COURSE OUTLINE

Course Number: BIO208
Credits: 4

Course Title: GENETICS
Hours: 3 lecture/3 laboratory

Required:

Concepts of Genetics by Robert J. Brooker
Or

Laboratory Manual for BIO208 Genetics by Laura A. Blinderman
Mercer County Community College bookstore

Course Coordinator:
Professor Laura Blinderman
Office: MS 110
Phone: 570-3833 blinderl@mccc.edu

Catalogue 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.

Prerequisites: Successful completion of BIO 101 (C grade or higher).
Course Competencies/Goals
1. Elucidate the structure, packaging, and regulation of DNA (GE 1, 2, 3, CS, A, B, F)
2. Analyze the architecture of eukaryotic and prokaryotic genes and describe the regulation of gene expression at the molecular level (GE 1, 3 CS A, B, D)
3. Explore transmission genetics and solve problems in the transmission of traits (GE 1, 2, 3, 4, 9 CS A, B, D, E, F)
4. Investigate chromosomes, sex linkage, karyotypes, and aneuploidy (GE 1, 2, 3, 9 CS A, B, D, E, F)
5. Examine microbial genetics, mechanisms of gene transfer, and the use of microbes as model organisms (GE 3, 9 CS A, B)
6. Explore techniques and goals of genomics, biotechnology, transgenics, and cloning (GE 1, 2, 3, 4, 9 CS A, B, D, E, F)
7. Elucidate the molecular mechanisms of DNA mutation and repair (GE 2, 3 CS B)
8. Investigate population and evolutionary genetics (GE1, 2, 3, 9 CS A, B, D, E, F)
9. Conduct scenario and problem-based learning in bioinformatics (GE 1, 2, 3, 4 CS A, B, D, E)
10. Develop skills in pipetting, gene cloning, bacterial transformation, restriction enzyme digestion, DNA fingerprinting, PCR, bioinformatics, gel electrophoresis, DNA and protein purification, spectrophotometry, centrifugation, and other laboratory techniques (GE 1, 2, 3, 4, 9 CS A, B, D, E, F)
11. Develop professional skills in maintaining a laboratory notebook, developing and implementing an experiment, troubleshooting, presenting data (oral and written) and collaboration with others. (GE 1, 2, 3 CS A, B, F)

General Education (GE) Knowledge Goals
Goal 1. Communication. Students will communicate effectively in speech and writing.
Goal 2. Mathematics. Students will use appropriate mathematical and statistical concepts and operations to interpret data and to solve problems.
Goal 3. Science. Students will use the scientific method of inquiry, through the acquisition of scientific knowledge.
Goal 4. Technology. Students will use computer systems or other appropriate forms of technology to achieve educational and personal goals.

MCCC Core Skills (CS)
Goal A. Written and Oral Communication in English. Students will communicate effectively in speech and writing, and demonstrate proficiency in reading.
Goal B. Critical Thinking and Problem-solving. Students will use critical thinking and problem solving skills in analyzing information.
Goal D. Information Literacy. Students will recognize when information is needed and have the knowledge and skills to locate, evaluate, and effectively use information for college level work.
Goal E. Computer Literacy. Students will use computers to access, analyze or present information, solve problems, and communicate with others.
Goal F. Collaboration and Cooperation. Students will develop the interpersonal skills required for effective performance in group situations.

Grading
Lecture: The lecture grade is based on examination grades, in-class activities, and homework assignments. The instructor must be informed within 12 hours of a missed exam. Makeup exams, given only for a valid and documented absence, are discouraged, and consist of essay questions.
Laboratory: The laboratory grade is based on pre-labs, laboratory work, attendance, and participation. The instructor will evaluate student performance throughout the semester. More than one unexcused absence will result in a lower lab grade. *There are no makeup laboratories.*

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<table>
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<tbody>
<tr>
<td>Lab exercises</td>
<td>25%</td>
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<tr>
<td>Lecture exams</td>
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<tr>
<td>Lecture homework</td>
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**Classroom conduct**

The college welcomes students into an environment that creates a sense of community pride and respect. Students are expected to follow ordinary rules of courtesy during class sessions. The instructor has the right to eject a disruptive student from the class at any time. *Phones and other devices are to be turned off prior to the start of class and are not to be used during the class or laboratory session.* Text messaging during class is not acceptable.

