MIDDLESEX COUNTY COLLEGE
EDISON, NEW JERSEY
DEPARTMENT OF NATURAL SCIENCES

Course ID and Name: BIO 105: Heredity, Evolution and Society

Department: Department of Natural Sciences

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Prerequisites: Appropriate score on the college placement test or MAT 013.

Co-requisites: N/A

Course Description: An introduction to classical and modern genetics and evolutionary theory. A survey on the historic and scientific developments leading to our current concepts of heredity and evolution. The individual and societal implications of the powerful ideas and technologies associated with modern genetics and evolutionary theory. Includes computer simulations, audiovisual materials and laboratory observations (without dissection). Recommended for non-science majors.

General Education Status: Science

Credits: 4 **Lecture Hours:** 3 **Lab Hours:** 2

Learning Outcomes:
Upon successful completion of this course, student will be able to:

1. Recognize the tentative nature of science & distinguish the difference between science & pseudoscience
2. Demonstrate knowledge of the theory of natural selection to explain the evolution of organisms
3. Use the basic principles & concepts of classical & molecular genetics & recognize how they support the theory of evolution
4. Evaluate the impact of genetics and evolutionary theory on society, including a consideration of current ethical issues
5. Use the scientific method to collect and evaluate data to draw valid conclusions

Course Requirements:
Students must attend every lecture and laboratory session. Lecture performance is evaluated by exams, homework assignments, and quizzes. Laboratory performance is measured by laboratory reports, quizzes and observation of student laboratory technique.

Assessment tool	% of final grade
4 Lecture Exams	50%
Lecture and Lab Quizzes	20%
Lab. Reports, Homework	25%
Lab. Performance	5%

GRADING STANDARD:
Upon completion of the course, grades will be assigned as follows:

A = 90 - 100%
B+ = 86 - 89%
B = 80 - 85%
C+ = 76 - 79%
C = 70 - 75%
D = 60 - 69%
F = <60%

Course Content Areas:

I. Diversity of Life
II. Darwinism
III. Human Evolution
IV. Biological Communication between Generations
V. Human Genetics and Diversity

Textbooks for Course:

Author	Title	Publisher	Copyright
Cummings, M. J.	Human Heredity: Principles and Issues, With MindTap Access. 11th Edition	Cengage Learning	2016
Fowler *et.al.*	Concepts of Biology	OpenStax (Free download)	2017
R.J. Furbee, P.D. Muley	Laboratory manual	MCC	2020

Behavioral Objectives

Students will:
1. Describe the scientific method and differentiate a hypothesis from a theory
2. Discriminate between observable, objective data and subjective interpretation
3. List basic cell structures and describe their functions
4. List and explain the basic technical terms associated with classical and modern genetics
5. List and explain the basic technical terms associated with evolutionary theory

6. Describe mitosis, meiosis and gamete formation
7. Summarize the theories of Mendelian and modern genetics
8. Solve genetic problems using Punnett Squares and pedigree charts
9. List the functions of proteins in cells and organisms
10. Describe the basic method of cellular protein synthesis
11. Summarize Darwinian and modern evolutionary theory
12. Contrast the theory of natural selection with Lamarck's idea of the inheritance of acquired characteristics
13. Describe the various genetic mechanisms that contribute to individual uniqueness
14. Compare and contrast the contributions of nature (heredity) and nurture in determining observable traits in organisms
15. Describe several genetic diseases in man that are associated with chromosomal abnormalities
16. Describe several genetic diseases in man that are associated with inborn errors in metabolism
17. Summarize several methods of diagnosing genetic diseases in man
18. Describe the practices of prenatal diagnosis, genetic screening, genetic counseling and gene therapy. Be able to describe ethical considerations of these practices
19. Describe and appraise recombinant DNA techniques and current applications
20. Discuss the ethical implications of recombinant DNA research and applications
21. Evaluate the concepts of Eugenics (selective breeding in humans), and Social
22. Darwinism (survival of the fittest as it is misapplied to human society)
23. Describe the structure of DNA and how it replicates
24. Describe the processes involved in protein synthesis
25. Describe how mutations occur and their role in producing genetic variation
26. Explain how science differs from "creation science" and "intelligent design."

