2023 Winter Biology 2171: Genetics Course Outline

Instructor: Dr. Wensheng Qin
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Office Hours: CB4016, Tuesdays, 11:45 am to 12:45 pm (or by appointment)
Lecture Location: SN 1015
Time: Tuesdays, Thursdays: 1:00-2:30 pm
Duration: 2023/01/09 – 2023/04/11
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, but not required. Whether you buy this 7th edition textbook or use other versions of the textbook or use another similar textbook, it is totally up to you. One copy of the book will be reserved in the library.

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 1-13 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 1-13.

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 1-13 are necessary.

1. Mid-term exam one: February 14, 2023 [15%]. Covering the chapters 1-3. The midterm exam one may include (1) Fill in the blank questions, (2) Multiple choice questions, (3) True/False questions, (4) Essay questions, etc.
2. Mid-term exam Two: March 2, 2023 [15%]. Covering the chapters 4-6. The midterm exam two may include (1) Fill in the blank questions, (2) Multiple choice questions, (3) True/False questions, (4) Essay questions, etc.
3. Final exam (Chapter 7-13) [40%]. Final exam may include (1) Fill in the blank questions, (2) Multiple choice questions, (3) True/False questions, (4) Essay questions, etc.

4. 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.
5. Assignment One [5%]. Submission deadline is 23:59 pm on February 20, 2023.
6. Assignment Two [5%]. Submission deadline is 23:59 pm on March 15, 2023.
7. Bonus marks: Some bonus points for raising your final grades may be offered when necessary (see the notes below).

Notes: If you miss any examination (midterm exams 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 or even Test C, Test D, etc.) will be made. Test B, C, D will be different or even totally different in formats and questions from the test questions in Test A for the class. Please try your best 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. Occasionally, I will provide some example questions in the class. The example questions will be related to our contents but may not be from the textbook.
(3) Slides in D2L and slides for lecturing may be slightly different. To encourage students to take good notes of the lectures, the lectured slides will not be sent to the students.

(4) Bonus points:
[1] Class attendance bonus: up to 10 bonus points will be awarded for class attendance or active discussion. I will randomly select some classes and ask the students to sign the attendance sheets or give pop quizzes.
[2] If you actively participate in class discussion, you may obtain extra bonus point(s).
[3] 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. If the class average marks are too low, pop quizzes may be arranged for extra bonus points.

Course contents and schedule

	January, 2023	Chapters	Part I: Basic Principles: How Traits Are Transmitted
Week 1	9-15	1	Mendel's Principles of Heredity
Week 2	16-22	2	Extensions to Mendel's Laws
Week 3	23-29	3	Chromosomes and Inheritance
Week 4	January 30-February 5, 2023	4	Sex Chromosemes

Week 5	6-12	5	Linkage, Recombination, and Gene Mapping
			Part II: What Genes Are and What They Do
Week 6	13-19 (February 14, Tuesday, Midterm one 15%, covering chapters 1-3)	6	DNA Structure, Replication, and Recombination
Week 7	20-26 (reading week, no class)	***	***
Week 8	February 27-March 5, 2023	7	Mutation
Week 9	6-12 (Midterm two 15%, March 7, 2023, covering chapter 4-6)	8	Using Mutations to Study Genes
Week 10	13-19	9	Gene Expression: The Flow of Information from DNA to RNA to Protein
			Part III: Analysis of Genetic Information
Week 11	20-26	10	Digital Analysis of DNA
Week 12	March 27-April 2	11	Genome Annotation
Week 13	April 3-9	12	Analyzing Genomic Variation
Week 14	April 10-16 (April 11 Final Day of Class)	13	The eukaryotic chromosome

Assignment One: Question 1-5 (Submission deadline is 23:59 pm on February 20, 2023, 1% each question, 20% deduction per day late).

[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] 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.

[3] 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.

[4] 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.

[5] 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?

Assignment Two: Questions 6-10 (Submission deadline is 23:59 pm on March 15, 2023, 1% each question, 20% deduction per day late).

[6] 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.

[7] 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.

[8] 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?

[9] 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?

[10] 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 progenies 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 progenies would result from nondisjunction in the male parent?