GENOMES & GENOMICS

PSS/BCH 8653
Fall 2008

Time and place: 12:30 – 1:45 PM TR, Dorman Hall, Room 156

Instructor: Daniel Peterson, 424 Dorman Hall, Phone: 325-2747, e-mail: dpeterson@pss.msstate.edu
Texts: There is no formal textbook for the class.
Grading: Traditional

There will be **two exams** (125 points each) and a **final exam** (150 points). Seventy-five points of the final will be based on the material covered since the 2nd "in-term" exam and 75 points will be based on material from the first two-thirds of the course.

An additional 100 points will be based on a **Reading/Writing Assignment** (see below for details).

In other words, grades will be based upon a total of 450 points distributed as follows:

Exam 1	125 points
Exam 2	125 points
Reading/Writing Assignment	100 points
Final Exam	150 points
	500 points

1) Material for the **first exam** will end Thursday September 18 and the exam will be held **Tuesday, September 23**.
2) Material for the **second exam** will end Thursday October 30 and the exam will be held **Tuesday November, 4**.
3) The **Reading/Writing Assignment** will be assigned on the second day of class.
4) The **final exam** will be held according to the final exam schedule on **Tuesday, December 9**.

Students are held responsible for the material in the same detail in which it was presented in class.

CLASS CALENDAR (subject to change)

AUGUST
19 - Lecture 1
21 - Lecture 2 – Discuss Essay Assignment
26 - Lecture 3
28 - Lecture 4
SEPTEMBER
2 – Lecture 5
4 - Lecture 6
9 - Lecture 7
11 - Lecture 8
16 - Lecture 9
18 - Lecture 10
23 - EXAM 1
25 - Lecture 11
30 - Lecture 12
OCTOBER
2 - Lecture 13, **Essay due**
7 – Fall Break Holiday, no class
9 - Lecture 14
14 - Lecture 15
16 - Lecture 16
21 - Lecture 17, **Essay revision 1 due**
23 – Lecture 18
28 - Lecture 19
30 - EXAM 2
NOVEMBER
4 - Lecture 20
6 - Lecture 21
11 - Lecture 22
13 - Lecture 23, **Essay revision 2 due**
18 - Lecture 24
20 - Lecture 25
25 – Lecture 26
27 - Thanksgiving Break, no Class
DECEMBER
2 - MGEL/LSBI Tour
9 - FINAL EXAM

TOPICS (subject to change)

Unit 1. Fundamental Biological Concepts

- A. *Genome* and *Genomics*
  - 1. Definitions
  - 2. Things w/ genomes and w/o genomes
- B. Editorial: "Failure of Scientific Education" and "The Balance of Nature"
- C. Fundamental biological concepts
  - 1. Central Dogma of Genetics
  - 2. Genetic Code
  - 3. Nucleic Acids
    - a. Nucleotides
    - b. Denaturation
    - c. Renaturation
  - 4. Replication
  - 5. Transcription
  - 6. Translation
  - 7. Genes, alleles, and loci
  - 8. cDNAs, ESTs, transcripts
  - 8. Recombination

Unit 2. Molecular Biology and Molecular Mapping

- A. Restriction enzymes
- B. Molecular cloning
  - 1. Constituents of a clone
  - 2. Plasmid features
    - a. Antibiotic resistance genes
    - b. Alpha-complementation
    - c. Partitioning and replication
- C. DNA libraries
  - 1. Major types
    - a. cDNA
    - b. Genomic
    - c. Expression
  - 2. Ordered libraries
    - a. Robot clone picking
    - b. Clone archival
- E. Gel electrophoresis
  - 1. Standard agarose
  - 2. Pulsed-field gel electrophoresis (PFGE)
- F. Molecular markers
  - 1. Features
  - 2. Types
    - a. RFLPs
    - b. AFLPs
    - c. SSRs
    - d. SNPs
  - 3. Molecular mapping
- G. Blotting techniques
- H. Polymerase Chain Reaction (PCR)
- I. Fluorescence *in situ* hybridization (FISH)

Unit 3. DNA Sequencing

- A. Chemical sequencing (Maxam-Gilbert)
- B. Chain termination sequencing (Sanger)
  - 1. Original Sanger sequencing
  - 2. Dye terminators
  - 3. Cycle sequencing
  - 4. Capillary electrophoresis
  - 5. Modern Sanger sequencing
- C. Synthesis sequencing
  - 1. Pyrosequencing
    - a. 454 sequencing
  - 2. Reversible chain termination
    - a. Illumina
    - b. SMRT - Pacific Biosciences
- D. Sequential ligation sequencing
  - 1. SOLiD (ABI)
- E. Nanopore sequencing

Unit 4. Prokaryotic Genomes

- A. Introduction
- B. Prokaryotes
  - 1. Characteristics
  - 2. Monera
  - 3. Archaea
- C. The Prokaryotic Cell
- D. The Prokaryotic Genome
  - 1. Bacterial chromosome
  - 2. Archaeal chromosome
- E. Prokaryotic Genes