Lecture Outline

I. Introduction

A. Purpose and objectives of the course
B. Organic evolution
C. Genetics
D. "Creation science"
E. Applied genetics
   1. Selective breeding
   2. Cloning of plants and animals
   3. Recombinant DNA/genetic engineering
   4. Embryo fusions
   5. Transgenic organisms
   6. Gene therapy
   7. Human genome project
   8. Conservation and biodiversity (optional)

II. Diversity of Life

A. Definition and characteristics of life (metabolism, reproduction, responsiveness, mutation, adaptability, evolution, unique biological molecules, and complex organization)
B. Cell structure and function)
   1. Cell membranes
   2. Cell wall (plants)
   3. Nucleus
   10. Chloroplasts (plants)
   11. Vacuoles
   12. Endoplasmic reticulum

4. Cytoplasm
5. Nucleolus
6. Ribosomes
7. Golgi complex
8. Mitochondria
9. Lysosomes
13. Chromosomes
14. Microtubules (spindle)
15. Centrioles (animals)
16. Cilia (eukaryotes)
17. Flagella
18. Chromosome

C. Differences between prokaryotic and eukaryotic cells
D. Hierarchy of organization (cells through ecosystems)
E. Classification
   1. Linnaeus
   2. Whittaker's Five Kingdoms
   3. Woese's Three Kingdoms
   4. Cladistics
F. Hypotheses on the origin of life
   1. Special creation myths
   2. Cozmozoan (panspermia) hypothesis
   3. Oparin/Haldane (chemical/biological evolution) hypothesis
   4. Spontaneous generation
G. Time scale of evolution

III. Darwinism

A. Pre-Darwinian views
   1. **Plato** (427-347 BC) his idea of perfect form or **Essentialism** was derived from the philosophical tradition that what we can see and measure in the world is merely the superficial and imperfect representation of an underlying reality or essence. Variation is superficial, unreal, and unimportant.
   2. **Aristotle** (384-322 BC) classified living things and developed the Scala Natura that represented a discontinuous hierarchy of life. He distinguishes between descriptions of the world based on the supernatural (theology) and descriptions based on natural causes (naturalistic thought).
   3. **Buffon** (1707-1788) first true evolutionist, recognizing both the importance and ubiquity of variation, and suggesting, with reservations, an evolutionary process based on degeneracy and the inheritance of acquired characteristics.
   4. **Erasmus Darwin** (1731-1802), C. Darwin's grandfather and a speculative evolutionist. His main theses were that the Earth's history was longer than specified by **Bishop Ussher's 6,000 years age of the earth** and that all life evolved from a common source.
   5. **Lamarck** (1744-1829) advanced the first comprehensive theory of evolution and invoked the concepts of a "**CREATIVE FORCE**", "sentiment interieur" or “fluida” and the inheritance of **acquired characteristics**.
   6. **Malthus** (1766-1834) Essay on the Principle of Population. How did this influence Charles Darwin and Alfred Russel Wallace?
   7. **Cuvier** (1769-1832) Lamarck's opponent and a defender of special creation. He explained fossil remnants of extinct life forms with the theory of **CATASTROPHISM** which says that in the past, life on earth had been decimated or destroyed several times, as in the Biblical accounts of the flood, and new kinds of organisms somehow appeared after each catastrophe (migration & serial creation?). He was the founder of modern paleontology and comparative anatomy.
   8. **Lyell** (1797-1875) provided an alternative to Catastrophism with Hutton's theory of **UNIFORMATARIANISM** which held that historical changes on the earth were NOT due

to a series of catastrophes but to the same gradual changes as may be observed today -- sedimentation, volcanism, erosion, etc.

9. **Wallace** (1823-1913) an outstanding biogeographer and evolutionist who in June of 1858 sent Darwin his essay entitled On the Tendencies of Varieties to Depart Indefinitely from the Original Type. This essay **forced Darwin to finally publish** his theory.

B. Darwin's Theory (Charles Darwin, born February 12, 1809-died April 19, 1882)
   1. Voyage of the Beagle (Dec. 27, 1831-Oct. 2, 1836) - Why was this nearly 5 year voyage important in the development of Darwin's Theories?
   2. Reasons for Darwin's reluctance to publish

C. **The Origin of Species** (November 1859, first of six editions)

D. Evidence for the Theory
   1. Evidence from domestication
   2. Geographical distribution of species
   3. Comparative embryology, anatomy, and vestigial structures
   4. Geological succession and the incomplete fossil record
   5. Argument from taxonomy

E. Post-Darwinian evidence
   1. Population Genetics
      a. Population (species) gene pool
      b. Factors involved in maintaining stability of the gene pool
         1) Random mating
         2) Isolation
         3) Large population size
         4) No mutation
         5) Lack of selection pressure
      c. Evolutionary Process
         1) Mutation
         2) Gene flow (immigration/emigration)
         3) Natural selection
            a) Stabilizing b) Directional
            b) Disruptive d) Sexual
            c) Frequency dependent
         4) Genetic drift
            a) Founder effect b) Bottleneck
      d. New Species formation
   2. Recent paleontology (the growing fossil record)
      a. Continental drift and biogeography
      b. Radioactive dating
      c. Geological eras
   3. Comparative biochemistry/molecular biology
   4. Evidence from protective resemblance
      a. Industrial Melanism (peppered moth lab)
      b. Mimicry

