2022 Winter Biology 2171: Genetics Course Outline

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Office Hours: CB4016, Mondays, 12:00 pm (noon) to 13:00 pm
or by appointment or by Zoom

Lecture Location: Zoom
Time: Mondays, Wednesdays: 1:00-2:30 pm
Duration: 2022/01/10 – 2022/04/08
Credits: 0.50

TA: Sarita Shrestha, PhD student
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Textbook: ISE Genetics: From Genes to Genomes (7th Edition) Michael Goldberg, Janice Fischer, Leroy Hood and Leland Hartwell. Publisher: McGraw-Hill Education. (Students are highly encouraged to buy this textbook).

Additional Requirements: (1) Preview the textbook and think about the questions in the related chapter(s) before the applicable class. (2) Review the textbook and try to answer the questions in the chapter(s) after the class. (3) Read the entire lectured chapters 1-12 for exams. (The PPT slides do not contain all the information needed for exams, you must study the textbook as well). (4) Students must understand well enough to solve all the problem questions in chapters 1-12.

Genetics Learning Objectives
Understand Mendel's genetic laws, experimental design, and how they apply to the heredity patterns which Mendel observed in pea plants.
Understand the link between genotype and phenotype.
Understand the difference between a character and a trait.
Understand the difference between dominant and recessive alleles and the difference between homozygous and heterozygous.
Understand extensions to the Mendel's laws.
Learn chromosome and inheritance and sex chromosomes.
Learn gene linkage, recombination, and gene mapping.
Learn DNA replication, gene mutation, and gene functional analysis.
Learn genome annotation and genomic analysis.
At the end of the course, students will also be able to finish the following tasks after their theoretical and experimental studies.
(1) Explain the mechanisms of simple Mendelian inheritance of traits, including X-linked traits, lethal traits and other gene linkage.

(2) Explain what epistasis is, how a few types work, and how they generate the phenotype ratios observed.
(3) Create a Punnett square for multiple generations to predict genotypes and phenotypes of progeny.
(4) Conduct a Chi-squared analysis (Goodness of Fit, as well as Test for Independence) with a properly formatted Chi-Squared table, an appropriate null hypothesis, correct calculations, and conclusions.
(5) Set up and maintain cultures of Drosophila melanogaster (fruit flies).
(6) Anesthetise and manipulate Drosophila melanogaster to observe traits.
(7) Identify and sort Drosophila melanogaster based on sex and deviations from wild-type features.
(8) Create and evaluate a pedigree using standard nomenclature and symbols.
(9) Explain the inheritance method, probability of inheritance, and pedigree flags of the BRCA1 gene and its associated cancers.
(10) Discuss the effect of mutation, reproduction, and selection on the evolution of organisms, and how that affects speciation or conservation efforts.
(11) Effectively communicate opinions on genetics related societal topics e.g.,GMO foodstuffs, species interpretation in canids.
(12) Describe how Single Nucleotide Polymorphisms (SNPs) and Genome Wide Association Studies (GWAS) can help increase our knowledge of genes and loci involved with traits and diseases across multiple organism models, specifically in dogs and humans.
(13)Identify phenotypes and likely genotypes for simple genes in cats, corn, fast plants, and fruit flies.
(14) Describe how epigenetics and transposable elements affect traits and gene expression.
(15) Discuss how data collection, sample size, and biases may affect scientific results.

Grading Scheme: (The PowerPoint slides do not cover all the information for exams, so intensive reading and understanding of the whole lectured chapters 1-12 are necessary).

1. Mid-term exam March 2, 2022 [30%]. Covering the chapters 1-5. The midterm exam may include (1) Fill in the blank questions, (2) Multiple choice questions, (3) True/False questions, (4) Essay questions, etc. TA will help to administer and mark the exam. Duration is up to 90 minutes.
2. Final exam (Chapter 8-14) [45%]. Exam may include (1) Fill in the blank questions, (2) Multiple choice questions, (3) True/False questions, (4) Essay questions, etc. Duration is up to 3 hours.
3. Lab components [20%]. This will be assigned and evaluated by the lab instructor Mr. Michael Moore. His office is CB 3011A, and his phone number is 807-343 8010-8909 and his email is mnmoore@lakeheadu.ca.
4. Class attendance marks [5%].
5. Bonus marks. Some bonus marks may be offered when necessary (see the notes below).

Notes: If you miss any examination (midterm exam or final exam), we strictly follow the university regulations of “Missed Examinations Due to Illness or Other Extenuating Circumstances”. If you are permitted to write your missed exam, an alternative test paper (Test

B) will be made. Test B may be different in questions and/or format from the test questions for the class (Test A). Please try to avoid missing an exam.

Extra notes:
(1) We strictly follow the course outline as rules for the course.
(2) The important contents and information for examinations will often be emphasized in class.
(3) Slides in D2L and slides for lecturing may be slightly different.
(4) Bonus points: If you actively ask questions or participate in class discussion, you may obtain up to 5 bonus points. Each bonus point can value more or less than 1% adding to the student's final grade. The bonus point value depends on class average marks.

