

**MIDDLESEX COUNTY COLLEGE  
EDISON, NEW JERSEY**

Course Title: Genetics Catalogue No. Bio 228

Class Hours: 3 Laboratory Hours: 3 Credit Hours: 3

Department Chair: \_\_\_\_\_ Division Dean: \_\_\_\_\_ Date: 2007-2008

Prerequisites:

Bio 124 (or departmental approval), Chm 124 (or departmental approval), Mat 014

**Textbooks for Course:**

<b><u>Author</u></b>	<b><u>Title</u></b>	<b><u>Publisher</u></b>	<b><u>Copyright</u></b>
<b>William S. Klug and Michael R. Cummings,</b>	<b><i>Concepts of Genetics</i> 8th edition</b>	<b>Prentice Hall</b>	<b>2005</b>
<b>Harry Nickla</b>	<b><i>Student Handbook - Solutions Manual and Art Notebook</i> 8th edition</b>	<b>Prentice Hall</b>	<b>2005</b>

**Supplementary Materials:**

PedigreeLab - Biology Labs Online

**Catalogue Course Description:**

Mendelian and molecular concepts of heredity and their relationship to cell function, development, and evolution. Topics include structure, function of genes, patterns of inheritance, nature and causes of mutations, mechanisms of gene regulation and population genetics. Lab includes genetics of fruit flies, fungi, bacteria, human pedigree analysis, and modern molecular techniques.

**Course Goals:**

The goal of this course is to introduce science transfer biology majors to principles of transmission genetics, molecular genetics and modern techniques of genetic analysis as well as an exploration of the social, ethical, and legal implications of genetic advances. Emphasis will be on developing and improving critical thinking and problem solving skills.

**Course Objectives:**

1. Use elements of the scientific method to design experiments to determine inheritance of various traits.
2. Define and explain technical terms associated with classical and modern genetics.
3. Diagram and explain mitosis and meiosis as it relates to inheritance of traits.

4. Summarize the theories of Mendelian and modern genetics.
5. Perform classical genetic crosses with fruit flies and collect, analyze and evaluate data from these crosses.
6. Describe the flow of genetic information from genes to proteins.
7. Explain inheritance at the molecular level.
8. Be able to predict the probability of inheriting specific traits.
9. Evaluate environmental and genetic factors that effect phenotypic expression.
10. Relate genetic disorders to mutations in DNA and chromosomal abnormalities.
11. Summarize several methods of diagnosing genetic disorders in man.
12. List and explain the basic technologies associated with Recombinant DNA.
13. Describe, explain and evaluate controversies surrounding Recombinant DNA Technology.
14. Perform a restriction digest, electrophoresis, and analysis of DNA.
15. Transform bacteria.
16. Perform a polymerase chain reaction (PCR).

# **GENETICS**

## **LECTURE OUTLINE**

### **I. INTRODUCTION**

- A. Purpose and objectives of the course
- B. Genetics
  - 1. Definition
  - 2. History
  - 3. Importance

### **II. CHROMOSOME STRUCTURE AND ORGANIZATION**

- A. Chromosomes
  - 1. Homologous pairs
  - 2. Structure
  - 3. Karyotype
  - 4. Haploid
  - 5. Diploid
  - 6. Chromatids
  - 7. Sex Chromosomes
  - 8. Genes
  - 9. Alleles
  - 10. Polyploid
- B. Evidence for the chromosomal theory of heredity
- C. Differences between prokaryotic and eukaryotic cells

### **III. BIOLOGICAL COMMUNICATION BETWEEN GENERATIONS**

- A. Cell division/cytokinesis
  - 1. Mitosis
    - a. Interphase ( $G_1$ , S,  $G_2$ ,  $G_0$ )
    - b. Prophase
    - c. Prometaphase
    - d. Metaphase
    - e. Anaphase
    - f. Telophase
  - 2. Meiosis (reduction division), gamete formation, crossing over, and nondisjunction
    - a. Meiosis I
      - 1) Prophase I (Leptonema Diakinesis)
      - 2) Metaphase I Telophase I
    - b. Meiosis II
      - 1) Prophase II Telophase II
    - c. Spermatogenesis
    - d. Oogenesis
    - e. Fertilization (restoration of diploid number)