**Attendance**

It is a student’s responsibility to attend all classes. If a class meeting is missed, the student is responsible for content covered, announcements made in his/her absence, and for acquiring any materials distributed in class. The laboratory component of the course is critical to satisfying the course objectives. Missed laboratories and associated assignments cannot be made up. *A student who misses more than two unexcused laboratory sessions will fail the course. A passing grade must be obtained in the laboratory in order to pass the course.*

Check the MCCC website [www.mccc.edu](http://www.mccc.edu) for all weather cancellations

**Tardiness**

It is expected that students will be on time for all classes. Students late for an exam may be denied the opportunity to take the exam. A student who enters the laboratory late may not be able to participate in the lab.

**General Information**

MyMercer contains your MercerMail, financial information, class schedule, grades, and other information. [www.mccc.edu/mymercer](http://www.mccc.edu/mymercer)

A student who has special needs because of a disability is entitled to receive accommodations (Americans with Disabilities Act and Section 504 of the Rehabilitation Act of 1973). Arlene Stinson, LB 217, 570-3525, stinsona@mccc.edu

**Academic Integrity**

Cheating of any kind is not tolerated. Cheating includes copying papers or website information, presenting another person's work as one's own in any way, looking at a student's paper during a test or quiz, looking at notes during an exam or quiz, obtaining information about an exam, quiz, or any other information that other students do not have and the instructor does not intend them to have, or talking during an exam or quiz. *All violations of academic integrity will be reported to the Academic Integrity Committee.* For additional information: Refer to the MCCC Student Handbook.
### Schedule of Lecture Topics

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<thead>
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<th>WEEK</th>
<th>TOPIC</th>
<th>CHAPTER</th>
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<td>DNA structure, organization of chromosomes in prokaryotes and eukaryotes</td>
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<td>2.</td>
<td>Epigenetics and chromatin remodeling</td>
<td>12, 6</td>
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<td>3.</td>
<td>Transcription and translation</td>
<td>14, 15</td>
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<td>4.</td>
<td>Gene expression (continued), Review</td>
<td>15, 17</td>
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<tr>
<td>EXAM 1</td>
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<tr>
<td>5.</td>
<td>Mendelian genetics and extensions of Mendel, multifactorial inheritance and quantitative traits</td>
<td>2, 3,5</td>
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<td>6.</td>
<td>Chromosomal basis of inheritance</td>
<td>4, 8</td>
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<td>7.</td>
<td>Chromosome variations, linkage mapping and meiosis</td>
<td>7</td>
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<td>8.</td>
<td>Continued, Review</td>
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<tr>
<td>EXAM 2</td>
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<tr>
<td>9.</td>
<td>Genetics of viruses and bacteria</td>
<td>9, 10</td>
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<td>10.</td>
<td>Regulation of gene expression in bacteria</td>
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<td>11.</td>
<td>Cloning (gene, reproductive, therapeutic), DNA technologies</td>
<td>20, 21</td>
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<tr>
<td>12.</td>
<td>DNA mutation and repair</td>
<td>19</td>
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<td>13.</td>
<td>Cancer genetics</td>
<td>22</td>
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<tr>
<td>14.</td>
<td>Continued, Review</td>
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<td>EXAM 3</td>
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### Laboratory Schedule

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<tr>
<th>Lab</th>
<th>Topic</th>
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<tr>
<td>1</td>
<td>Laboratory Notebook and Bioinformatics: NCBI, pBLAST</td>
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<tr>
<td>2</td>
<td>Isolation of DNA</td>
</tr>
<tr>
<td>3</td>
<td>Dilutions, pipetting, metric conversions, spectrophotometry, DNA analysis.</td>
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<tr>
<td>4</td>
<td>Primer Design and DNA fingerprinting via the polymerase chain reaction (PCR)</td>
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<td>5</td>
<td>Gel electrophoresis and analysis of PCR data</td>
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<td>6</td>
<td>Mendelian Genetics, Chi Square, Probability, Pedigree analysis</td>
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<td>7</td>
<td>Lab Practical 1</td>
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<td>8</td>
<td>Cytogenetics</td>
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<td>9</td>
<td>SPRING BREAK</td>
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<tr>
<td>10</td>
<td>Transformation of bacteria</td>
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<tr>
<td>11</td>
<td>Transformation analysis and plasmid miniprep</td>
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<tr>
<td>12</td>
<td>Restriction enzyme digestion of DNA and DNA mapping</td>
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<tr>
<td>13</td>
<td>Bioinformatics exercise restriction enzymes</td>
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<tr>
<td>14</td>
<td>Lab Practical 2</td>
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THE COURSE INSTRUCTOR RESERVES THE RIGHT TO CHANGE THE SCHEDULE AND GRADING PROCEDURE AT ANY TIME
UNIT 1 (Course Goals 1, 2, 9, 10, 11)

