BIO-150H: HONORS PRINCIPLES OF BIOLOGY I

Cuyahoga Community College

Viewing: BIO-150H : Honors Principles of Biology I

Board of Trustees:
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Academic Term:
Fall 2023

Subject Code
BIO - Biology

Course Number:
150H

Title:
Honors Principles of Biology I

Catalog Description:
Honors course designed for science majors with exploration of the molecular and cellular basis of life through an introduction to cell biology, molecular biology, genetics and evolution with a strong focus on inquiry-based learning as the basis of scholarly research. Emphasis on evolution as the unifying theory in biology.

Credit Hour(s):
4

Lecture Hour(s):
3
Lab Hour(s):
3

Requisites

Prerequisite and Corequisite
ENG-1010 College Composition I with grade of "B" or higher; or ENG-101H Honors College Composition I; and MATH-0955 Beginning Algebra or qualified math placement.

Outcomes

Course Outcome(s):
Independent Research: Apply scientific methods of inquiry to develop and explore questions about the natural world, critically evaluate information, gather data and draw evidence-based conclusions and disseminate the results in written and/or oral form.

Essential Learning Outcome Mapping:
Information Literacy: Acquire, evaluate, and use information from credible sources in order to meet information needs for a specific research purpose.
Written Communication: Demonstrate effective written communication for an intended audience that follows genre/disciplinary conventions that reflect clarity, organization, and editing skills.
Quantitative Reasoning: Analyze problems, including real-world scenarios, through the application of mathematical and numerical concepts and skills, including the interpretation of data, tables, charts, or graphs.

Objective(s):
a. Distinguish among an observation, hypothesis, experiment, conclusion, and theory.
b. Critically evaluate sources of information, and distinguish between primary and secondary resources.
c. Distinguish between observations and inferences.
d. Develop an independent research project by reviewing primary literature and making qualitative and/or quantitative observations on a relevant scientific question.
e. Construct a hypothesis and design an experiment to test the hypothesis using appropriate statistical methods.
f. Revise experimental designs based on peer and instructor feedback.
g. Disseminate the results of an experiment through written laboratory reports and/or oral presentations.

h. Discuss the limitations and reproducibility of scientific data as it relates to an independent research project.
i. Demonstrate safe and proper use of lab equipment when observing specimens and performing experiments and procedures, and respond appropriately to instructor feedback as it is given.
j. Use lab equipment to collect and analyze data pertaining to metabolic processes in living organisms.

Course Outcome(s):

Chemical Aspects of Life: Evaluate the biochemical underpinnings of life including the chemical properties of atoms, molecules, and bonds as they relate to biological processes.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Distinguish among elements, atoms, compounds and molecules.
b. Describe atomic structure, the characteristics of subatomic particles, and how they determine chemical properties of an atom.
c. Explain how the atomic number, atomic mass, and mass number of an element are defined.
d. Identify the elements that make up living organisms.
e. Provide an example of how isotopes are used in biological research or medicine.
f. Explain how the behavior of electrons is central to the potential energy and reactivity of atoms.
g. Compare and contrast ionic, covalent, and hydrogen bonds, and Van der Waals interactions, and explain the importance of these in organic molecules.
h. Illustrate how the structure of a water molecule results in hydrogen bonding, and how that bonding results in the unique properties of water in living systems.
i. Explain how the concentration of free hydrogen relates to acids, bases, and the pH scale and provide an example of how acid base chemistry influences living organisms.
j. Explain how carbon atoms form the backbone of biological molecules and recognize hydrocarbons and the major functional groups.
k. Provide examples of isomers in living systems.
l. Describe and recognize the biological macromolecules including protein, lipids, nucleic acids, and carbohydrates.
m. Provide examples of the macromolecules and state their function in living organisms.
n. Explain the reactions involved in the synthesis and degradation of macromolecules.
o. Predict how the structure of a molecule will determine its function.