Course contents and schedule

	January, 2022	Chapters	Part I: Basic Principles: How Traits Are Transmitted
Week 1	10-16	1	Mendel's Principles of Heredity
Week 2	17-23	2	Extensions to Mendel's Laws
Week 3	24-30	3	Chromosomes and Inheritance
Week 4	January 31-February 6, 2022	4	Sex Chromosemes
Week 5	7-13	5	Linkage, Recombination, and Gene Mapping
			Part II: What Genes Are and What They Do
Week 6	14-20	6	DNA Structure, Replication, and Recombination
Week 7	21-27 (Study Week, no class)	***	*****
Week 8	February 28-March 6, 2022 (Midterm March 2, 2022 covering chapter 1-5)	7	Mutation
Week 9	7-13	8	Using Mutations to Study Genes
Week 10	14-20	9	Gene Expression: The Flow of Information from DNA to RNA to Protein
			Part III: Analysis of Genetic Information
Week 11	21-27	10	Digital Analysis of DNA
Week 12	March 28-April 3	11	Genome Annotation
Week 13	4-10 (April 8 Final Day of Class)	12	Analyzing Genomic Variation

Assignments

The following twenty-eight (28) assay questions should be finished and practised well. The standard answers will be provided to you later.

[1] The trait of medium-sized leaves in iris is determined by the genetic condition *PP′*. Plants with large leaves are *PP*, whereas plants with small leaves are *P′P′*. A cross is made between two plants each with medium-sized leaves. If they produce 80 seedlings, what would be the expected phenotypes, and in what numbers would they be expected? What is the term for this allelic relationship?

[2] The trait for medium-sized leaves in iris is determined by the genetic condition *PP′*. Plants with large leaves are *PP*, whereas plants with small leaves are *P′P′*. The trait for red flowers is controlled by the genes *RR*, pink by *RR′*, and white by *R′R′*. A cross is made between two plants each with medium-sized leaves and pink flowers. If they produce 320 seedlings, what would be the expected phenotypes, and in what numbers would they be expected? Assume no linkage.

[3] A color-blind woman with Turner syndrome (XO) has a father who is color-blind. Given that the gene for the color-blind condition is recessive and X-linked, provide a likely explanation for the origin of the color-blind and cytogenetic conditions in the woman.

[4] Dosage compensation leads to a variety of interesting coat color patterns in certain mammals. For instance, a female cat that is heterozygous for two coat color alleles, say black and orange, will usually have the "calico" or mosaic phenotype. Describe the chromosomal basis for the mosaicism (calico) in the female. Explain why chromosomally normal male cats do not show the mosaic phenotype, but XXY male cats can be calico.

[5] Give the sex-chromosome constitution (X and Y chromosomes) and possible genotypes of offspring resulting from a cross between a white-eyed female (Xw XwY) and a wild-type male (normal chromosome complement) in *Drosophila melanogaster*. Include all zygotic combinations whether viable or unviable.

[6] Assume that investigators crossed a strain of flies carrying the dominant eye mutation Lobe on the second chromosome with a strain homozygous for the second chromosome recessive mutations smooth abdomen and straw body. The F_1 Lobe females were then backcrossed with homozygous smooth abdomen, straw-body males, and the following phenotypes were observed:

smooth abdomen, straw body	820
Lobe	780
smooth abdomen, Lobe	42
straw body	58
smooth abdomen	148
Lobe, straw body	152

(a) Give the arrangement of alleles of the F1 Lobe females
(b) Which gene is in the middle?
(c) Determine the distances in map units for these three loci.
(d) What is the coefficient of coincidence and interference values?
(e) Is there positive, negative, total or no interference?

[7] In the fruit fly, *Drosophila melanogaster*, a spineless (no wing bristles) female fly is mated to

a male that is claret (dark eyes) and hairless (no thoracic bristles). Phenotypically wild-type F_1 female progeny were mated to fully homozygous (mutant) males, and the following progeny (1000 total) were observed:

Phenotypes	*Number Observed*
spineless	321
wild-type	38
claret, spineless	130
claret	18
claret, hairless	309
hairless, claret, spineless	32
hairless	140
hairless, spineless	12

(a) With respect to the three genes mentioned in the problem, what are the genotypes of the homozygous parents used in making the phenotypically wild-type F_1 heterozygote?
(b) Which gene is in the middle?
(c) What are the map distances for the three genes? A correct formula with the values "plugged in" for each distance will be sufficient.
(d) What is the coefficient of coincidence? A correct formula with the values "plugged in" will be sufficient.
(e) What is the value for interference? Is there positive, negative, total, or no interference?

[8] Explain the composition and use of minimal medium in the study of bacterial genetics.

