and no antenna, your stomach fluids complete the power source and your body transmits the unique number generated by the sensor.

The **patch**, body-worn and disposable, captures and relays your body's physiologic responses and behaviors. It receives information from the ingestible sensor, detects heart rate, activity, and rest, and sends information to your mobile device.

Using a Bluetooth-enabled device – like the one you already carry in your pocket or purse – you can access secure **applications** that display your data in context and support care in a variety of different ways.

Powered by you

***You** make informed choices about your health, connecting and sharing information with those who support you.*

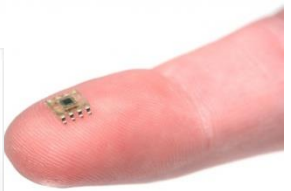
proteus®
DIGITAL HEALTH

Financial investors:

NOVARTIS

Otsuka

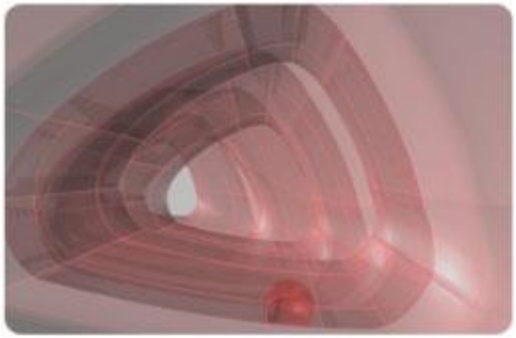
PHOTO: PROTEUS DIGITAL HEALTH



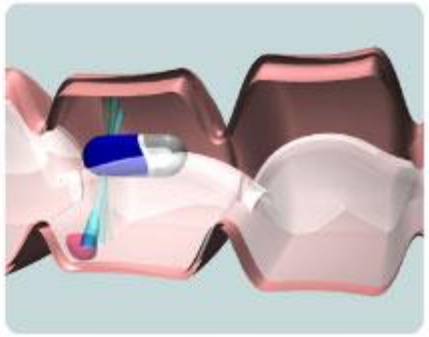
Check Cap *A New Era in Colon Cancer Screening*

X-ray Radar Technology

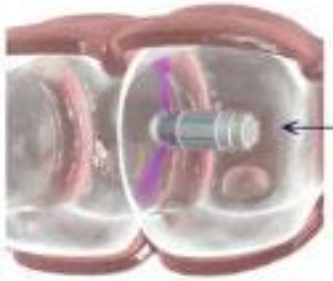
1 Check-Cap = 1 Chest X-ray = 1/300 CTC



3-D reconsructed image of all internal surfaces



"Sees through" colon content



wrist-worn receiver

belt-worn receiver

Oscan: a Smartphone Based Screening Device for Oral Cancer

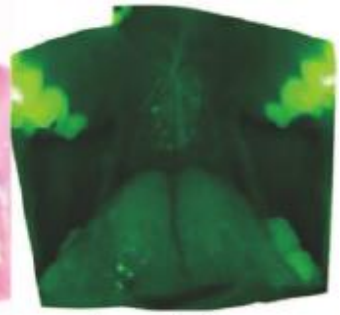
Supported by:

Prakash Lab, Stanford University

Vodafone Americas Foundation Wireless Innovation Project™ FINALIST

mHealth Alliance

The OScan team at Stanford University has developed an affordable screening tool that brings standardized, multi-modal imaging of the oral cavity into the hands of rural health workers around the world, allowing individuals to conduct screenings for oral lesions. This inexpensive device mounts on a conventional camera phone and allows for data to be instantly transmitted to dentists and oral surgeons.