### **IV. MENDELIAN GENETICS**

- A. Mendel's experiments
- B. Dominant and recessive genes (elements or factors)
- C. Particulate theory of inheritance
- D. Phenotype
- E. Genotype

- F. Principle of Parental Equivalence
- G. Principle of Segregation
- H. Principle of Independent Assortment (dihybrid cross)

## V. MODIFICATIONS OF MENDELIAN INHERITANCE

- A. Incomplete/Partial Dominance
- B. Codominance
- C. Multiple Alleles
- D. Lethal Alleles
- E. Gene Interactions
- F. Sex Linkage
  - 1. Sex chromosomes
  - 2. Sex-linked inheritance
  - 3. Sex influenced and sex limited inheritance
- G. Imprinting
- H. Penetrance and Expressivity
- I. Environmental effects on inheritance

## VI. LINKAGE, CROSSING OVER, CHROMOSOME MAPPING

- A. Mechanisms of Crossing Over
- B. Methods of Mapping Cross-Over Data
- C. Somatic Cell Hybridization & Human Chromosome Mapping

## VII. CHROMOSOMAL VARIATIONS

- A. Sex Determination Systems in animals
- B. Sex differentiation
  - a. Sex determining region Y (**SRY**)
  - b. dosage sensitive sex reversal
- C. Genetic sexual disorders
  - 1. Testicular feminization (androgen insensitivity)
  - 2. Guevodoces (male pseudohermaphroditism)
  - 3. Chimeras and mosaics (true hermaphrodites)
- D. X inactivation
  - a. Barr body formation and Lyonization
  - b. Ectodermal dysplasia
  - c. Tortoiseshell cats
- E. Chromosomal aberrations
  - 1. Nondisjunction
  - 2. Aneuploidy
  - 3. Monosomy
    - a. Turner syndrome [**XO**]
  - 4. Trisomies
    - a. Klinefelter syndrome [**XXY**]
    - b. Metafemales [**XXX**] and metamales [**XYY**]
    - c. Down syndrome
    - d. Edward syndrome

- e. Patau syndrome
- 5. Polyploids
  - a. Autopolyploidy
  - b. Allopolyploidy
- 6. Deletions
- 7. Duplications
- 8. Inversions
- 9. Translocations
- 10. Isochromosomes
- 11. Fragile X

## VIII. MOLECULAR GENETICS

- A. History of discovery
- B. Chemical structure of hereditary material
  - 1. DNA
  - 2. RNA
- C. DNA replication
  - 1. prokaryotic
  - 2. eukaryotic
- D. Chromosomal Organization of DNA
  - 1. viral
  - 2. prokaryotic
  - 3. mitochondrial/chloroplast
  - 4. eukaryotic
- E. Unexpressed genetic information (hnRNA, introns and exons)
- F. Mutations
  - 1. Point mutations
  - 2. Frame shift mutations
  - 3. Mutation rates
  - 4. Somatic vs. gametic mutations
- G. DNA repair mechanisms
- H. Natural and artificial causes of mutation and cancer
  - 1. Radiation
    - a. Types of radiation
    - b. Exposure levels
    - c. Practical uses of radiation
  - 2. Chemicals
    - a. Biological test for mutagenic and carcinogenic chemicals
    - b. Ames test
  - 3. Mutations and Cancer
  - 4. Site-directed mutagenesis

## IX. GENE EXPRESSION

- A. Protein synthesis
  - 1. Transcription (DNA--> **all** RNAs)

- 2. Translation (messenger RNA--> protein)
- B. Universal Genetic Code
- C. Inborn Errors of Metabolism
- D. One-gene : one-enzyme hypothesis
- E. Protein Structure and Function