Course Outcome(s):

Cell: Evaluate the evidence for the evolution of cells and explore how the structure and components of a cell determines its function.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Discuss the development of the cell theory and the definition of life.
b. Evaluate the evidence for the evolutionary processes that have resulted in the similarities and differences between prokaryotic and eukaryotic cells.
c. Differentiate and define the unique features of bacteria, single-celled eukaryotes, plant cells, animal cells, and fungal cells in the laboratory by observing prepared slides and living cultures of prokaryotic and eukaryotic cells under a compound light microscope.
d. Explain the structure and function of cellular organelles and other cellular structures.
e. Evaluate the evidence for the endosymbiotic theory for the origin of the eukaryotic cell.
f. Illustrate the role of the endomembrane system by explaining how macromolecules are synthesized and distributed.
g. Evaluate the evidence for the fluid mosaic model of the cell membrane.
h. Describe the molecular composition of the plasma membrane and explain how it relates to membrane fluidity.
i. Provide examples of how membrane composition adapts in organisms living in hot or cold environments to maintain membrane fluidity.
j. Explain how proteins embedded in the plasma membrane are essential for membrane transport, cell identification, and cell signaling.

k. Compare and contrast various types of passive, active, and bulk transport.
l. Predict the net direction and rate of movement of solutes across the plasma membrane based on the type of transport, and environmental conditions.
m. Describe the role of the sodium potassium exchange pump in establishing membrane potentials.
n. Predict the impact of a solution on the shape of a cell based on the solution's tonicity.
o. Provide examples of how cells maintain osmotic balance in a given environment.
p. Explain the pathway from an extracellular chemical signal to an intracellular response.
q. Differentiate among the types of cell junctions and their roles in tissue formation and cell communication.

Course Outcome(s):

Energy: Explain the acquisition, transformation, utilization, and storage of energy in living things.

Objective(s):

a. Explain the laws of thermodynamics and how they relate to living systems.
b. Describe potential and kinetic energy, and recognize how one form of energy is converted to another.
c. Compare and contrast exergonic and endergonic reactions and describe how they relate to metabolism.
d. Discuss how metabolic pathways are emergent properties resulting from the interaction of molecules inside cells.
e. Explain the properties of enzymes and how the structure of an enzyme determines its function.
f. Predict how environmental conditions like temperature and pH can alter the molecular structure and thereby the function of enzymes.
g. Explain how enzyme inhibition or activation is used to regulate the rate of metabolic reactions in cells.
h. Describe how the structure of ATP is linked to its role in energy storage and transfer.
i. Compare and contrast aerobic respiration, anaerobic respiration and fermentation and provide examples of each.
j. Describe how a cell extracts energy from macromolecules in the presence or absence of oxygen.
k. Compare and contrast substrate-level phosphorylation, oxidative phosphorylation and photophosphorylation as a means of generating ATP for the cell.
l. Describe the role of oxidation and reduction reactions in energy transfer in the cell, recognize these reactions in metabolic pathways, and explain how electron carriers play a central role in this process.
m. Evaluate the metabolic reactions collectively known as glycolysis and explain how these reactions result in the production of ATP and electron carriers.
n. Predict the fate of pyruvate in a facultative anaerobe with or without oxygen.
o. Explain the role of fermentation in living organisms and provide examples of organisms that utilize this type of metabolism.
p. Evaluate the metabolic reactions collectively known as Kreb's cycle and explain how these reactions result in the production of ATP and electron carriers.
q. Explain how the electron carriers generated during chemical reactions are utilized by the electron transport chain to generate a proton gradient to power ATP production through chemiosmosis.
r. Review the literature on the ATP synthase to describe how scientists determine the Net ATP production from cellular respiration.
s. Locate the processes of cellular respiration in a eukaryotic cell and describe how the structure of the mitochondria facilitates its function.
t. Compare the catabolic and anabolic pathways of carbohydrates, proteins, and fats and predict how cells will utilize the pathways during energy surpluses or deficits.
u. Explain how negative feedback regulation is utilized to regulate the rate metabolism and relate this to activation and inhibition of enzymes.
v. Compare and contrast oxygenic and anoxygenic photosynthesis and provide examples of organisms that carry out each process.
w. Consider the scientific breakthroughs that lead to the modern-day understanding of photosynthesis and discuss how it exemplifies the process of science.
x. Explain how plants convert light energy into chemical energy through the process of photosynthesis.
y. Locate the major events of photosynthesis in a plant cell and describe how the structure of the chloroplast facilitates its function.
z. Explain how living organisms utilize pigment molecules to capture the energy from photons of light.
aa. Evaluate the light-dependent reactions of photosynthesis and relate the products of these reactions to the production of carbohydrates by the cell.
bb. Evaluate the light-independent reactions of photosynthesis and calculate how many carbon dioxide molecules are needed to generate one molecule of glucose.
cc. Explain how plants have evolved mechanisms to reduce photorespiration.
dd. Compare and contrast cellular respiration and photosynthesis.
ee. Explain the major events in the evolution of metabolism.