IV. **Human Evolution**

A. Man's antecedents (Primates, Hominoids and Hominids)
1. Prosimians (Tarsier, Lemur, Galago, and Loris)
2. Anthropoids (Monkeys, Apes, and Hominids)
3. Hominids (Ardipithecus, Australopithecus, and Homo)

B. Cultural evolution (non-Darwinian and **Lamarckian in nature**)
1. Tools (2.5 **million years before present--mybp**)
2. Oldest definite "campsite" (2 mybp)
3. Last definite signs of multiple species of coexistent **hominids** (approximately (1 mybp)
4. Cave drawings (1 mybp)
5. Definite signs of controlled fire (300-700 thousand + ybp)
6. Neanderthals disappear [interbreeding with *H. sapiens*] (30,000 ybp)
7. Representational art (35,000 plus ybp)
8. Mechanical devices like bows and spear throwers (30 thousand ybp)
9. Animal domestication (10-15 thousand ybp)
10. Agriculture (7-12 thousand ybp)
11. Urbanization (5-6 thousand ybp)
12. Recorded history (6 thousand ybp)
13. Metallurgy (5 thousand ybp)
14. Industrial revolution (220 ybp)
15. Publication of Darwin's Origin of Species (140 years ago)
16. Utilization of nuclear energy (54 years ago)
17. Discovery of DNA functions (about 50 years ago)

C. Multiregional (regional continuity) **vs** monogenesis (out of Africa) **vs** combination models of modern human origins

V. Biological Communication between Generations

A. Cell division/cytokinesis
1. Mitosis
a. Interphase (Growth 1, Synthesis, Growth 2)
b. Prophase
c. Metaphase
d. Anaphase
e. Telophase
2. Meiosis (reduction division), gamete formation, crossing over, and nondisjunction
a. Diploid chromosome number
b. Haploid chromosome number
c. Fertilization (restoration of diploid number)

B. Mendelian genetics
1. Mendel's experiments
2. Dominant and recessive factors (elements or genes)
3. Particulate theory of inheritance
4. Phenotype
5. Genotype
6. Principle of Parental Equivalence
7. Principle of Segregation

8. Principle of Independent Assortment (dihybrid cross)

C. Genetics of sex
   1. Sex chromosomes
   2. Evidence for the chromosomal theory of heredity
   3. Sex determining systems (insects, fish, amphibians, reptiles, birds, and mammals)
   4. Sex-linked inheritance
      a. Hemophilia
      b. Red-green color differentiation
      c. Defective dentine (dominant & more common in females)
      d. Hypophosphatemia (dominant in females)
   5. Sex differentiation
      a. Sex determining region Y (**SRY**)
   6. Genetic sexual disorders
      a. Turner syndrome [**XO**]
      b. Klinefelter syndrome [**XXY**]
      c. Metafemales [**XXX**] and Jacob syndrome [**XYY**]

D. Molecular genetics
   1. Chemical structure of hereditary material
   2. DNA replication
   3. Protein synthesis
      a. Transcription (DNA → **all** RNAs)
      b. Translation (messenger RNA → protein)
   4. Cellular protein functions (be able to list several)
   6. Mutations
      a. Point mutations
         1) Sickle cell anemia
      b. Frame shift mutations
         1) Cystic fibrosis
      c. Mutation rates
      d. Somatic vs. reproductive cell mutations
      e. Cancer
         1) Viral causes
         2) Chemical causes
   7. DNA repair mechanism
   8. Natural and artificial causes of mutation
      a. Radiation
         1) Types of radiation
         2) Exposure levels
         3) Practical uses of radiation
      b. Chemicals
         1) Biological test for mutagenic and carcinogenic chemicals
            a) Ames test

VI. Chromosomal basis of inheritance

A. Chromosome structure
   1. Chromosome aberrations
      a. Causes

b. Types
   1) Deletion
   2) Duplication
   3) Isochromosomes
   4) Inversion
   5) Translocation
   6) Fragile sites [fragile X syndrome]

B. Mitochondrial heredity

VII. Nature (Heredity) and Nurture (Environment)

A. Phenotypic variation

B. Heritability

C. Twin studies

D. Intelligence (What is it and how would you measure it?)

E. Mental retardation and mental disease

F. Personality and behavior

G. Disease susceptibility
   1. Sickle cell anemia and malaria
   2. Blood groups A and O (A appears more susceptible to stomach cancer, pernicious anemia and diabetes while group O individuals appear more susceptible to ulcers, smallpox and pituitary adenomas)

VIII. Human Genetics and Diversity

A. Blood type polymorphism
   1. ABO blood groups
   2. Rh positive and negative

B. Photocopies- environmentally induced phenotype **NOT** characteristic of the organism's genotype under other environmental conditions.

