COURSE OUTLINE

Course Number	Course Title	Credits
BIO208	**Genetics**	**4**

Hours: 3/3 Lecture/Lab	Prerequisites	Implementation Semester & Year
	BIO101: C grade or higher	**Spring 2022**

Catalog description:

A course examining gene activity at the molecular and organismal levels. Principles of transmission, molecular, and population and evolutionary genetics are covered with emphases placed on genetic technology and applications. The laboratory exercises address topics in heredity, chromosome structure, recombinant DNA, bioinformatics, and other molecular biology techniques. Three hours of lecture and one three-hour laboratory per week.

General Education Category:
Goal 3: Science

Course coordinator:
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Required Text: BIO208 Lab Manual by Laura A. Blinderman. In-house publication.

Recommended Text:
Concepts of Genetics by Robert J. Brooker 2nd edition ISBN-13: 978-0073525358 or ISBN-10: 0073525359 or 3rd edition ISBN13:9781259879906 or ISBN10: 1259879909

Course Student Learning Outcomes (SLO):

Students will be able to:
1. Elucidate the architecture, packaging, and regulation of DNA (gene expression) in viruses, eukaryotes and prokaryotes (ILG #s 1, 3, 11, PLO #s 1, 2, 3, 4, 5)
2. Explore transmission genetics and solve problems in the transmission of traits (ILG#s 1, 2, 3, 11, PLO#s 1, 2, 3, 4, 5)
3. Investigate chromosomes, sex linkage, karyotypes, and aneuploidy (ILG #s 1, 2, 3, 11, PLO #s 1, 2, 3, 4, 5)
4. Explore mechanisms, tools, goals, and implications of cloning, CRISPR, transgenics and other biotechnology methods (ILG#s 1, 2, 3, 11, PLO#s 1, 2, 3, 4, 5)
5. Elucidate the molecular mechanisms of DNA mutation and repair. Explore cancer genetics. (ILG#s 1, 2, 3, 11, PLO#s 1, 2, 3, 4, 5)

6. Conduct scenario and problem-based learning in bioinformatics (ILG ILG#s 1, 2, 3, 4, PLO#s 1, 2, 3, 4)
7. Develop skills in pipetting, gene cloning, bacterial transformation, restriction enzyme digestion, DNA fingerprinting, PCR, bioinformatics, gel electrophoresis, DNA and protein purification, centrifugation, presenting data, and other laboratory techniques that support lecture concepts. (ILG #s 1, 2, 3, 4, PLO#s 1, 2, 3, 4, 5).

Course-specific Institutional Learning Goals (ILG):

ILG 1. Written and Oral Communication in English. Students will communicate effectively in both speech and writing.
ILG 2. Mathematics. Students will use appropriate mathematical and statistical concepts and operations to interpret data and to solve problems.
ILG 3. Science. Students will use the scientific method of inquiry, through the acquisition of scientific knowledge.
ILG 11. Critical Thinking: Students will use critical thinking skills understand, analyze, or apply information or solve problems.

Program Learning Outcomes for BIOLOGY (PLO):

PLO 1: Demonstrate an understanding of the fundamental principles, concepts, and terminology of biology
PLO 2: Explain the structures and fundamental processes of life at molecular, cellular, and organismal levels
PLO 3: View the living world with greater understanding, insight, and appreciation as it relates to the field of biology and contemporary problems and issues
PLO 4: Demonstrate the ability to apply the scientific method of inquiry to gather and use information for the purposes of critical thinking, information analysis, and problem solving
PLO 5: Exhibit proficiency in the laboratory and in field by using standard equipment and measurement and observation techniques that allow one to gather, analyze, and interpret qualitative data.

Units of study in detail – Unit Student Learning Outcomes:

Lab-specific student learning outcomes: [Support SLO #s 1, 2, 3, 4, 5, 6, 7]
The student will be able to:

1. Perform problem-based bioinformatic analyses on peptide sequences using NCBI databases and alignment tools
2. Research PubMed to find articles relating the use of disintegrins to modulate VEGF, angiogenesis, and cancer
3. Isolate DNA from eukaryotic cells
4. Conduct the PCR (DNA fingerprinting) and analyze via electrophoresis polymorphisms in a dimorphic Alu element
5. Design PCR primers
6. Communicate laboratory results via oral and written communication
7. Prepare solutions and dilutions. Employ knowledge of molarity, concentration, metric system of measurement
8. Conduct molecular modeling of gene expression in animal development
9. Collect and statistically analyze data with respect to transmission of gene traits
10. Examine control of fur characteristics and gene product interactions in corn, mice, cats, and fruit flies
11. Conduct microscopic evaluation of mutant and normal chromosomes and gene product effects on phenotype