Course Outcome(s):

Continuity of Life: Evaluate how cell-cycle regulation controls cell division and development.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Describe how prokaryotes reproduce and discuss the implications on genetic diversity.
b. Compare and contrast the structure of the genetic material in prokaryotes and eukaryotes and discuss the implications for cellular division.
c. Explain the purpose of each phase of the eukaryotic cell cycle and describe how the length of the cycle varies depending on the type of cell.
d. Explain the function of DNA and why it must be replicated before cell division.
e. Describe how the structure of DNA in eukaryotic cells varies across the cell cycle.
f. Compare and contrast cytokinesis in animal and plant cells.
g. Describe how the eukaryotic cell cycle is regulated by cyclin-dependent kinases and other molecules at specific checkpoints.
h. Explain how cancer results from mutations of a tumor suppressor genes or proto-oncogenes.
i. Draw the stages of mitosis labeling the structures involved in the organization and division of the chromosomes.
j. Compare the purpose and products of mitosis and meiosis in a multicellular eukaryotic organism.
k. Identify the stages in the sexual life cycle and explain the roles of mitosis and meiosis.
l. Explain reduction division and describe when it occurs.
m. Explain the evolution of sexual reproduction and meiosis, and describe how they contribute to genetic diversity.
n. Draw the stage of Meiosis I and Meiosis II labeling the structures involved in the organization and division of the chromosomes.
o. Describe how crossing over creates recombinant chromosomes in Meiosis.
p. Describe how independent alignment of tetrad chromosomes in Meiosis I relates to genetic diversity in the daughter cells.
q. Explain how nondisjunction in meiosis can lead to aneuploid gametes.

Course Outcome(s):

Genetics: Relate molecular genetics and patterns of inheritance to genotype and phenotype.

Essential Learning Outcome Mapping:

Quantitative Reasoning: Analyze problems, including real-world scenarios, through the application of mathematical and numerical concepts and skills, including the interpretation of data, tables, charts, or graphs.

Objective(s):

