Harvard-MIT Division of Health Sciences and Technology
HST.950J: Engineering Biomedical Information: From Bioinformatics to Biosurveillance
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Harvard Medical School

Massachusetts Institute of Technology

Biomedical Computing

Introductory Lecture
September 8, 2005

6.872 / HST 950

Introduction

Definition: Development and application of information science and technology for/to/in biomedical sciences.

Background: Biomedical sciences and engineering.

For (support): Improve management, research and care in terms of speed, accuracy, efficiency (electronic clinical records).

To (enablement): Do something that would be otherwise impossible (CAT scan and shotgun sequencing).

In (embedment): Be integral part of biomedical research (bioinformatics).

History of Biomedical Informatics

1950: R. Ledley's dental data at National Bureau of Standards.

1959: Reasoning foundations of medical diagnosis, *Science*.

1964: NIH Computer Research Study Section.

1966: MGH starts the development of COSTAR/MUMPS.

1971: MEDLARS Online, National Library of Medicine.

1972: NLM fellowship training program started.

1974: Mycin/Internist: dawn of Artificial Intelligence in Medicine.

1988: Human Genome Initiative and NCBI started.

1995: Shotgun sequencing (computer intensive) developed.

2001: Publication of Human Genome draft.

2003: Medical Informatics becomes Biomedical at Columbia.

2003: Computer scientist moves to Genetics, Stanford.

2006: HMS Dean announces Center for Biomedical Informatics

For (Support) Biomedical Informatics

Scope: Processing of biomedical information.

Goal: Support, streamline, and make more efficient the processing of biomedical information (clinical records, lab tests, etc).

Impact: Empower patients with control and dissemination of information; make healthcare delivery more efficient and cheaper; improve healthcare quality (96,000 death/year in US due to medical error).

Applications: Electronic medical records, information security and confidentiality, telemedicine.

To (Enabling) Biomedical Informatics

Scope: Use computer to .

Goal: Develop applications leveraging on information science and technology.

Impact: Change the way medical care is delivered; develop new tests and therapies; deliver new methods to control and manage disease outbreaks.

Applications: Genomic sequencing; image processing; real-time surveillance and early detection of population-wide events.

In (Embedded) Biomedical Informatics

Scope: Analysis of biomedical information.

Goal: Develop methods to analyze biomedical data as part of the overall research endeavor.

Impact: Change the way biomedical data are analyzed; deliver new views of natural phenomena; develop new methods to discover the bases of diseases.

Applications: Genomics, proteomics, bioinformatics.

Topic Areas

Bioinformatics: Application of information technology to genomic information.

Clinical Informatics: Application of information technology to medical (clinical) information.

Biosecurity and Public Health: Application of information technology to population data to monitor and infer global behavior and detect unexpected events.

Note: there are for/to/in components of biomedical informatics in all of these areas.

Bioinformatics

Bioinformatics*:* Research, development, or application of computational tools and approaches for expanding the use of biological, medical, behavioral or health data, including those to acquire, store, organize, analyze, or visualize such data.

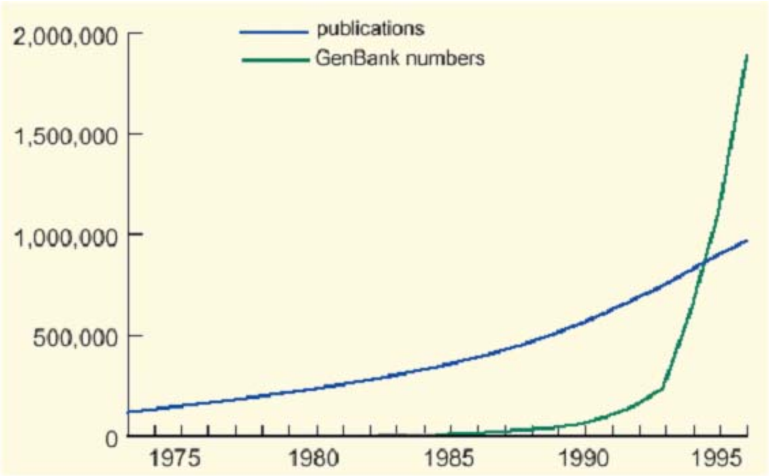
Computational Biology*:* Development and application of data-analytical, theoretical methods, mathematical modeling and computational simulation to the study of biological, behavioral, and social systems.

BISTIC Definition Committee, NIH, 2000.