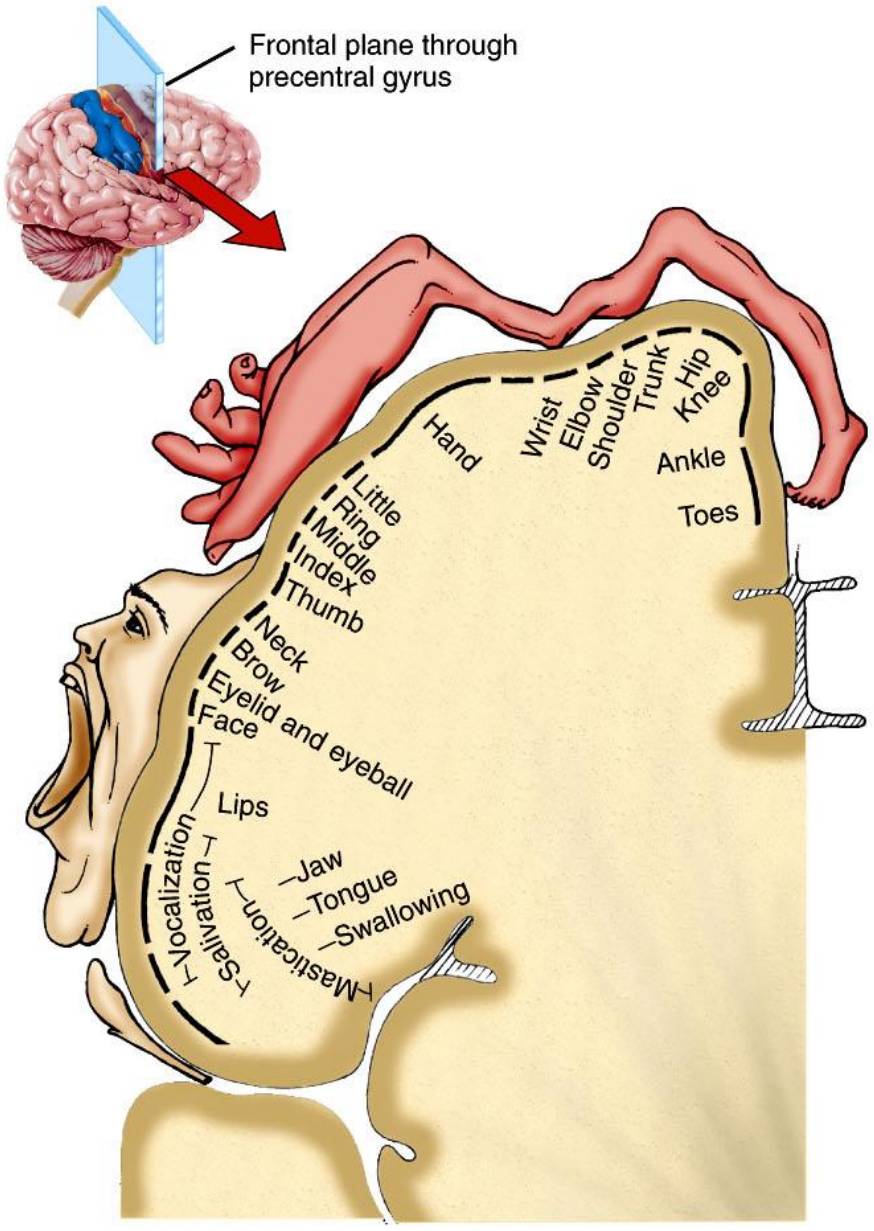
A quick scan allows a health worker to wirelessly send data to a remote location for assessment.

Brain / machine interface

Product name: (none)

Developers: University of Pittsburg and Massachusetts General Hospital

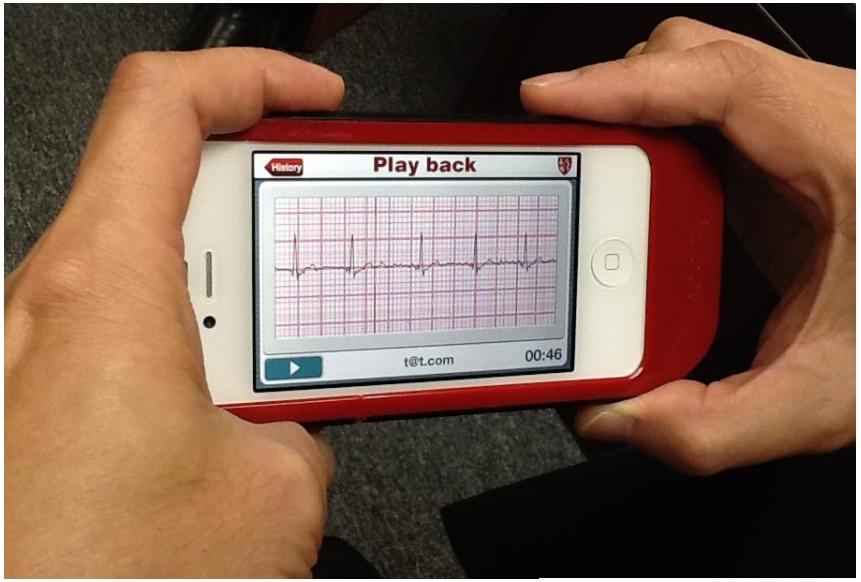
This sophisticated prosthetic, also known as a brain-machine interface, or BMI, allowed a paralyzed patient to move a robotic arm. Surgeons implanted two grids of hair-thin electrodes in the patient's brain to capture signals from regions involved in planning hand and arm movements; a computer translated those signals into commands and physical movement. Earlier in the year, two tetraplegic patients grasped and manipulated objects using a different BMI.