a. Consider the scientific breakthroughs that lead to the modern-day understanding of molecular genetics and discuss how it exemplifies the process of science.
b. Consider the role female scientists played in the elucidation of the structure and function of DNA and discuss how their contributions were viewed then and now.
c. Evaluate the evidence that was used to develop an accurate three-dimensional model of DNA.
d. Consider how the scientific consensus on the role of DNA in heredity was altered through landmark experiments.
e. Explain the landmark study that supported the semiconservative theory of DNA replication.
f. Describe how DNA is replicated by specific enzymes in a semi-discontinuous process and link this concept to DNA synthesis in the cell cycle.
g. Define gene, genome, and gene expression in both layman's and scientific terms.
h. State the central dogma of molecular biology where genes are expressed through transcription of mRNA and translation of proteins.
i. Discuss why RNA exists as a middle man in the process of making proteins from a evolutionary perspective.
j. Explain transcriptional and post-transcriptional control of gene expression in prokaryotic and eukaryotic cells.
k. Illustrate how mutations affect genotype and phenotype, and explain the evolutionary significance of these changes.
l. Discuss the evolutionary consequences of epigenetic inheritance.
m. Identify patterns of inheritance determined by Mendelian and non-Mendelian genetics.
n. Link the Mendelian Principles of inheritance to specific behaviors of the chromosomes during meiosis.
o. Calculate probabilities for phenotypes and genotypes in offspring using the Principles of Mendelian inheritance.
p. Explain the effect of abnormal chromosome number on development and phenotype.
q. Evaluate the landmark study that provided evidence for the chromosomal theory of inheritance.

r. Explain why mitochondrial and chloroplast genes do not follow Mendelian Principles of inheritance.
s. Calculate recombination frequency as a relative measure of distance between linked genes using data from a test cross.
t. Explain how biotechnology is being used to advance our understanding of genetics, and how it is applied in medicine, agriculture, and everyday life.
u. Use one or more examples from model organisms to test the predictions for monohybrid crosses, and apply the concept of inheritance patterns to the transmission and expression of genetic traits in organisms.
v. Analyze the applications and limitations of important historical and modern innovations in molecular genetics that have enabled scientists to develop and implement tools to study and manipulate genetic material.

Course Outcome(s):

Evolution: Analyze how populations change genetically over time through the process of evolution resulting in the unity and diversity of life.

Essential Learning Outcome Mapping:

Quantitative Reasoning: Analyze problems, including real-world scenarios, through the application of mathematical and numerical concepts and skills, including the interpretation of data, tables, charts, or graphs.

Objective(s):

a. Explain the effect of a changing environment on the gene pool of a population.
b. Differentiate among the mechanisms by which populations change genetically over time.
c. Predict the impact on a population's gene pool when multiple evolutionary forces interact simultaneously.
d. Calculate allele and genotype frequencies over time in populations using the Hardy-Weinberg Principle of Equilibrium.
e. Compare how different types of selection impact phenotype distribution.
f. Use evidence to support the scientific theory of evolution.
g. Using scientific evidence and theory, address the common misconceptions and criticisms of evolution.
h. Explain how experiments can be used to test evolutionary hypotheses.
i. Explain how new species form through sympatric and allopatric mechanisms.
j. Describe the natural mechanisms that keep species reproductively isolated.
k. Explain the concepts of gradualism and punctuated equilibrium as they relate to the rate of evolution.

Course Outcome(s):

Integration of Science and Society: Discuss how scientific research may be used and/or misused in a global society.

Essential Learning Outcome Mapping:

Civic Responsibility: Analyze the results of actions and inactions with the likely effects on the larger local and/or global communities.

Objective(s):

a. Participate in discussions on the limitations and reproducibility of scientific data and how the process of science is interpreted in society.
b. Evaluate how scientific advances impact the contemporary world.
c. Practice science communication through peer-teaching and reframing of primary literature in everyday language.
d. Reflect on historical examples of scientific breakthroughs causing societal shifts.
e. Investigate the scientific contributions of individuals from under-represented populations and consider the value of diversity and inclusion in science.
f. Predict how biological research can contribute to the resolution of ethical, social, and environmental issues.

