

Biomedical and Healthcare Informatics

2003 Fall
Seoul National University
College of Medicine

Biomedical & Healthcare Informatics

- *Administrivia*
- *What's medical Informatics?*
- *The discipline*
- *Who are the drivers?*
- *Cybernetics perspective*
- *Real world applications*
- *Emergence of New Medicine*

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Informatics

- *Russian Translation: 1967*
 - ✓ *Informatika, Informatikii (1967)*
 - ✓ *Medical Informatics (formerly medical information science, 1974)*
 - ✓ *Bionformatics (80's)*
- *To include both*
 - ✓ *Information (what is processed)*
 - ✓ *Computers (how it was processed)*
- *To encompass all the aspects of*
 - ✓ *Science*
 - ✓ *Technology*
 - ✓ *Engineering*

Administrivia

09/17, 1:00	김주한	의료정보학의 소개
09/24, 1:00	최진욱	의학 문헌정보 및 임상정보 검색
10/01, 9:00	김주한	의학자료 및 의학지식의 해석과 판단
10/08, 1:00	최진욱	의료 정보 시스템과 데이터베이스
10/22, 1:00	김주한	의학적 의사결정 과학
10/29, 1:00	최진욱	의학 용어, 분류체계, 표준화, 통신
11/05, 9:00	김주한	전자 의무기록 시스템
11/07	최진욱	의사결정지원시스템
11/12, 9:00	최진욱	병원정보시스템
11/14	최진욱	컴퓨터 시뮬레이션(의학영상과 신호처리)
11/19, 9:00	김주한	원격 의학 / 컴퓨터기반 의학 교육
11/26, 1:00	김주한	의료정보와 의료법, 의료윤리, 환자의 비밀보안

교재: 보건의료정보학(헌문사), 임상의료정보학입문(교려의학)

<http://informatics.snubi.org/2003Fall/>

What is medical informatics?

Simplistic definition: Computer applications in medical care

Complicated definition: Medical Informatics is a developing body of knowledge and a set of techniques concerning the organizational management of information in support of medical research, education, and patient care... Medical Informatics combines medical science with several technologies and disciplines in the information and computer sciences and provides methodologies by which these can contribute to better use of the medical knowledge base and ultimately to better medical care.

*Definition by Association of American Medical Colleges (AAMC 1986)
Sited by Hirpsack and Sideli (<http://cpmc.columbia.edu/edu/textbook/>)*

Medical Informatics Definition

Medical informatics is the rapidly developing scientific field that deals with **resources, devices and formalized methods** for optimizing the **storage, retrieval and management** of biomedical information for **problem solving and decision making**.

[Edward Shortliffe, M.D., Ph.D.
What is medical informatics? 1995.]

Fields of Medical Informatics



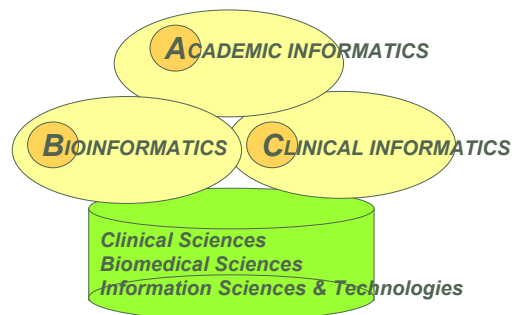
Medical Informatics Definition

Medical informatics is the rapidly developing scientific field that deals with **resources, devices, and formalized methods** for optimizing the **storage, retrieval and management** of biomedical information for **problem solving, decision making, and biomedical discovery and understanding**.

[2001.]

"Biomedical and Healthcare Informatics"

Cornerstones of Medical Informatics



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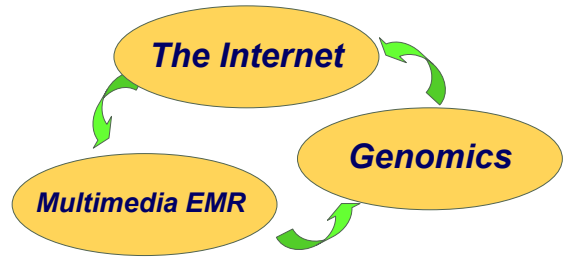
ACADEMIC INFORMATICS