[9] Assume that one counted 67 plaques on a bacterial plate where 0.1 ml of a 10^{-5} dilution of phage was added to bacterial culture. What is the initial concentration of the undiluted phage?

[10] If the linker DNA between nucleosomes is 103 base pairs in length, how many H4 proteins are expected in a stretch of DNA 30,000 base pairs long?

[11] Describe the role of chemical modification in the generation of CpG islands. Predict where CpG islands are likely to be found within the genome.

[12] Describe a difference between the RNA polymerases of eukaryotes and prokaryotes.

[13] In eukaryotes, which three factors appear to encourage the specific association of RNA polymerase(s) to a specific region of DNA?

[14] Describe the basic structure of normal adult hemoglobin and the abnormality observed in sickle-cell hemoglobin.

[15] In what ways do the amino acid side chains interact to influence protein function?

[16] Under which condition(s) might have an amino acid substitution in a protein that does not result in an altered phenotype?

[17] Three major types of RNAs are mRNA, rRNA, and tRNA. For each of the conditions

below, predict the consequences in terms of the population of proteins being synthesized in a particular cell. What qualitative and quantitative changes, if any, are expected in the individual protein involved (if one is involved) and in the population of proteins produced in that cell?
(a) A frameshift mutation in mRNA. The condition is heterozygous in the involved cell.
(b) A deletion (homozygous) that removes approximately half of each type of rRNA genes.

[18] Imagine that an Ames test was performed on a new red dye to determine if it will be safe for consumers. For this *his*$^-$ mutants are grown in growth media and the disk is soaked in the red dye. The results show that the reversion rate is not significantly above the spontaneous rate. Would you conclude that this dye is safe? Explain why or why not.

[19] Short hair in rabbits is produced by a dominant gene (l^+) and long hair by its recessive allele (l). Black hair results from the action of a dominant gene (b^+) and brown hair from its allele (b). Determine the genotypic and the corresponding phenotypic ratios of the F_2 offspring, beginning with a parental cross of a female rabbit with brown hair and a male rabbit with long hair. Assume that the P female is homozygous for short hair and the P male is homozygous for black hair.

[20] In rats, the gene for the pigment (P) is dominant to no pigment (p). The gene for black (B) is dominant to the gene for cream (b). If a pigment gene (P) is absent, genes B and b are inoperative. Predict the genotypes and phenotypes of the F_2 of a parental cross between a homozygous black rat and an albino homozygous for cream.

[21] You have obtained an interesting flower for your garden from your neighbor. The neighbor has given you two pure lines of the plant, one with red flowers and one with yellow flowers. You decide to cross them and find that you obtain all orange flowers. The curious molecular geneticist in you decides to test two independent hypotheses: Hypothesis 1: Incomplete Dominance; Hypothesis 2: Recessive Epistasis. The first step in your test is to self the F_1 orange plants, which you complete only to find that the results do not statistically distinguish the two hypotheses. a) What ratio of yellow, orange, and red would you expect in the F_2 population for each hypothesis and b) what crosses would you complete next to definitively test your two hypotheses?

[22] In Drosophila, white eyes (w) and yellow body (y) are both recessive X-linked mutations. The wild type alleles, w+ and y+, control red eyes and dark body color, respectively. If a homozygous yellow body, red-eyed female is crossed with a dark body, white-eyed male, and F1 progeny are interbred, what will the phenotypes and ratios of the F1 and F2 be?

[23] In crosses of white-eyed *Drosophila* females with red-eyed males, Bridges recovered white-eyed daughters and red-eyed sons at a rate of around one per 2,000 offspring. (Most of the offspring were white-eyed males and red-eyed females.) He hypothesized that these exceptional progeny resulted from nondisjunction of the X chromosomes in meiosis in the female. Why did he suspect that nondisjunction was occurring in the female parent? What types of progeny would result from nondisjunction in the male parent?

24] The Holliday model of recombination has been modified. The current model, termed the consensus model, is now consistent with current research. What are the five properties of recombination, as they are now understood?

[25] When Meselson and Stahl performed the experiment that showed that replication is a semiconservative process, they utilized E. coli, and various isotopes of nitrogen (15N and 14N). Explain briefly what their results would have been if DNA replicated conservatively.

[26] How is DNA altered by hydrolysis, radiation, UV light, and oxidation respectively?

[27] Chemical X has just been screened using the Ames test. A total of 5,000 bacteria were tested against 0.001 M, 1 M, 0.1M, and 1M concentrations for which 4, 1, 0, and 200 colonies grew respectively. Control plate of minimal media supplemented with histidine had 5,000 colonies while minimal media alone had only two. Interpret these data.

[28] The local pet store received several shipments of albino ferrets. You choose two males and two females as pets one breeding pair from the same litter, one from two different litters. When your ferrets' litters are born, one litter has normally pigmented offspring. State which offspring are albino and which are pigmented and explain why?