Methods of Evaluation:

a. Required research paper and/or project
b. Quizzes
c. Exams
d. Laboratory practicals
e. Written reports
f. Presentations (individual or group)
g. Poster Presentations

h. Article discussions/reviews/summaries
i. Discussion boards
j. Homework assignments
k. Case studies

Course Content Outline:

a. Concepts
   i. Characteristics of life
   ii. Cell theory
   iii. Biological hierarchy
   iv. Process of science, including observations and hypothesis testing
   v. Experimental design, including data, variables, and controls
   vi. Scientific theory
   vii. Inductive and deductive reasoning
   viii. Primary and secondary sources
   ix. Matter and elements
   x. Atomic structure
   xi. Bonds, including covalent, ionic, and hydrogen
   xii. Chemistry and properties of water
   xiii. pH, acids, bases, and buffers
   xiv. Dehydration synthesis and hydrolysis
   xv. Biological macromolecules, including carbohydrates, lipids, proteins, and nucleic acids
   xvi. Levels of protein structure
   xvii. Prokaryotic and eukaryotic cell structure
   xviii. Cell membranes and cell walls
   xix. Surface area to volume ratio
   xx. Evolution of endomembrane system and nucleus
   xxi. Endosymbiotic theory of mitochondrion and chloroplast evolution
   xxii. Evolution of structures for cell motility
   xxiii. Cell transport, including active, passive, and bulk
   xxiv. Cell-cell interactions
   xxv. Potential and kinetic energy
   xxvi. Laws of thermodynamics
   xxvii. Enzyme structure and function
   xxviii. Oxidation-reduction reactions
   xxix. ATP as an energy carrier
   xxx. Metabolic pathways
   xxxi. Feedback inhibition and activation
   xxxii. Catabolism of carbohydrates, proteins, and fats
   xxxiii. Aerobic cellular respiration (glycolysis, pyruvate oxidation, Krebs cycle, electron transport, and chemiosmosis)
   xxxiv. Anaerobic cellular respiration by methanogens and sulfur bacteria
   xxxv. Fermentation
   xxxvi. Electromagnetic spectrum
   xxxvii. Photosynthesis, including C_3 (light dependent and independent reactions), C_4, and CAM pathways
   xxxviii. Cyclic and non-cyclic phosphorylation
   xxxix. Photorespiration
   xl. Types of cellular receptors
   xli. Signal transduction pathway, including ligands, receptors, signal amplification, and response
   xlii. Prokaryotic cell division
   xliii. Eukaryotic cell cycle and mechanisms of control
   xliv. Mitosis
   xlv. Loss of cell cycle control and cancer
   xlvi. Proto-oncogenes and tumor suppressor genes
   xlvii. Eukaryotic chromosomes, including chromatids and homologues
   xlviii. Meiosis and crossing-over
   xlix. Gametogenesis in animals
   l. Embryological development in animals

li. Independent assortment and segregation of chromosomes
lii. Nondisjunction of chromosomes
liii. Aneuploid gametes
liv. Alleles
lv. Patterns of inheritance
lvi. Phenotype versus genotype
lvii. Monohybrid and dihybrid crosses
lviii. Mutation
lix. Double helix structure of DNA and complementary base pairing
lx. Semiconservative replication of DNA
lxi. Applications of biotechnology
lxii. Gene expression, including transcription and translation
lxiii. Transcriptional and post-transcriptional control of gene expression in prokaryotes and eukaryotes
lxiv. The genetic code
lxv. Theory of evolution
lxvi. Agents of evolution, including natural selection, mutation, genetic drift, gene flow, and nonrandom mating
lxvii. Types of selection, including frequency-dependent, stabilizing, disruptive, directional, sexual, and artificial
lxviii. Population genetics
lxix. Adaptations
lxx. Evidence for evolution
lxxi. Common misconceptions of evolution
lxxii. Speciation
lxxiii. Punctuated equilibrium and gradualism