- **Medical Data & Semiology**
data structure / abstraction / representation / formalism
- **Medical Ontology & Standards**
terminology / vocabulary / language / classification
- **Medical Databases**
documents / literature / factual / knowledge
- **Medical Reasoning & Decision Making**
decision science / uncertainty decision making / decision analysis / probabilistic reasoning
- **Knowledge Engineering**
data mining / warehousing / amoebizing
- **Artificial Intelligence in Medicine**
machine learning, supervised and unsupervised

CLINICAL INFORMATICS

- **Computer-based Patient Record**
patient-centered information system
- **Clinical Multimedia**
signal processing / image analysis / multimedia
- **Clinical Information System**
"hospital information system is dead"
- **Clinical Decision Support / Expert system**
- **System Evaluation / Quality Control / Medical Activity Analysis**
- **Global Health Information Server**
- **Healthcare Delivery Networking / Telemedicine**
- **Computer-aided Learning / Medical Education**
- **Security / Privacy / Confidentiality**
- **Ethical-Legal Aspects of Informatics**

Transforming the cancer center

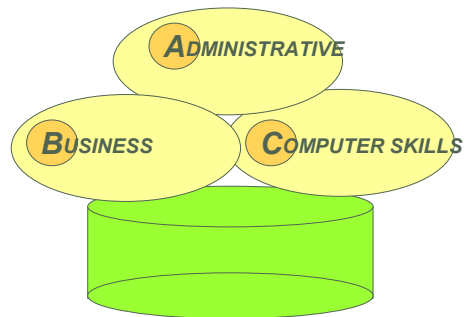


*Integration of cancer protocols
Standardized biomedical vocabularies for data representation*

BIOINFORMATICS

- **Computational Biology, Biocomputing (cf. biological computing)**
- **Bio-molecular Databases**
amino acid sequences & motifs / nucleotide sequence / 3-d structures / orthologues and paralogues / pathways
- **Structural (Classical) Bioinformatics**
sequence alignment / phylogenetic analysis / prediction of structures and functions / genetic network analysis / metabolic pathway reconstruction / signal pathway analysis
- **Functional Genomics**
massive parallel data acquisition (DNA microarray, 2-D gel electrophoresis, protein chips, flux analysis) / pharmacogenomics / clinical genomics /
- **Systems Biology?**

Connerstones???



ACADEMIC INFORMATICS

- **Knowledge Engineering**
data mining / warehousing / amoebizing
- **Artificial Intelligence in Medicine**
machine learning, supervised and unsupervised

BIOINFORMATICS

- **Functional Genomics**
massive parallel data acquisition (DNA microarray, 2-D gel electrophoresis, protein chips, flux analysis) / pharmacogenomics / clinical genomics

CLINICAL INFORMATICS

- **Computer-based Patient Record**
patient-centered information system
- **Security / Privacy / Confidentiality**



Shanahan

"Our integrated approach to medicine skillfully combines an array of holistic alternative treatments with a sophisticated computerized billing services"

Disciplinary Basis

Medical informatics touches on all basic and applied fields in biomedical science

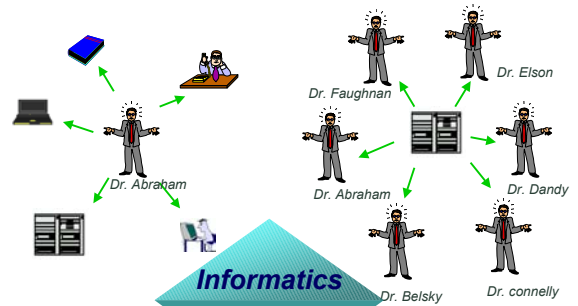
Closely tied to:

- information technologies
- computing and communications
- information science
- cognitive / behavioral sciences

Knowledge Management Paradigm Shift

Clinician-directed

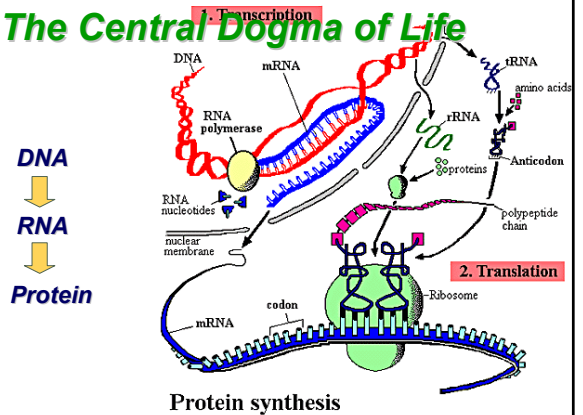
Resource-directed



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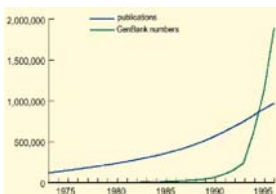
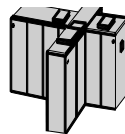
The Central Dogma of Life



Who are the drivers?