Flesch Readability Index: 0.1 - Bush Inaugural (75), *Sports Illustr.* (65); *NY Times* (39); Auto Insurance Policy (10).

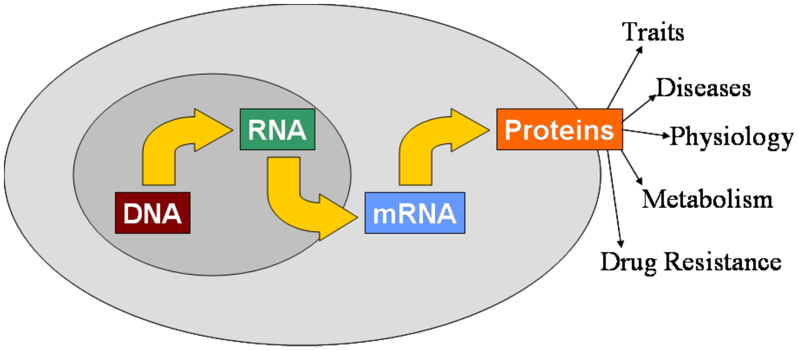
Bioinformatics

- Since work started in the past decade, we now have the complete genetic sequences of over 600 organisms.
- Complete human genome draft published, with final quality sequence, on April 25, 2003.
- At least 40-60% of genes in genome have unknown function. Many, many fewer have a solved structure.



Bioinformatics

- Genome: sequencing and genotyping.
- Transcriptome: expression and regulation.
- Proteome: protein expression and interactions.
- Metabolome: biological process on a larger scale.
- Bibliome: navigation and mining of annotation databases.
- Pharmacogenomics: genomics to create/test terapies.
- Genomic Privacy: data security.



Clinical Informatics

Clinical Databases: electronic medical records.

Patient Privacy and Confidentiality: cryptology and distributed systems.

Just in time clinical information: real-time delivery of medical information.

Telemedicine: remote distribution/collection of medical information.

Pharmaco-economics: Optimization and prediction of drug discovery and development.

Biosecurity

Public Health Informatics: Collection and distribution of population-wide medical information.

Geospatial Analysis: Analysis of population-wide medical data.

Population Confidentiality: Collecting population data without endangering the single individual.

Biosecurity: Real-time surveillance of man-made or natural disease outbreaks.

Syllabus

Class**:** Tuesdays and Thursdays, 2:30-4:00pm.

Text: Shortliffe EH, Perreault LE, Wiederhold G and Fagan LM, Medical Informatics: Computer Applications in Health Care and Biomedicine, 2nd Edition. Springer 2001.

Goals and Rationale

Objective: Introduction to the basic notions and current trends of biomedical informatics.

Strategy: In-depth description of basic notions through their presentation in basic trends:

- Basic Notion Lectures: Necessary and sufficient information covering a particular topic.
- Case Study Lectures: Guest lecturers describe a particular project/problem/trend in a domain.

Lecturers: Computer scientists, CIOs, computational biologists, geneticists, clinical trials leaders, biosecurity experts.

Grading

Class participation (30%) Attendance and contribution to discussions are a critical component of the class. Much of the material will be taught by guest lecturers who are uniquely knowledgeable in their areas.

Homework assignments (30%) We plan to give a half-dozen homework assignments Some of these will include programming tasks as well as thinking and writing. **Note:** *With the exception of medical excuses, assignments will be penalized 50% if they are turned in up to two days late, and will receive no credit thereafter.*

Project (40%) Students will work on projects of their own choice related to the topic of the class. Grading will be based on both a written paper due at the end of the semester and oral class presentations on each project. Ask guest lecturers for help!

Faculty

Bioinformatics

- Alvin Kho, HMS/CHIP
- Stefano Monti, Broad/MIT
- Gil Alterovitz, HMS/CHIP
- Scott Weiss, HMS/BWH
- Steve Sonis, HSDM/BWH

Clinical Informatics

- Aneel Advani, HMS/CHIP
- Octo Barnett, HMS/MGH
- Daniel Nigrin, HMS/CHIP
- John Halamka, HMS/BI
- John Glaser, Partners
- Hamish Fraser, HMS/CHIP
- Stan Finkelstein, Sloan/MIT

Public Health and Biosecurity

- Kenneth Mandl, HMS/CHIP
- Ben Reis, HMS/CHIP
- Chris Cassa, HMS/CHIP