#### **X. REGULATION OF GENE EXPRESSION**

- A. Prokaryotes
  - 1. operons
- B. Lambda Phage
- C. Eukaryotes
  - 1. gene level
  - 2. RNA level
  - 3. protein level

#### **XI. BACTERIAL AND VIRAL RECOMBINATION**

- A. Conjugation
- B. Transformation
- C. Transduction

#### **XII. RECOMBINANT DNA TECHNOLOGY AND BIOTECHNOLOGY**

- A. History and Controversy
- A. Restriction Enzymes
- B. Vectors
  - 1. Plasmid
  - 2. Bacteriophage
  - 3. Cosmid
- C. Bacterial Transformation
- D. Library Construction
- E. Clone Selection
- F. Clone Analysis
  - 1. Electrophoresis
  - 2. Southern Blot
  - 3. DNA Sequencing
  - 4. PCR Analysis
- G. Applications
  - 1. Genome Projects
  - 2. Diagnosis of disease
    - a. Biochemistry
    - b. Restriction Fragment Length Polymorphism (RFLP)
    - c. Gene probes
  - 3. Gene therapy
  - 4. DNA fingerprinting

#### **XIII. GENETICS, LAW AND BIOETHICS**

Current issues, such as stem cell research, cloning, pre-implantation genetic

Diagnosis, personalized medicine, eugenics, etc.

#### **XIV. DEVELOPMENTAL GENETICS**

- A. Prokaryotes
- B. *Caenorhabditis elegans*
- C. *Drosophila melanogaster*

#### **XV. POPULATION GENETICS**

- A. Darwin - Origin of Species
- B. The Hardy-Weinberg equilibrium
  - 1. Population (species) gene pool
  - 2. Factors involved in maintaining stability of the gene pool
    - a. Random mating
    - b. Isolation
    - c. Large population size
    - d. No mutation
    - e. Lack of selection pressure
  - 3. Factors disturbing gene pool stability (causes of evolution)
    - a. Mutation
    - b. Gene flow (immigration/emigration)
    - c. Natural selection
      - 1) Stabilizing
      - 2) Directional
      - 3) Disruptive
      - 4) Sexual
      - 5) Frequency dependent
    - d. Genetic drift
      - 1) Founder effect
      - 2) Bottleneck
  - 4. Molecular Evolution

**GENETICS  
LABORATORY OUTLINE**

<b>LAB #</b>	<b>TOPIC</b>
1	Mitosis – preparation of onion root tip squashes and identification of stages of mitosis
2	Principles of Probability and Chi-Square
3	Maize Genetics – Students explore basic transmission genetics by analyzing data of monohybrid and dihybrid crosses and gene interactions using genes for color of aleurone and endosperm to determine kernel color.
4	Linkage and Crossing over in Sordaria
5	Pedigree Analysis – Students use PedigreeLab to locate genes for various genetic disorders on chromosomes using large family pedigrees and different probes
6	Human Genetics and Karyotyping – students generate a karyotype from a chromosome squash using a computer simulation and then identify the genetic condition.
7	Bioinformatics – tutorial and exercises to develop familiarity with NCBI website.
8	DNA Sequencing – Students first sequence a portion of the amylase gene using a sequencing gel and then use the NCBI website to identify the gene. Students also perform a self-guided exploration of this website.
9 - 10	DNA Fingerprinting using PCR – By amplifying a non-coding region of chromosome 16 (from their cheek cells) containing a VNTR, students can see polymorphism at this site.
11 - 12	Restriction Digestion and Mapping of DNA – Students characterize DNA by digesting it with HindIII, EcoRI, and BamHI and drawing a tentative map of restriction sites. Students practice mapping of restriction sites with many examples and problems.
13	Bacterial Transformation – Students perform a ligation and transformation and determine transformation efficiency by counting blue and white colonies based on -galactosidase activity