Clinical Information

- Clinical data explosion
- Genomic data explosion
- Databases, algorithms, and HPC
- The Internet



- Sequences
- Linkage map
- Physical map
- Polys/gene (1-2/kb?)
- Expression profiles
- Structural info.
- How would you begin to estimate?

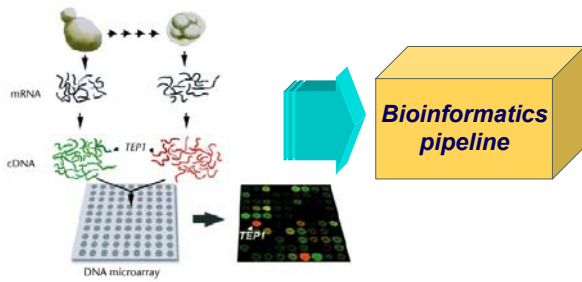
Growth of the unknown

Organism	# Genes	% Unknown function
S cerevisiae	6034	49%
E coli	4288	38%
B subtilis	4000	42%
Synechocystis sp.	3168	56%
A fulgidus	2471	52%
H influenzae	1740	42%
M thermoautotrophicum	1855	56%
H pylori	1590	43%
M jannaschii	1692	54%
B burgdorferi	863	42%
M pneumoniae	677	51%
M genitalium	470	31%
Total	28848	47%

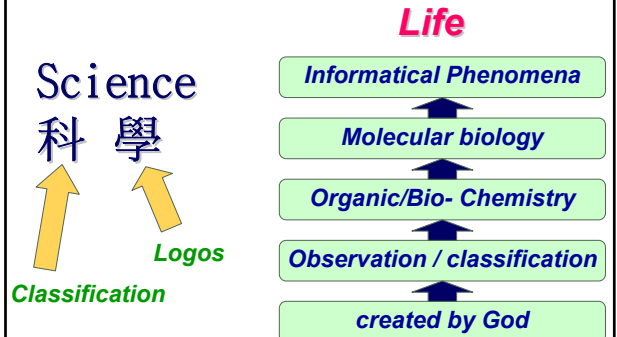
Science 277: 1433 (1997)

Slide courtesy of G. Church

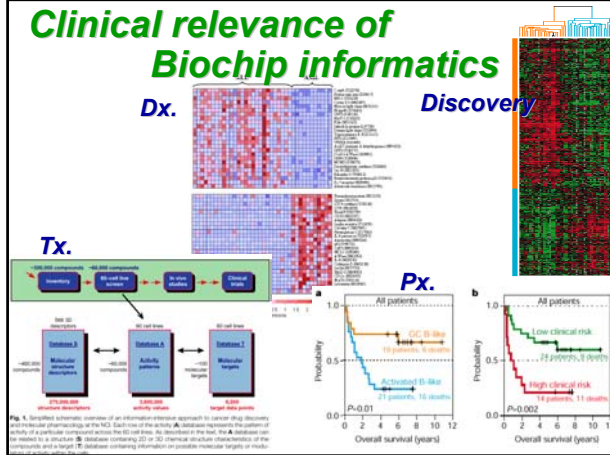
Biochip basics



Isn't it just a tool?