12. Examine human single gene traits and perform pedigree analysis of autosomal recessive and autosomal dominant traits
13. Perform karyotype analysis of chromosomal aberrations
14. Describe the translocation that leads to the Philadelphia chromosome and CML cancer
15. Perform restriction enzyme digestion of DNA and analyze results via gel electrophoresis. Perform DNA mapping
16. Examine the pGLO plasmid, ori, $amp^{r,\ the}$ GFP gene, and the portion of the arabinose promoter that allows for the regulation of gene expression of GFP by arabinose sugar
17. Transform competent *E. coli* with a GFP-containing plasmid and calculate transformation efficiency (colonies/ug DNA) from given data

Unit I DNA and Gene Expression **[**Supports Course SLO #s 1, 6, 7]

Learning Objectives
The student will be able to:

1. Review model organisms used in genetics
2. Distinguish between molecular, transmission, population, and quantitative genetics
3. Describe functional properties of DNA including replication, storage of information, mutation
4. Describe Meischer's observation of nuclein
5. Analyze experiments by Griffith that uncovered a transforming factor
6. Evaluate work by Avery et al and Hershey and Chase to identify DNA as genetic material.
7. Discuss the elucidation of the DNA double helix by Watson and Crick. Understand the significance of the X-ray diffraction data provided by Franklin.
8. Provide a description of DNA structure including base complementation, antiparallel strands, sugar/phosphate backbone, nucleotide composition, hydrogen bonding, major, minor grooves
9. Identify the 3 components of a nucleotide
10. Distinguish between purines and pyrimidines
11. Examine Chargaff's observations of nucleotide composition in DNA
12. Contrast B-, Z-, and A-DNA
13. Review the life cycle of T2 bacteriophage
14. Explain the relationship between genomes, genes, chromosomes, and DNA
15. Examine different forms of viral DNA
16. View prokaryotic chromosome (s), plasmids, supercoiled DNA, and the nucleoid region
17. Explain role of histone proteins and nucleosomes in DNA packaging and gene expression (epigenetics)
18. Contrast heterochromatin with euchromatin and provide an example of each
19. Review unique sequence DNA
20. Compare LINES, SINES and dispersed DNA sequences
21. View telomeric and centromeric tandem DNA repeats
22. Distinguish between amino acids, peptides, polypeptides, and proteins
23. Understand the flow of information in gene expression, DNA → RNA → Protein
24. Compare and contrast the function of various types of RNA
25. Provide a detailed overview of transcription and translation
26. Distinguish between the template and non-template (coding) strands of DNA
27. Describe the role of RNA polymerase in the 5' -> 3' transcription of template strand of DNA
28. Compare RNA polymerase and DNA polymerase
29. Describe the role of the sigma factor in the initiation of transcription in prokaryotes
30. Distinguish between initiation and elongation of the transcript
31. Contrast upstream and downstream sequences
32. Describe the mechanism of promoters in the initiation of transcription
33. Explain cotranslation in prokaryotic cells

34. Describe eukaryotic promoters (TATA and CAAT boxes)
35. Outline the general role of transcription factors in the generation of mRNA by RNA pol II and in the formation of the pre-initiation complex
36. Describe the mechanism of mRNA processing including 5' capping and 3' polyadenylation
37. Examine components of pre-mRNA including 5' and 3' untranslated regions, introns, cap, polyA tail
38. Discuss the concept of split genes in eukaryotes
39. Describe formation of the spliceosome complex, splicing group III introns in split genes
40. Describe the genetic causes and clinical symptoms of beta thalassemia (class activity).
41. Analyze coding and noncoding region mutations in the β globin gene that lead to forms of beta thalassemia and explain effect of mutations on gene transcription or mRNA translation
42. Define alternate splicing
43. Compare primary, secondary, tertiary, and quaternary protein structures
44. Describe the relationship of codons to the encoding of amino acids and describe aspects of the genetic code - degenerate, non-overlapping, ordered, near universal, reading frame.
45. Become proficient in the use of a codon table including the initiator codon and stop codons.
46. Describe translation of mRNA including ribosome binding, initiator codon, stop codons and elongation and termination steps
47. Discuss translation including the reading frame, cloverleaf tRNA, codon, anticodon, wobble, large and small ribosomal subunits
48. Examine post translational protein processing