(b) Frontal section of primary motor area in right cerebral hemisphere

Example — A Great Helper

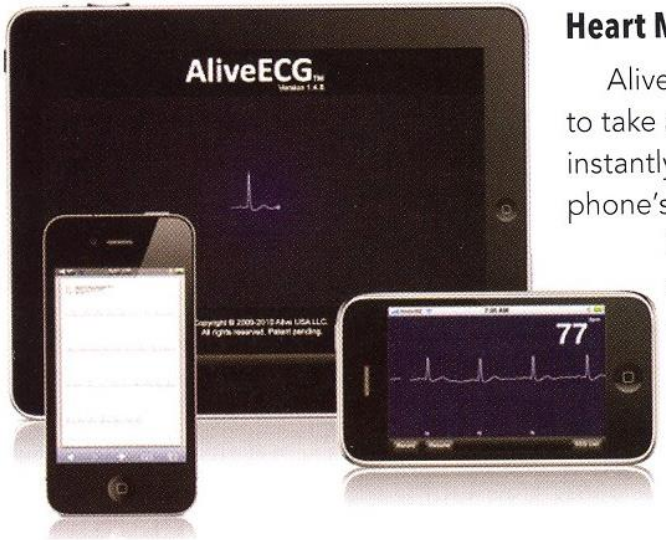
Ambient Assisted Living



- ICT Applications
- Care for Elderly Living Alone
  - ✓ Remote Physiological Signal Monitoring
  - ✓ Reminders to Take Medicine
  - ✓ Risk Prediction

NeuroSky
神 念 科 技

Apparatus for iPhone APP
Personalized ECG

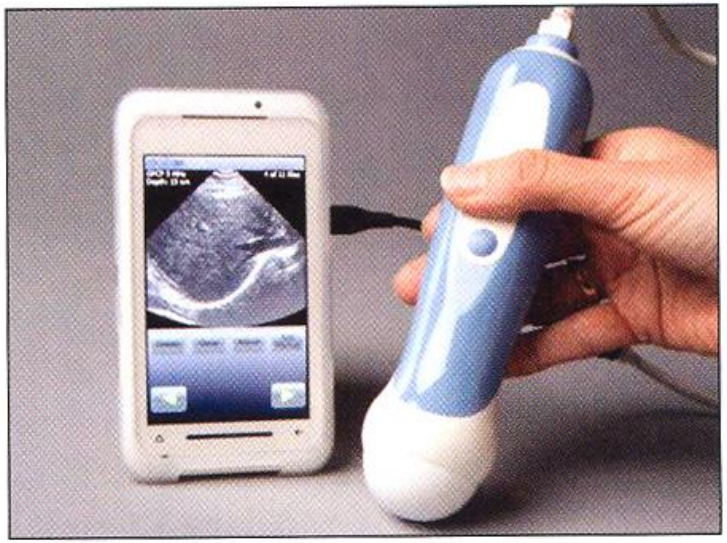


Heart Monitor

AliveCor's Heart Monitor snaps onto an iPhone to take and record a person's heart rate and rhythm instantly. It can display an electrocardiogram on the phone's screen, store it in memory, or transmit it wirelessly. The device has received FDA clearance and is available starting in 2013 for $199. *www.alivecor.com*

Glucose Monitor

Sanofi's iBGStar blood glucose monitor (below) can be used on its own or connected directly to an iPhone to display, manage, or share a person's blood glucose level. A pinprick of blood is applied to a test strip and inserted into the device for analysis. Cleared by the FDA in December 2011, the iBGStar sells for anywhere from $50 to $75 plus the cost of test strips, which are covered by most insurers.
www.ibgstar.us



Portable Ultrasound

MobiSante's MobiUS SP1 (above) is a hand-held ultrasound imaging system that plugs into a smartphone to generate and display the image, making it a portable point-of-care diagnostic tool. The device, which received FDA clearance in early 2011, is sold only to medical professionals and costs about $7,500.
www.mobisante.com

Ambient Assisted Living – IT solutions for active & healthy aging

Using modern ICT solutions can contribute to enable elderly people to stay in their familiar surrounding for a longer time and to increase quality and efficiency of care related services.