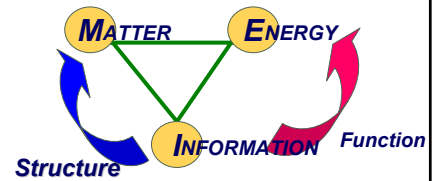
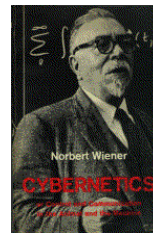


Clinical relevance of Biochip informatics



Cybernetics perspective

Theory of communication and control between biological systems and machines



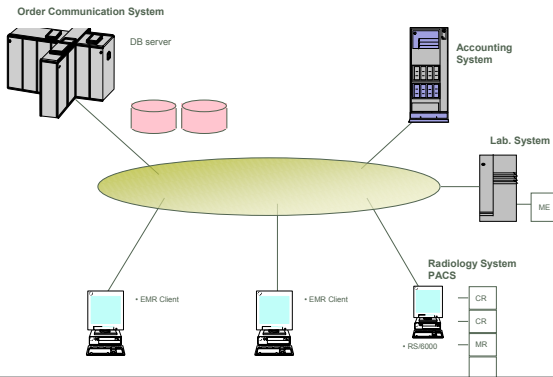
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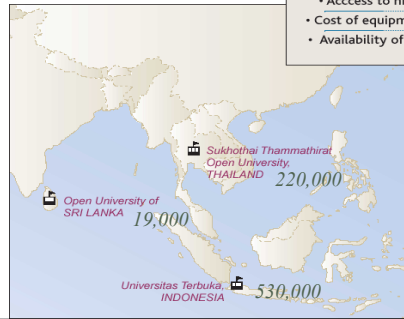
Hospital Information System



Asian mega-universities are providing rural populations with an opportunity for postsecondary instruction. But most have been unable to deliver the type of scientific and technical training that is vital to developing nations

BARRIERS TO ONLINE SCIENCE EDUCATION IN ASIA

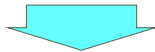
- Access to high-quality labs
- Cost of equipment and facilities
- Availability of good instructors



Clinical Information System

Intelligent Integration of

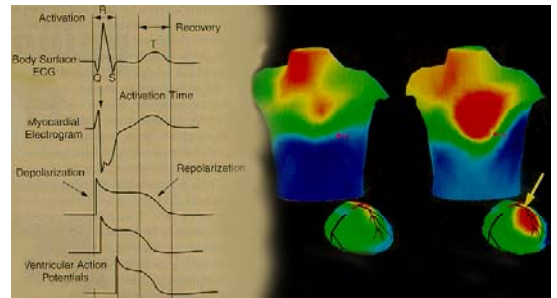
- OCS - LIS - RIS - PACS - EMR
- Departmental Information Systems
- Library / Factual Information Systems
- Research Database



Hospital Information System is Dead!

Signal and image processing

Computer-Based Reading of ECG (early 1960's)



Modified from: Brooks and MacLeod, IEE Signal Proc 14: 24-42, 1997

MIT Offers World-Class Courses, for Free

Major universities may hesitate to teach undergraduate science online, but they seem ready to cash in on continuing education. A growing number of schools—including Columbia, Duke, Stanford, and New York University—hope to profit from online courses, typically targeted to working adults. Businesses such as the University of Phoenix Online and eCollege also contribute to the estimated \$4 billion e-learning market. Now, in the midst of all this enriching education, one school has announced plans to teach the world—for free.

This spring, the Massachusetts Institute of Technology (MIT) announced that it would post lecture notes, course outlines, or other teaching material for virtually every class offered, free of charge. MIT's so-called "OpenCourseWare" Web site could debut within 2 years, including content from 500 classes. Within a decade, MIT officials say, over 2000 courses could be posted online. The effort is the first of its kind for a university.

"There's a sense that universities are losing their direction by getting too involved in e-commerce," says Harold Abelson, an MIT computer scientist helping to develop OpenCourseWare. "The Web was invented for the sharing of scientific research, and this initiative is really about sharing. MIT plans to use the Internet as a way to disseminate the stuff from which our courses are made."

OpenCourseWare is the brainchild of an MIT council on education technology that wanted to use the Net to enhance teaching. Abelson, part of the council, compares the future Web site to a monograph series or expanded course catalog. The site will not offer actual courses or class credit; instead, it will provide raw information for anyone with an urge to click and learn. "Undergraduate education really draws on a collaborative enterprise, and our hope is that students and faculty can learn from each other," Abelson says. Perhaps other schools will follow suit, he adds, building a new way to communicate science and teaching.