Unit 5. Viral Genomes

- A. Definition of Virus
- B. Structure - Virion shapes
- C. Transfection
- D. Viroids
- E. Virus reproductive cycle
  - 1. Lytic reproductive cycle
  - 2. Lysogenic reproductive cycle
  - 3. Enveloped virus reproduction cycle
- F. Plant viruses
- G. Types of Viral genomes
  - 1. DNA viruses
  - 2. RNA viruses
  - 3. Retroviruses - Generic retrovirus genome
- H. Transduction
- I. Viruses 'R' Us – Us 'R' Viruses

Unit 6. Organellar Genomes

- A. Introduction to chloroplasts & mitochondria
- B. Endosymbiont theory
- C. Secondary endosymbiosis
- D. Chloroplasts
- E. Mitochondria
- F. Reproduction of mitochondria and chloroplasts
- G. Maternal inheritance of mitochondria

Unit 7. Eukaryotic Genomes

A. Eukaryotes – Definition
B. Ring of Life
C. Characteristics of eukaryotes
D. Eukaryotic genomes
1. Ploidy, Polyploidy, and Aneuploidy
2. C-value and the C-value paradox
3. Gene duplication
4. Repetitive DNA
E. Eukaryotic genes
1. Exons
2. Introns
3. Spliceosome and alternative RNA splicing
4. Regulation of eukaryotic genes
5. Induction
6. Eukaryotic vs. prokaryotic gene regulation
7. Other gene control mechanisms
8. Promoter model
F. Gene expression
1. Enhancers
2. Silencers
3. Insulators and Insulators in imprinting
G. Gene islands and interspersion
H. Gene evolution and speciation
I. Differential gene expression

Unit 8. DNA Reassociation Kinetics

A. Cot analysis
1. Cot
2. Cot point
3. Cot curve
a. Curve analysis
b. Single component Cot curves
c. Two Cot decade region
d. DNA outside of the Cot curve
e. Small genome eukaryotes
f. Large genome eukaryotes
g. What we learn from Cot curves
4. Calculating genome size
5. Reassociation rate
6. Sequence complexity
7. Kinetic complexity
B. Fractionating genomes (Cot filtration)

Unit 9. Mobile Elements

A. Introduction
1. Discovery
2. Origins
3. Autonomy
B. Classification
1. Retrotransposons
a. LTR retrotransposons
b. LINEs
c. SINEs
2. DNA transposons
a. TIR elements
b. Helitrons
c. Mavericks
C. Non-autonomous elements
1. MITEs
2. LARDs
3. SNACs
4. TRIMs
D. Mobile elements in evolution

Unit 10. Nucleus and Chromatin

A. Nuclei
1. Size and shape
2. Nucleus structure
a. Envelope
b. Pores
c. Lamina
d. Matrix
B. Chromatin
1. Matrix attachment regions (MARs)
2. Scaffold attachment regions (SARs)
3. Eukaryotic nucleosomes
4. 10 nm chromatin fiber
5. 30 nm chromatin fiber
6. Eukaryotic chromosome condensation
7. Nucleosomes & transcription
C. Euchromatin and heterochromatin
1. Definitions
2. CpG islands
3. Types of heterochromatin
4. Position-effect variegation (PEV)
5. Nucleolus

Unit 11. Chromosomes & Cell Cycle

A. Chromosomes
1. Homologous chromosomes
2. Idiogram and karyotype
3. Sister chromatids
4. Nucleolus Organizer Regions (NORs)
B. Cell cycle of eukaryotes
C. Euploidy & aneuploidy
D. Chromosome aberrations

Unit 12. Meiosis, Recombination, and Sex

A. Meiosis and sex
1. Fertilization
2. Meiosis and ploidy
3. Meiocytes
4. Mixis and apomixes
5. Amixis
B. Evolution of meiosis
C. Results of meiosis
D. Stages and substages of meiosis
E. Sex, meiosis, & diversity

Unit 13. Physical Mapping

A. BACs
1. BACs vs. YACs

2. BAC vectors
3. "Ordered" BAC libraries
4. Genome coverage

B. Macroarrays

C. Probes
1. ESTs
2. Molecular markers
3. Sequence tagged sites (STSs)
4. Sequence tagged connectors & BAC end sequences
5. Overgos

C. Traditional physical mapping
1. Steps in physical mapping
2. Minimum tiling paths
3. Insert sizes

D. Bar-code physical mapping
1. Steps
2. Minimum tiling paths
3. Advantages and limitations

F. Cytomolecular mapping

Unit 14. Genome Sequencing

A. Sequencing strategies
1. Whole genome shotgun sequencing (WGSS)
2. Clone-by-Clone Sequencing
3. Gene enrichment
a. EST sequencing
b. Methylation Filtration (MF)
c. Hypomethylated partial restriction
d. Methyl-spanning linking libraries
e. Cot Filtration (CF)
f. Gene enrichment combinations
4. Bar-code synthesis sequencing
a. Utility
b. A case study