What is Ambient Assisted Living?

Ambient assisted living (AAL) is the use of information and communication technologies (ICT) in a person's daily living and working environment to enable individuals to stay active longer, remain socially connected and live independently into old age.

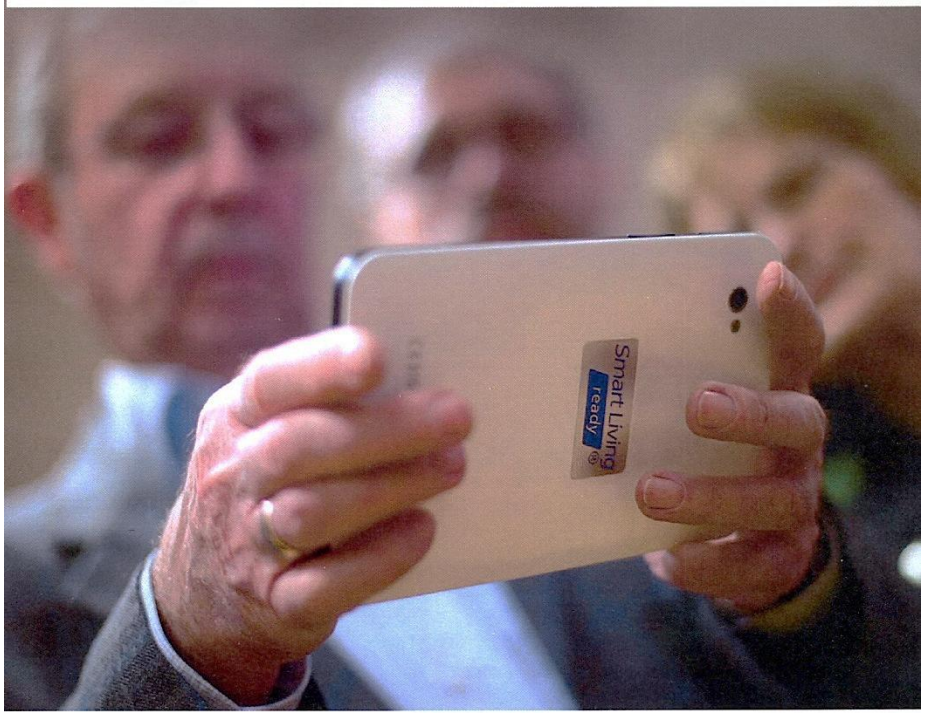
ICT for independent living can be as simple as an alarm button or a reminder to take medication. It may also be very sophisticated such as a system that can predict when an older person is at risk of falling (a major cause of loss of personal independence). The box "Technology for users" gives examples of ICT for independent living. Whether simple or sophisticated, the philosophy of ambient intelligence is that the technology is at the service of the user, not the other way around.

As part of its overall action plan, Ageing Well in the Information Society[3], the Commission is supporting a new Ambient Assisted Living (AAL) joint research programme of Member States. Since 2008, this programme is joining together national research activities in the area and is complementing EU-funded activities within the seventh European Research Framework Programme (FP7)[4].

Between 2008 and 2013, the EU and Member States, and the private sector will have invested more than €1 billion in research and innovation for ageing well: some €600M in the Ambient Assisted Living Joint Programme, an expected €400M in the EU's latest research framework programme and so far more than €50M on large scale pilot projects in the EU's ICT Policy Support Programme[5].