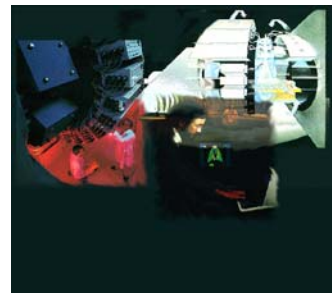
"That wouldn't surprise Frank Mayadas, a program director at the Sloan Consortium. "Over time, we'll see significant progress," Mayadas says. "There's a lot of room to grow."

-K.B.

Education

X-ray computed tomography

Dynamic Spatial Reconstructor (1979-1996)



Artificial intelligence in Medicine

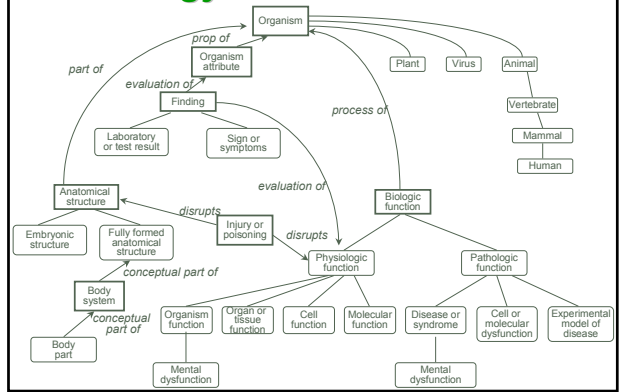
Informatics: knowledge about knowledge

The acts of the mind wherein it exerts its power over simple ideas, are chiefly these three: 1. **Combining several simple ideas** into one compound one, and all **complex ideas** are made. 2. The second is **bringing two ideas**, whether simple or complex, together, and setting them by one another so as to take a view of them at once, without uniting them into one, by which it gets all its ideas of **relations**. 3. The third is **separating them from all other ideas** that accompany them in their real existence: this is called **abstraction**, and thus all its general ideas are made.

John Locke, *An Essay Concerning Human Understanding* (1690)

Ontology

Semantic Network : UMLS



Data, Data Structure, Abstraction, Representation

• Binding



• Combining



• Relating



• Abstracting

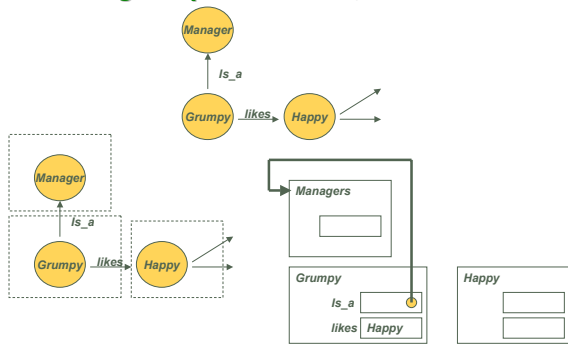


Electronic Medical Record

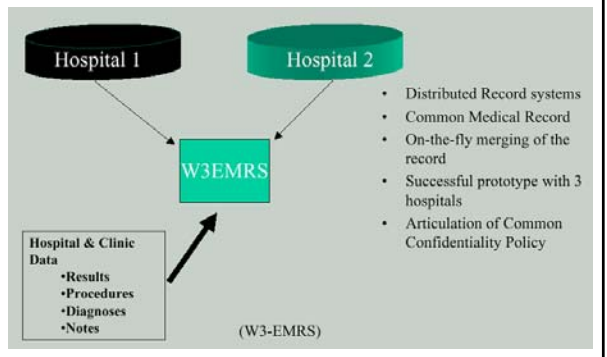
PsyBase 1.0

The screenshot shows the PsyBase 1.0 interface. At the top, it says 'PSYBASE 1.0 Report Generator' and '09:00:21 01/10/98'. Below this is a patient record with fields for name, age, sex, and date of birth. A table of symptoms is visible, with columns for 'Symptom', 'Onset', 'Duration', and 'Severity'. The symptoms listed include 'SAD pain', 'Depression/d/t trauma', 'Alcohol depression', 'Schizophrenia', 'Schizophrenia Pseudo', and 'Schizophrenia psychopath'. The interface also includes a search bar and various control buttons.