Students will be able to:
1. Review model organisms used in genetics
2. Define genetic terms (homework assignment)
3. Distinguish between molecular, transmission, population, and quantitative genetics
4. Describe functional properties of DNA including replication, storage of information, mutation
5. Describe Meischer’s observation of nuclein
6. Analyze experiments by Griffith that uncovered a transforming factor
7. Evaluate contributions of Avery et al and Hershey and Chase to the identification of DNA as the genetic material.
8. Discuss the elucidation of the DNA double helix by Watson and Crick. Understand the significance of the X-ray diffraction data provided by Franklin.
9. Provide a description of DNA structure including base complementation, antiparallel strands, sugar/phosphate backbone, nucleotide composition, hydrogen bonding, major, minor grooves
10. Identify the 3 components of a nucleotide
11. Distinguish between purines and pyrimidines
12. Examine Chargaff’s observations of nucleotide composition in DNA
13. Contrast B-, Z-, and A-DNA
14. Review the life cycle of T2 bacteriophage
15. Explain the relationship between genomes, genes, chromosomes, and DNA
16. Examine different forms of viral DNA
17. View prokaryotic chromosome (s), plasmids, supercoiled DNA, and the nucleoid region
18. Explain role of histone proteins and nucleosomes in DNA packaging and gene expression (epigenetics)
19. Contrast heterochromatin with euchromatin and provide an example of each
20. Review unique sequence DNA
21. Compare LINEs, SINEs and dispersed DNA sequences
22. View telomeric and centromeric tandem DNA repeats
23. Distinguish between amino acids, peptides, polypeptides, and proteins
24. Understand the flow of information in gene expression, DNA \( \rightarrow \) RNA \( \rightarrow \) Protein
25. Compare and contrast the function of various types of RNA
26. Provide a detailed overview of transcription and translation
27. Distinguish between the template and non-template (coding) strands of DNA
28. Describe the role of RNA polymerase in the 5’ -> 3’ transcription of template strand of DNA
29. Compare RNA polymerase and DNA polymerase
30. Describe the role of the sigma factor in the initiation of transcription in prokaryotes
31. Distinguish between initiation and elongation of the transcript
32. Contrast upstream and downstream sequences
33. Describe the mechanism of promoters in the initiation of transcription
34. Explain cotranslation in prokaryotic cells
35. Describe eukaryotic promoters (TATA and CAAT boxes)
36. 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
37. Describe the mechanism of mRNA processing including 5’ capping and 3’ polyadenylation
38. Examine components of pre-mRNA including 5’ and 3’ untranslated regions, introns, cap, and polyA tail
39. Discuss the concept of split genes in eukaryotes
40. Describe formation of the spliceosome complex, splicing group III introns in split genes
41. Describe the genetic causes and clinical symptoms of beta thalassemia (class activity).
42. 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
43. Define alternate splicing
44. Compare primary, secondary, tertiary, and quaternary protein structures
45. 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.
46. Become proficient in the use of a codon table including the initiator codon and stop codons.
47. Describe translation of mRNA including ribosome binding, initiator codon, stop codons and elongation and termination steps
48. Discuss translation including the reading frame, cloverleaf tRNA, codon, anticodon, wobble, large and small ribosomal subunits
49. Examine post translational protein processing
50. Perform bioinformatic analyses using the NCBI databases and alignment tools (lab)
51. Research PubMed to find articles relating the use of disintegrins to modulate VEGF, angiogenesis, and cancer (lab)
52. Isolate DNA from eukaryotic cells (lab)
53. Develop skills in pipetting, spectrophotometry, PCR, DNA fingerprinting, electrophoresis (lab)
54. Analyze via electrophoresis polymorphisms in a dimorphic Alu element (lab)
55. Communicate laboratory results via oral and written communication (lab)
56. Prepare solutions and review molarity, concentration, metric system of measurement, and use of balance (lab)