Unit II Transmission genetics, multifactorial traits, chromosomal basis of inheritance, chromosomal variations, and linkage mapping. [Supports Course SLOs # 1, 2, 3]

Learning Objectives
The student will be able to:

1. Discuss the work of Gregor Mendel (*Experiments in Plant Hybridization*, 1865)
2. Describe limitations in using humans as genetic subjects
3. Describe the utility of *Pisum sativum* in monohybrid and dihybrid genetic crosses
4. Describe experiments by which Mendel developed principles of: dominance, unit factors in pairs, random segregation of alleles into gametes, independent assortment
5. Terms and concepts: true breeding, 1st and 2nd filial generations (F1, F2), self-fertilization, cross fertilization, genotype, phenotype, homozygous, heterozygous, dominant allele, recessive allele, gene, gene locus, reciprocal cross, gamete
6. Complete problems illustrating 1 and 2 factor (monohybrid, dihybrid, test) crosses
7. Calculate phenotypic and genotypic ratios using forked line method
8. Examine use of a testcross in determining genotype of organism with dominant phenotype.
9. Utilize product rule in calculating probabilities of genetic events
10. Recognize human pedigree symbols. Employ pedigree analysis to determine if a trait is inherited in an autosomal recessive, autosomal dominant or sex-linked fashion.
11. Use pedigrees to determine genotype of particular individuals and probability of passing on a particular allele to offspring
12. Review concept of one gene: one enzyme and Garrod's work on inborn errors of metabolism
13. Examine genetic based enzyme pathway deficiencies including PKU, albinism, alkaptonuria
14. Examine autosomal dominant alleles for achondroplasia and polydactyly
15. Provide appropriate nomenclature for wildtype and mutant alleles in *Drosophila*
16. Investigate X- linked gene inheritance and discuss mechanism of criss-cross inheritance.
17. Provide examples of X-linked genetic traits and complete compute expected progeny frequencies in transmission of X-linked traits
18. Solve problems illustrating incomplete dominance, codominance (MN blood group), and multiple alleles, (human ABO blood group system)

19. Examine the effect of recessive lethal alleles on expected phenotypic ratios
20. Examine epistatic interactions. Compute the outcome of 2 gene crosses with epistasis.
21. Define penetrance, expressivity, pleiotropy, polygenic traits (continuous inheritance)
22. Examine the effects of the environment on gene expression and phenotype (age on onset, sex, temperature and chemicals)
23. Relate fertilization of egg by sperm with number of chromosomes in diploid organisms
24. Distinguish between autosomes and sex chromosomes
25. Compare sex determination systems for various animals including Drosophila and temperature determination in (some) reptiles.
26. Investigate sex determination in humans and role of TDF and the SRY.
27. Analyze X chromosome inactivation using the following concepts: Barr body, dosage compensation
28. Relate the number of Barr bodies to number of X chromosomes in a cell
29. Review karyotype for metacentric, submetacentric, acrocentric, chromosomes, p + q arms.
30. Define: polyploidy, monoploidy, aneuploidy, deletion, inversion, translocation, duplication
31. Note autosomal monosomy is lethal in humans excepting partial monosomy, 46,5p-
32. Describe a position effect that may result from a chromosomal abnormality
33. Analyze human aneuploid 47, 21+, 45, XO, 47 13+, and euploid 46, XX and 46, XY
34. Explain how a Robertsonian translocation can result in familial Down Syndrome
35. Compare amniocentesis and CVS
36. View generalities concerning the numbers of spontaneously aborted fetus versus live births of aneuploid individuals

Unit III: Genetics of viruses and bacteria, gene regulation, DNA technologies, mutation and repair, cancer genetics. [Supports SLO #s 4, 5]

Learning Objectives
The student will be able to:

1. Describe mitochondrial DNA and mt genes and explore the maternal inheritance of mitochondrial DNA
2. Examine the outcome of mt heteroplasmy and relate LHON to mt DNA disorders
3. List structural and functional aspects of virions
4. Discuss molecular mechanisms that virions use to gain entry into a cell and run a replication program.
5. Differentiate between +RNA, -RNA, ds DNA, segmented viral genome
6. Compare and contrast RNA dependent and DNA dependent RNA polymerases and RNA dependent RNA polymerases
7. Compare the family name, mode of transmission, symptoms, numbers infected, genome size, envelope, vaccine strategy of various viruses
8. Describe the *E. coli* chromosome, size of genome, and nucleoid region. Define binary fission.
9. Distinguish between a bacterial cell, colony, and lawn
10. Describe stages of bacterial growth: log, lag (exponential growth), stationary, death phases
11. Define: prototroph, auxotroph, minimal, selective, and complete media
12. Contrast nutritional, conditional, and resistance mutations in bacteria
13. Describe parasexual mating (conjugation) between F+ and F- bacteria including role of pilus-.
14. Explain why recipient cells of an Hfr mating remain F-.
15. Examine homologous recombination in a recipient, exconjugant cell
16. Analyze the creation of knockout mice via homologous recombination and provide an example of a knockout mouse used as a disease model
17. View aspects of plasmids used in transformation including ori, amp^r, plasmid size, extrachromosomal maintenance, copy number, and multiple cloning sites for insertion of foreign genes
18. Analyze mechanism of bacterial recombination via faulty head stuffing/generalized transduction
19. Contrast lysogenic and lytic infection, virulent and temperate phages
20. Explore the use of viral mediated gene therapy
21. Contrast constitutively expressed housekeeping genes and regulated genes

22. Describe an operon and the usefulness to prokaryotic cells. Define the term: polycistronic
23. Understand regulation of the lac operon by lactose (inducer), repressor, Lac I gene, promoter, RNA polymerase, structural genes Z, Y, A, beta galactosidase enzyme, operator.
24. Describe the steps involved in cloning human genes into bacteria and advantages of producing human recombinant drugs in bacteria
25. Discuss benefits and potential drawbacks of GM foods
26. Describe steps involved in cloning genes into animals (transgenic animals) and advantages of cloning genes into animals for tissue specific expression in milk.
27. Examine issues of patenting genes and organisms
28. Discuss the mechanism of gene editing by Crispr
29. Compare and contrast 3 types of cloning: gene, reproductive, and therapeutic
30. Discuss the steps involved in somatic cell nuclear transfer (SCNT) for therapeutic cloning
31. Define: pluripotent, totipotent, multipotent stem cell, blastocyst, inner cell mass, differentiation and use of embryonic stem cells (ES cells)
32. Discuss the relationship between mutation, natural selection, and evolution
33. Contrast the concepts of adaptation and mutation
34. Define mutation classifications: somatic, germinal, lethal, induced, spontaneous
35. Examine and identify point mutations classified as transitions, transversions, frameshift, nonsense, missense, and silent mutations
36. Analyze molecular aspects of genetic diseases, xeroderma pigmentosum (XP), Fragile X (FMR-1), and Li Fraumeni (p53)
37. Distinguish between the genome, transcriptome, metabolome, microbiome, and proteome
38. Define cancer, transformed cell, neoplastic cell, and protooncogene and oncogene
39. Compare benign and malignant tumors
40. Explain the concept of contact inhibition and its loss in cellular transformation
41. Examine classes of oncogenes including growth factor, growth factor receptor, and signal transducer genes and their protein products
42. Explain why cancer is considered to be a multi hit disease as in familial colon cancer
43. Review the dominant nature of oncogene alleles in cancer and the recessive nature of tumor suppressor alleles in cancer
44. Explain how predisposition genes increase susceptibility to cancer
45. Examine the processes of metastasis, apoptosis, and angiogenesis
46. Contrast carcinoma, sarcoma, and leukemia/lymphoma

Evaluation of student learning:

Exams, homework, in-class graded activities, lab quizzes and lab practicals contribute to the points in the course. Lecture is 75% of the total points. Lab contributes 25% of the total points.
All problems for assessments and graded activities are selected to evaluate student understanding of the course student learning outcomes.

% of Total Points Earned:	Final Course Grade:
93 – 100	A
90 – 92	A-
87 – 89	B+
83 – 86	B
80 – 82	B-
77 – 79	C+
70 – 76	C
60 – 69	D
0 – 59	F