Data, Data Structure, Abstraction, Knowledge Representation, & Formalism



W3EMRS: The 1st Generation



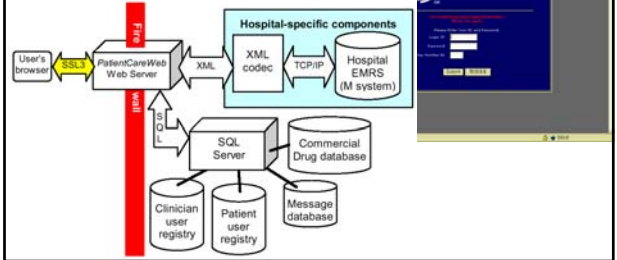
CareWeb: The 2nd Generation



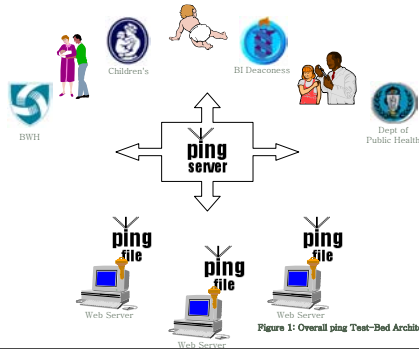
Transforming healthcare

SeniorMed Connecting patients to their medication record

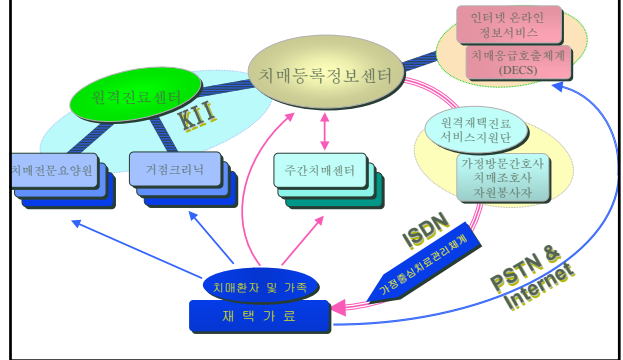
With Clinical Decision Support



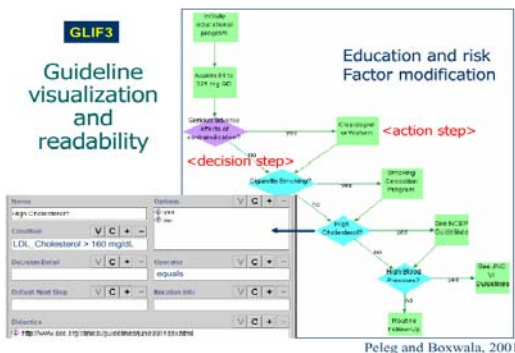
PING (Personalized Internetworked Notary and Guardian): The 3rd Generation



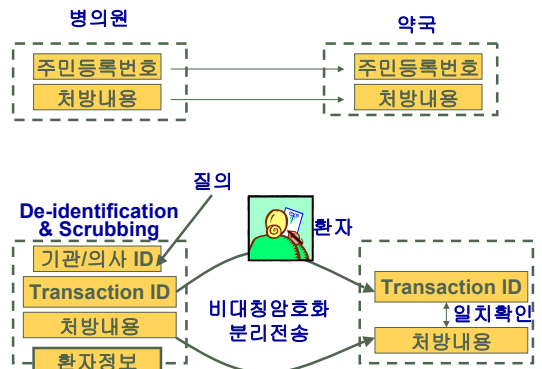
원격치매진료 시스템 개념도 (Telemedicine System for Dementia)