UNIT 2 (Course Goals 3, 4, 10, 11)
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
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. Explain the existence of XY females and XX males.
27. Analyze X chromosome inactivation using the following concepts: Barr body, dosage compensation (calico cat example of female mosaic).
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. Spot generalities concerning the numbers of spontaneously aborted fetus versus live births of aneuploid individuals
37. Collect and statistically analyze data with respect to transmission of gene traits (lab)
38. Examine control of fur characteristics and gene product interactions in the cat (lab)
39. Examine human single gene traits and perform pedigree analysis of autosomal recessive and autosomal dominant traits (lab)
40. Utilize Chi Square analysis to determine goodness of fit of observed to predicted data (lab)
41. Perform karyotype analysis of chromosomal aberrations (lab)
42. Describe the translocation that leads to the Philadelphia chromosome and CML cancer (lab)

UNIT 3 (Course Goals 5, 6, 10, 11)
Students will be able to:
1. Describe mitochondrial DNA and mt genes
2. Discuss the endosymbiont theory of mitochondrial evolution
3. Explore the maternal inheritance of mitochondrial DNA
4. Examine the outcome of mt heteroplasmy
5. Relate LHON to mt DNA disorders
6. Examine a pedigree of maternal inheritance
7. Distinguish between plasmid, virus/phage, bacteria, and eukaryotic cell
8. List the 3 functional aspects of all virions
9. Discuss the molecular mechanism that virions use to gain entry into a cell and run a replication program. Distinguish between cytoplasmic and nuclear replication factories and provide an example of each
10. Describe the role of capsid proteins
11. View the role of the endosome in bringing the viral nucleocapsid into cell.
12. Differentiate between +RNA, -RNA, ds DNA, segmented viral genome
13. Review the recombination strategy of influenza
14. Compare and contrast RNA dependent and DNA dependent RNA polymerases and RNA dependent RNA polymerases
15. Compare the family name, mode of transmission, symptoms, numbers infected, genome size, envelope, vaccine strategy of zika, polio, herpes, and influenza viruses
16. Describe the E. coli chromosome, size of genome, and nucleoid region
17. Distinguish between a bacterial cell, colony, and lawn
18. Utilize bacterial genetic nomenclature
19. Define binary fission
20. Describe stages of bacterial growth: log, lag (exponential growth), stationary, death phases
21. Define: prototroph, auxotroph, minimal, selective, and complete media
22. Contrast nutritional, conditional, and resistance mutations in bacteria
23. Describe parasexual mating (conjugation) between F+ and F- bacteria including role of pilus
24. Explain the F factor, what it encodes, and the mechanism of transfer from F+ to F-.
25. Explain why recipient cells of an Hfr mating remain F-.
26. Examine homologous recombination in a recipient, exconjugant cell
27. Analyze the creation of knockout mice via homologous recombination and provide an example of a knockout mouse used as a disease model
28. View aspects of plasmids used in transformation including ori, amp\(^\text{r}\), plasmid size, extrachromosomal maintenance, copy number, and multiple cloning sites for insertion of foreign genes
29. Understand the relationship between competent cells and transformation
30. Describe the mechanism/steps of bacteriophage infection
31. Analyze mechanism of bacterial recombination via faulty head stuffing/generalized transduction
32. Contrast lysogenic and lytic infection, virulent and temperate phages
33. Explore the use of viral mediated gene therapy
34. Contrast constitutively expressed housekeeping genes and genes that are regulated
35. Describe an operon and the usefulness to prokaryotic cells
36. Define the term: polycistronic
37. Understand the regulation of the lac operon by lactose (inducer), repressor, Lac I gene, promoter, RNA polymerase, structural genes Z, Y, A, beta galactosidase enzyme, operator.
38. 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 (lab)
39. View examples of the use of GFP as a reporter gene (lab)
40. Review steps of gene cloning using plasmid/bacterium. Including isolation of DNA from jellyfish, isolation of GFP gene/restriction enzymes, ligating GFP gene into plasmid (lab)
41. Transform competent E. coli with a GFP-containing plasmid and calculate transformation efficiency (colonies/ug DNA) from given data (lab)

