FW5085 Functional Genomics & Biotechnology

Chung-Jui Tsai
Office: Rm 164
Lab: Rm 147
Phone: 7-2914
Office Hours: by E-mail
chtsai@mtu.edu

Lecture Schedule

Monday, Wednesday, Friday

10:05 - 10:55 pm, Rm 143

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Course Objectives

To provide an in-depth examination of new and emerging technologies in genomics and biotechnology and their application in life sciences.

Class Evolution: 1997 to 2007

- **Wood Biotechnology:**

1997-1998: Recombinant DNA, Antisense, Tissue culture, Gene transfer, Gene Cloning, Wood quality, Lignin, Cellulose, Stress, Sterility, Pharmaceutical applications

2000: DNA microarray, Signal transduction, GMO regulatory

- **Tree Biotechnology:**

2002: Microarray data analysis, Post-transcriptional gene silencing, T-DNA mechanism, DNA fingerprinting & genome mapping, EST sequencing

2003: RNAi, Promoter

- **Functional Genomics and Biotechnology:**

2005: micro- & small-RNAs, Forward and reverse genetics, Proteomics, Metabolomics, Ecological genomics, Systems biology

2007: New sequencing technologies, Association genetics

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Homework

1. Omics
2. PCR degenerate primers
3. EST assembly
4. Microarray data analysis
5. Southern puzzle
6. Weekly biotech/genomics news update
   - Every Friday, one person will introduce current-week biotech related science news to the class.
   - Authorized News media/magazines/websites only, no chat-room news.
   - Send internet links to instructor before Wednesday midnight.

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Term Paper and Presentation

Writing Assignment: A 10-page (double spaced) review on functional genomics and biotechnology application to your chosen area, using at least three major research articles.

Your subject choice is due Nov 9. Term Paper is due Dec 10.

Format of the review paper: **Introduction**
Research Methods (summary)
Results
Discussion
References Cited

Presentation: You are also asked to present your review paper in class, covering the following aspects:
Background introduction
Research problems
Strategy and/or Research methods
Results and Discussion
Future Perspectives

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Grading Procedure

Two Lecture Exams	50%
Homework	15%
Term Paper and Presentation	25%
Class Participation	10%

Introduction to Biotechnology and Functional Genomics

An Overview of Biotechnology

Many Definitions

- The use of living organisms to solve problems or make useful products.
- The use of cells and biological molecules to solve problems or make useful products.
  - Biological molecules: DNA, RNA, and proteins.
- The commercial application of living organisms or their products, which involves the deliberate manipulation of their DNA molecules.
  - The primary aim is to make a living cell perform a specific task in a predictable and controllable way.
- Biotechnology: A collection of technologies.

The Technologies and Their Uses

1. Genetic Engineering (Recombinant DNA) Technology
   - The use of cellular enzymes to manipulate DNA.
   - Transferring DNA between unrelated organisms.
2. Protein Engineering Technology
   - Improve existing/create novel proteins to make useful products.
3. Antisense or RNAi Technology
   - Block or decrease the production of certain proteins.
4. Cell and Tissue Culture Technology
   - Grow cells/tissues under laboratory conditions to produce an entire organism, or to produce new products.
5. Bioinformatics Technology
   - Computational analysis of biological data, e.g., sequence analysis, macromolecular structures, high-throughput profiling data analysis.
6. The -Omics
   - Genomics, transcriptomics, proteomics, metabolomics, etc.

Functional Genomics

Definition: The use of genome-wide, high-throughput approaches to determine the biological function of all of the genes and their products.

High-throughput technologies (the -omics): HW 1

- Transcriptomics (e.g. microarray expression profiling)
- Proteomics (e.g. structures/modifications/interactions of proteins)
- Metabolomics (e.g. metabolite profiling, chemical fingerprinting, flux analysis)
- Transgenomics (e.g. knock-out, knock-in, gene tagging, mutagenesis)
- Translational genomics

Homework 1: the Omics

One paragraph description of (1) the definition and (2) experimental approaches of an "omics" of your choice, with (3) a scientific reference.

Find something that is less "ordinary".

No Wikipedia definition allowed.

Due Wed, Sep 12.

Applications of Biotechnology & Genomics

1. Environmental Biotechnology

   Problems ?

   A. Environmental monitoring
      - Diagnosis of environmental problems via biotechnology

   B. Waste management
      - Bioremediation: the use of microbes to break down organic molecules or environmental pollutants.
      - Phytoremediation: the use of plants to remove pollutants (e.g. heavy metals) from the environment.

   C. Pollution prevention
      - Renewable resources
      - Biodegradable products
      - Alternative energy sources

Applications of Biotechnology & Genomics

2. Medical Biotechnology
   - A. Diagnostics
   - B. Therapeutics
   - C. Vaccines
   - D. Medical research tools
   - E. Human Genome Research

3. Agricultural Biotechnology
   - A. Animal Biotechnology
   - B. Crop Biotechnology
   - C. Horticultural Biotechnology
   - D. Tree Biotechnology

Medical vs. Agricultural biotechnology:

The former aims to produce high-value products that will be used in small amounts, whereas the latter seeks to produce large quantities of low-cost products.

Common goals: health, productivity

Applications of Biotechnology & Genomics

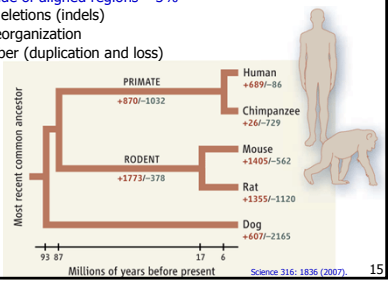
4. Evolutionary and Ecological Genomics

Finding genes associated with ecological traits and evolutionary diversification.

Examples?

Relative Differences: The Myth of 1%

- 1% Genetic difference between human and chimp (King and Wilson, 1975).
  - "Their macromolecules are so alike that regulatory mutations may account for their biological differences." Science 188: 107-116.
- Validated by genome data (human genome in 2000 and Chimp's in 2005)
  - 1.23% difference based on alignment of 2.4 Gb high quality sequence
  - More differences outside of aligned regions – 3%
    - insertions and deletions (indels)
    - chromosomal reorganization
    - gene copy number (duplication and loss)
- What really matters?
  - Diseases
  - Behaviors
  - Evolution



Science 316: 1836 (2007).

Societal Issues

- A balanced and fair opinion of new technology depends on analysis of its costs and benefits side-by-side.
  - Risk is a certainty
  - Cost may be prohibitive
  - Will the benefit outrate the cost and the risk?
- Issues at large:
  - Agricultural Biotechnology & Genomics
    - Environmental introductions of GMOs
    - Crossing genetic boundaries established by nature
    - The evolution of resistance to pesticides
    - The safety of genetically modified foods or plant products
  - Medical Biotechnology & Genomics
    - Genetic testing & screening for inherited disorders
    - The meaning of genetic information, genetic privacy?
    - Cloning & stem cell research