Clinical Decision Support



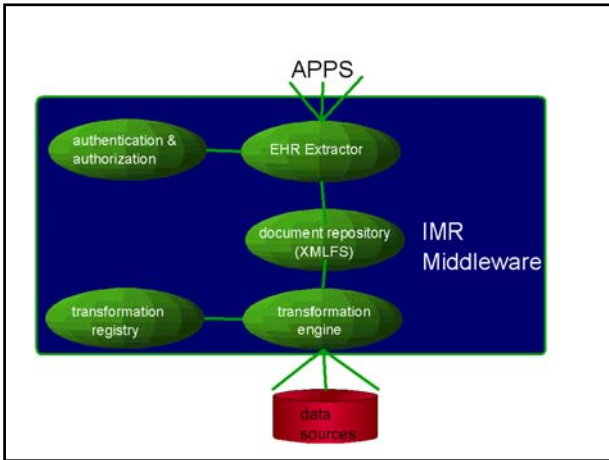
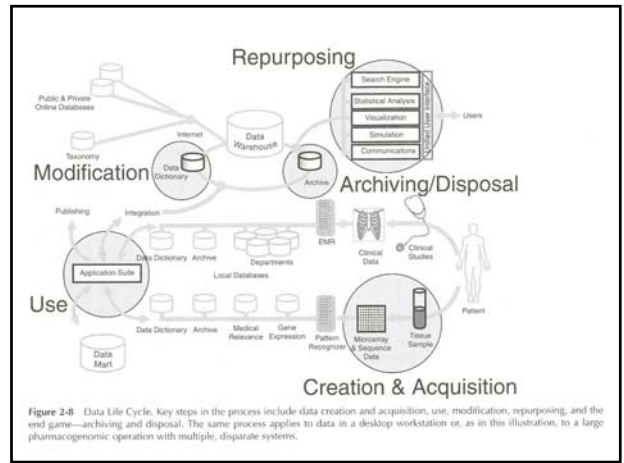
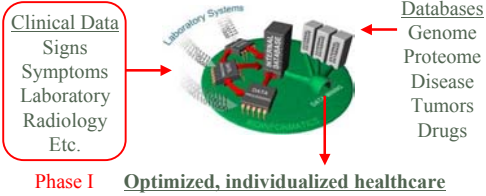
SeniorMed Security / privacy / confidentiality





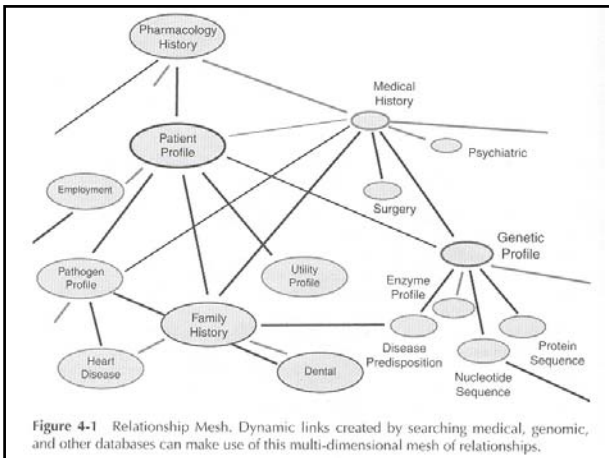
IBM/Mayo Clinic Collaboration Applied Genomics Data Analysis

Genomic data (DNA) – GeneChip array data (RNA)
Protein data



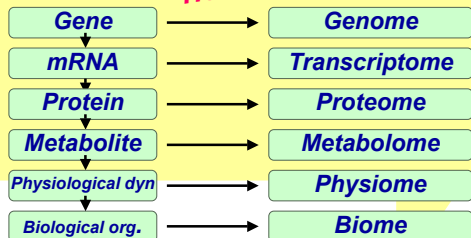
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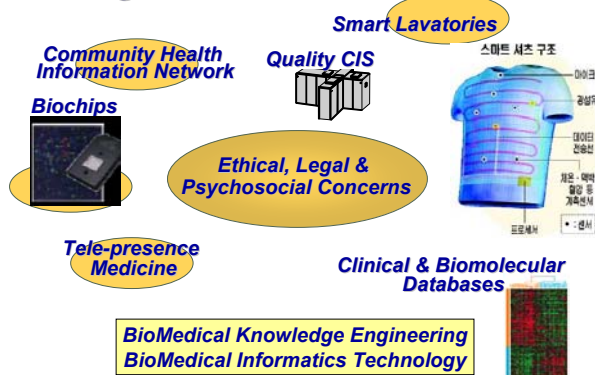


My view of the 'Omic' revolution

*Molecularly-informed
Horizontal integration*



Emergence of New Medicine



My view of 'informatics' revolution

*Informatically-empowered
vertical integration*

Health Science Informatics

Clinical Informatics

Chemoinformatics

pharmacogenomics
drug design

Structural Informatics

digital anatomy

Computational Physiology

neuroinformatics
cardiovascular sim.

Computational Cell Biology

E-cell
in silico biology

Biomolecular Informatics

structural biology
functional genomics

Emergence of New Medicine

Weaving the revolutions!

The new medicine will be

both

*Molecularly-informed &
Informatically-empowered*

*Biomedical Informatics
& Genomic Medicine*