UNIT 4 (Course Goals 7, 8, 10, 11)
Students will be able to:
1. Describe the steps involved in cloning human genes into bacteria and rationale for doing so
2. Discuss the advantages of producing human recombinant drugs in bacteria
3. Provide examples of medicines produced in genetically engineered bacteria
4. Compare genomic, cDNA, and chromosome-specific libraries
5. Examine horizontal gene transfer
6. Discuss benefits and potential drawbacks of GM foods
7. Provide examples of GM plants
8. Describe steps involved in cloning genes into animals (transgenic animals)
9. Discuss the advantages of cloning genes into animals for tissue specific expression in milk.
10. Provide examples of transgenic animals used as research models, food source, medicine
11. Examine issues of patenting genes and organisms
12. Discuss the mechanism of gene editing by Crispr
13. Compare and contrast 3 types of cloning: gene, reproductive, and therapeutic
14. Discuss the steps involved in somatic cell nuclear transfer (SCNT) for therapeutic cloning
15. Discuss the ethical aspects of embryonic stem cell research
16. Define: pluripotent, totipotent, multipotent stem cell, blastocyst, inner cell mass, differentiation
17. Define the terms: mutation, natural selection
18. Discuss the relationship between mutation, natural selection, and evolution
19. Contrast the concepts of adaptation and mutation
20. Define mutation classifications: somatic, germinal, lethal, induced, spontaneous
21. Examine and identify point mutations classified as transitions, transversions
22. Describe frameshift, nonsense, missense, and silent mutations
23. Examine the point mutation in the beta hemoglobin gene that causes sickle cell disease
24. Discuss the specific causes of mutations, both spontaneous and induced
25. Examine the genetic disease, xeroderma pigmentosum
26. View the buildup of trinucleotide repeats in the promoter region of the FMR-1 gene in Fragile X syndrome
27. Understand the importance of synaptic plasticity in learning and memory
28. Discuss pharmacogenomics goals, benefits, drug absorption and metabolism differences
29. Discuss some of the benefits of pharmacogenomics
30. Describe single nucleotide polymorphisms and their potential usefulness in medicine
31. Distinguish between the genome, transcriptome, metabolome, microbiome, and proteome, providing examples of the utility of each.
32. Define cancer, transformed cell, neoplastic cell, and oncogenesis
33. Compare benign and malignant tumors
34. Explain the concept of contact inhibition and its loss in cellular transformation
35. Describe the cell cycle and its check points on growth at G1/S, G2-M, and M
36. Examine classes of oncogenes including growth factor, growth factor receptor, and signal transducer genes and their protein products
37. Contrast protooncogenes and oncogenes
38. Explain why cancer is considered to be a multi hit disease as in familial colon cancer
39. Review the dominant nature of oncogene alleles in cancer
40. Review the recessive nature of tumor suppressor alleles in cancer
41. Explain how predisposition genes increase susceptibility to cancer
42. Analyze how the loss of heterozygosity is involved in familial retinoblastoma
43. Examine the processes of metastasis, apoptosis, and angiogenesis
44. Relate Li-Fraumeni hereditary cancer syndrome to mutations in alleles encoding p53
45. Contrast carcinoma, sarcoma, and leukemia/lymphoma
46. View a short film detailing evidence to suggest that p53 is a tumor suppressor including evidence from rat fibroblasts in culture, humans, and knockout mice
47. Perform restriction enzyme digestion of DNA and analyze results (lab)
48. Perform DNA mapping using restriction enzyme data (lab)
LABORATORY SAFETY

FOOD AND DRINKS ARE NOT ALLOWED IN THE LABORATORY, ever!

Be professional
1. Be on time
2. Maintain your focus
3. Follow instructions and read procedures carefully
4. Observe safety procedures
5. Work collegially with others
6. Be prepared to spend the entire laboratory period working

When working with DNA, chemicals, and bacteria:
1. Wear gloves
2. Wash your hands with soap and water
3. Wipe down your lab bench with disinfectant before and after use
4. Read labels and follow instructions carefully
5. Do not contaminate solutions
6. Dispose of items appropriately

Note the location of:
1. eye-wash station, shower, fire blanket, fire extinguisher, and safety goggles
2. regular trash, biohazard and glass waste disposal units
3. master shut-off switch for electricity
4. unobstructed exits

Before leaving, make certain that:
1. all equipment is turned off
2. the chair is pushed in
3. all work surfaces and equipment in the chemical or biological laboratory are thoroughly cleaned and left in a neat condition
4. your hands are washed