B. Assembly

C. Utilizing whole genome sequences

Unit 15. Gene Expression

A. ORFs (open reading frames)

B. Differential gene expression techniques
1. Northern blotting
2. EST sequencing
3. Microarrays
4. Gene microarrays
5. Bisulfite sequencing

C. Microarray methods
1. Quantifying gene expression
2. Changes in expression over time
3. Large-scale expression analysis
4. Unigene sets
5. Limitations

Unit 16. Genomic Diversity

A. A genome sequence?

B. SNPs and indels

D. SNPs as molecular markers

E. Reference genomes

F. Detecting SNPs and indels

G. DNA resequencing techniques
1. PCR and resequencing
2. Oligonucleotide chips
3. Array-based resequencing
4. Detecting base mismatches
5. DHPLC
6. Flow cytometry
7. Synthesis sequencing

H. Synteny

I. Molecular phylogenetics

Unit 17. Evolution of Genomics

A. *Omes* and *Omics*
1. Proteomics
2. Transcriptomics

B. Genomics subdisciplines
1. Functional genomics
2. Comparative genomics
3. Structural genomics

C. Gene -> Protein -> Phenotype
1. Gene knockout
2. Yeast two-hybrid system
3. Directed mutagenesis & gene synthesis
4. Gene knockdown/RNAi

Writing Assignment (worth 100 points)

All students should be able to get the full credit (100 points) or nearly full credit on this assignment. Essays should be turned in by October 2. Dr. Peterson will read the essays, give each an "initial score," and suggest revisions. Students can improve their score by making the suggested revisions and returning a revised copy of their essay to Dr. Peterson for re-grading. If Dr. Peterson finds that the essay needs no further revisions, the student will receive full credit. If not, the essay will be returned with additional suggested revisions. After two rounds of review it is hoped that, through the revision process, all students will have essays that merit full credit.

Each student is required to write an overview of his/her dissertation or thesis research project. The overview is limited to a 1 to 2 page *Project Description* and a *References Cited* page(s) (i.e., a page providing an alphabetized

listing of publications cited in the *Project Description*). The *Project Description* should provide key background information, outline the main goals of the project, and provide an overview of the methods to be utilized. In addition, **it should clearly discuss the value of the project (directly or indirectly) to humankind**. Students can summarize preliminary research results if desired. The *Project Description* should be prepared so that it can be readily understood by someone with a moderate knowledge of biology (*e.g.*, someone with a B.S. degree in biological sciences). References should be cited in the text and listed on the *References Cited* page using the format described below. Ask Dr. Peterson if you have questions about citation format and appropriateness.

Citing References

References should be cited in the text using the Harvard (name–date) system. Where there are three or more authors, only the first author's name should appear, followed by *et al*. Where several references are cited at the same point in the text, these should be arranged in chronological order. In the *References Cited* list, citations should be arranged in alphabetical order. References should include: names and initials of all authors; year of publication; full title of the article; source using abbreviations for journals as shown in *Medicus*; volume number; and first and last page numbers. Abstracts should be identified as such. For citations from books, the chapter title should be followed by the names and initials of all editors, the title of the book, edition, place of publication, publisher and first and last page numbers.

Examples:

Beatles Database [://www.beatlesdb.com]

Harrison G (1989) When we was fab. *J. Fab* **16**:E231.

Lennon JW (1968) An estimate of holes in Blackburn, Lancashire. *J. Holes* **22**: 45-48.

Lennon JW, Harrison G, Starkey R, McCartney JP (1969) A day in the life of a hole filler. In: *Confessions of a Day Tripper*. Edited by: Martin G. Apple Publishing, Liverpool, England, pp. 53-69.

Lennon JW, McCartney JP (1968) *A Census of Holes in the British Isles*. George Martin Publishing, London.

McCartney JP, Starkey R, Harrison G, Lennon JW (1970) Fixing a hole. *Sgt. Pepper's J. Constr. Sci.* **29**: 12-34.

Starr R (2008) "I've got blisters on my fingers!" - An interview with Ringo Starr. [://www.ringostarr.com].

Only accepted papers should be referenced; all other material should be referred to in the text as 'in preparation', 'personal communication,' or 'unpublished observations' and should not be included in the reference list.

World Wide Web: All references should include the same information that would be provided for a printed source (or as much of that information as possible). The Web information is then placed at the end of the reference. It is important to use "Retrieved from" and the date because documents on the Web may change in content, move, or be removed from a site altogether. To cite a Web site in text (but not a specific document), it is sufficient to give the address (e.g., http://www.apa.org) there and no reference entry is needed. However, when citing a particular web page a citation in the text (e.g., Gaten 2000) and an entry in the reference list will be required.

For example:

Gaten E. (2000) Internet references. Retrieved from ://www.le.ac.uk/biology/teach/mod300/ecitations.html on 19-Sep-2000.

One of the most comprehensive guides to citing internet references is provided by the American Psychological Association: ://www.apastyle.org/elecref.html

Wikipedia – In my humble opinion, Wikipedia is one of the greatest things ever invented. However, **DO NOT CITE WIKIPEDIA!** It is not a refereed source of information.