C. Race
   1. Genetic classification (definition) of race
   2. 1952 United Nations statement on race

IX. Human Genetics

A. History
   1. Family pedigree analysis
   2. A. Garrod and The Inborn Errors of Metabolism
   3. Cytogenetic techniques
      a. Karyotyping
      b. Chromosome staining and banding patterns

B. Selected hereditary diseases (possible examples to follow)
   1. Huntington disease
   6. Glucose-6-phosphate dehydrogenase deficiency

2. Tay Sachs
3. Cystic fibrosis
4. Sickle cell anemia
5. Albinism
7. Phenylketonuria (PKU)
8. Xeroderma pigmentosa
9. Marfan syndrome
10. Galactosemia

C. Chromosomal aberrations
   1. Aneuploidy (wrong chromosome number)
   2. Trisomies
      a. Down syndrome
      b. Edward syndrome
      c. Patau syndrome
   3. Deletions
      a. Wilm's kidney tumors in babies and children
      b. Cri Du Chat
   4. Translocations

D. Consanguineous mating
   1. Effects in man
   2. Social prohibitions

E. Diagnosis of genetic disease
   1. Family pedigree analysis
   2. Prenatal diagnosis
      a. Amniocentesis
      b. Chorionic villus analysis
      c. Fetoscopy/Embryoscopy
      d. Restriction Fragment Length Polymorphism (RFLP)
      e. Preimplantation embryo biopsy (optional)
      f. Gene probes (optional)

F. Genetic counseling

G. Genetics, law and bioethics
   1. Paternity suits
   2. Wrongful birth and wrongful life suits
   3. Forensic medicine and DNA fingerprinting

H. Management of the human gene pool
   1. Eugenics (program for improving mankind by positive or negative selective breeding)
   2. Euphenics (improvement of the individual phenotype by biological means)
   3. Euthenics (improvement in environmental quality in order to improve many phenotypes)
   4. Dysgenics (causing or perceived to be causing deterioration of hereditary qualities)

I. Politics, religion, evolution, and genetics
   1. Creationism
   2. Eugenics
   3. Lysenko
   4. Recombinant DNA technologies and cloning
   5. Patenting life forms

Lab Outline

WEEK	TOPIC and Description
1	**The Scientific Method**: Using the simulation of **Stridulation** behavior in crickets, formulate and test a hypothesis on the effect of air temperature and humidity on the rate of chirping. Describe the independent, dependent, control, and controlled variables in the experiment. Analyze the data, plot a graph, and draw valid conclusions.
2	**Systematics and Taxonomy**: Classification, taxonomic levels, Domains.
3	**Evolution by Natural Selection I**: Industrial Melanism in Peppered Moth. Using the online simulation, formulate and test a hypothesis on the effect of natural selection on the survival and fitness of peppered moth. Collect data, analyze and plot a graph, draw valid conclusions.
4	**Evolution by Natural Selection II**: Evolution of Human Skin Color. Using Howard Hugh Medical Institutes documentary, evaluate the current evidence for the evolution of human skin color by Natural Selection.
5	**Evidence for Evolution-I**: Observe and evaluate the evidence for evolution based on Fossil Record. Watch a short film and evaluate and explain how paleontologists determine the past geological and biological history.
6	**Evidence for Evolution-II**: Observe and evaluate the evidence for evolution based on Comparative Anatomy. Watch a short film on the evolution of modern humans. Compare and contrast the human and rhesus macaque skeleton. Identify the homologous and vestigial structures.
7	**Microscopy and Cells**: Introduction to Microscopy, parts and function, observe various Protist, Plants, and Animal Cell permanent slides
8	**Mitosis**: Using Onion root Tip and Whitefish eggs slide observe various phases of cell division (mitosis and meiosis), compare and contrast the two types of cell divisions
9	**Meiosis**: Using Onion root Tip and Whitefish eggs slide observe various phases of cell division (mitosis and meiosis), compare and contrast the two types of cell divisions
10	**Genes in Human Populations-I**: Phenotype/Genotype determination, determine the Phenotype and probable Genotype of various traits observable in humans.
11	**Genes in Human Populations-II**: Offspring Phenotype/Genotype determination, Pedigree Analysis, various Autosomal and Sex-Linked inheritance patterns, Human Genetic Disorders and Pattern of Inheritance.
12	**Karyotes and Genetic Disorders:** Using the Karyotype for Humans, 23 autosomal pairs and one sex chromosome pair study of impact of various Genetic Disorders.
13	**DNA-The Master Molecule:** Using computer software understand basic structure of DNA, differences between DNA and RNA, DNA replication, Transcription and Translation and DNA mutations.