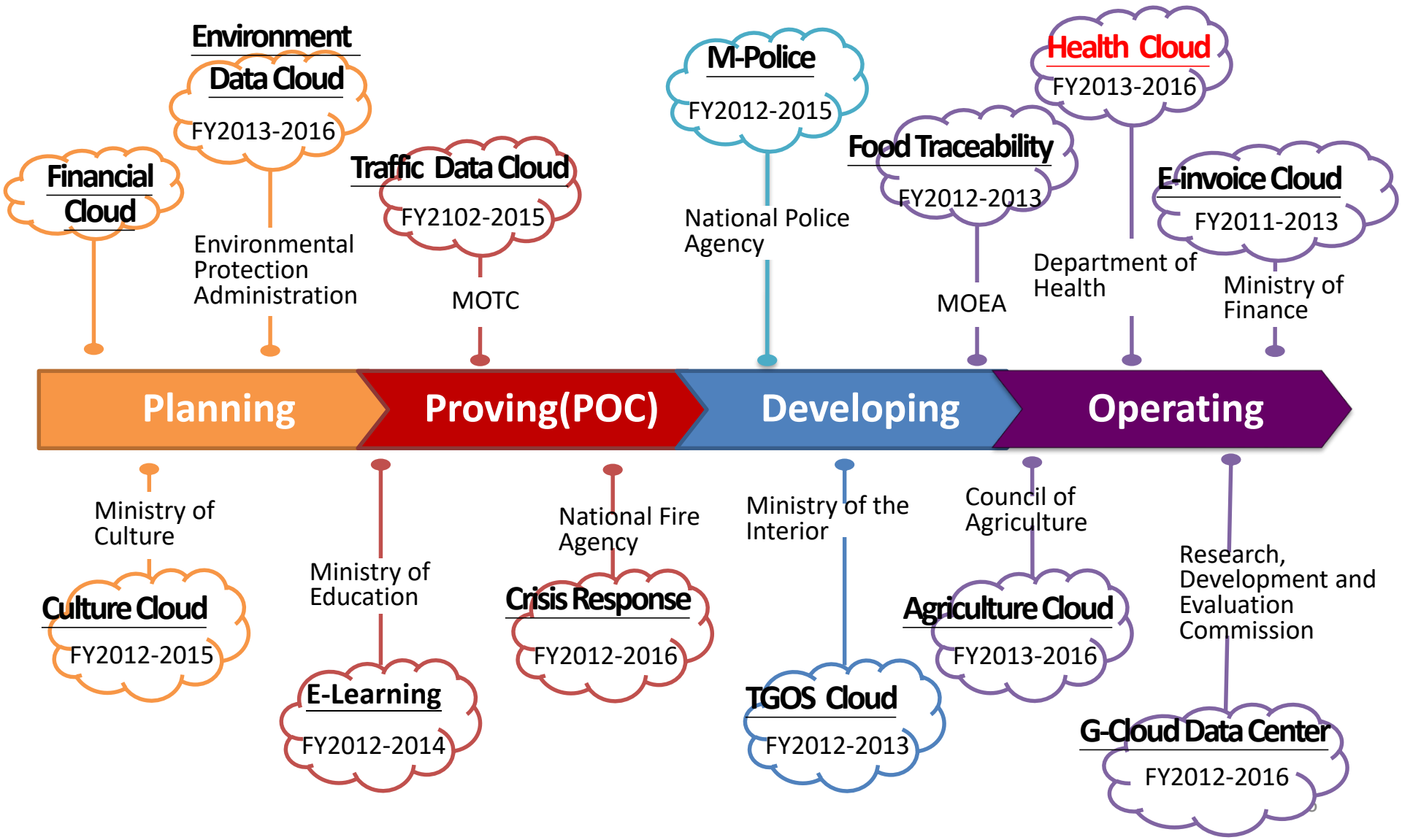
Bundesministerium
für Bildung
und Forschung

DIE DEMOGRAFISCHE CHANCE



Smart Living for Seniors

G-Cloud Status toward Smart Living



Summary

- **Precision Medicine (Personalized Medicine):**

1. **A New Taxonomy will lead to better health care.**
2. **The time is right to modernize disease taxonomy.**
3. **New models for population-based research will enable development of the Knowledge Network and New Taxonomy.**

- **Digital Health: Outlook for Smart Living**

1. **Inexpensive, ubiquitous computing is revolutionizing the delivery of Healthcare.**
2. **We have a real opportunity to shift from a sickness model to a wellness model via the digital health.**
3. **Digital Health is creating new means of access of delivery of care, moving the patient to the center of the healthcare world, and providing more personalized, preventive, and cost effective care.**

Thank you for your attention