b. Skills
i. Demonstrate proper lab safety procedures.
ii. Write a hypothesis.
iii. Design and perform an experiment to analyze questions about the natural world.
iv. Critically evaluate the source of information.
v. Distinguish between primary and secondary resources.
vi. Document experimental results in a written format.
vii. Gather, organize, and analyze data using computer graphing programs.
viii. Measure mass, volume, and length using the metric system.
ix. Measure liquids utilizing standard pipettes and micropipettes.
x. Calculate simple statistics, including mean, standard deviation, percent error, r-squared values, t-test, and chi-squared test.
xi. Utilize the compound microscope and dissecting microscope.
xii. Prepare wet mount slides, utilizing stains when appropriate.
xiii. Differentiate between types of prokaryotic and eukaryotic cells using a microscope.
xiv. Measure absorbance and transmittance using a spectrophotometer.
xv. Create a standard curve to determine the concentration of an unknown.
xvi. Identify stages of mitosis in animal and plant cells under the microscope.
xvii. Differentiate between sister chromatids and homologous chromosomes.
xviii. Identify early stages of development in animal embryos.
xix. Construct a Punnett square to predict genotypic and phenotypic probabilities of offspring.
xx. Identify patterns of inheritance using a pedigree.
xxi. Solve Mendelian genetics problems.
xxii. Interpret a karyotype to determine gender and chromosomal abnormalities.
xxiii. Transcribe a DNA sequence and translate an RNA sequence.
xxiv. Determine the sequence of a gene based on the amino acid sequence of a protein.
xxv. Predict the results of a mutation in a gene.
xxvi. Perform gel electrophoresis and interpret the results.
xxvii. Interpret a DNA fingerprint.
xxviii. Calculate frequencies of alleles and genotypes using the Hardy-Weinberg equation.

c. Issues
i. Relationship between structure and function
ii. The nature of science
iii. Biodiversity
iv. Evolution as a scientific theory

v. Continuity of life
vi. Cells as the basic unit of life
vii. Homeostasis
viii. Populations change over time
ix. The species concept
x. Flow of energy through living systems
xi. The unity and diversity of life due to evolution
xii. Universal nature of the genetic code

Resources

Brooker, R.J., Widmaier, E.P., Graham, L.E., & Stiling, P.D. *Biology*. 5th ed. New York: McGraw-Hill, 2020.

Clark, M. A., Douglas, M., and Choi, J. *Biology 2e*. Houston, TX: Rice University, 2018. https://openstax.org/books/biology-2e/pages/1-introduction

Dawkins, R. *The Selfish Gene.* 3rd ed. Oxford University Press, 2006.

Dolphin, W. and Vleck, D. *Biological Investigations: Form, Function, Diversity & Process*. 12th ed. New York: McGraw-Hill, 2019.

Gould, S.J. *The Structure of Evolutionary Theory.* 1st ed. Belknap Press of Harvard University Press, 2002.

Lewis, R. *Human Genetics*. 12th ed. New York: McGraw-Hill, 2018.

Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A. Ploegh, H. Martin, K. C., Yaffe, M., and Amon, A. *Molecular Cell Biology*. 9th ed. New York: W.H. Freeman, 2021.

Jenkins, C. Freer, M., Koch, J., Lehnert, M., Vaidya, E., and Kowalczyk, T. *Principles of Biology I Bio 1500 Laboratory Manual*. 3rd Ed. Minneapolis, MN: Bluedoor, 2020.

Raven, P.H., Johnson, G.B., Mason, K.A., Losos, J.B., & Singer, S.R. *Biology*. 12th ed. New York: McGraw-Hill, 2020.

Urry, L.A., Cain, M.L., Wasserman, S.A., Minorsky, P.V. and Reece, J.B. *Campbell: Biology in Focus*. 3rd ed. New York: Pearson, 2020.

Vodopich, D.S. & Moore, R. *Biology Laboratory Manual*. 12th ed. New York: McGraw-Hill, 2019.

Resources Other

a. The Biology Project - http://www.biology.arizona.edu/
b. Virtual Cell Animation Collection - http://vcell.ndsu.edu/animations/
c. Learn Genetics - http://learn.genetics.utah.edu/
d. Howard Hughes Medical Institute Biointeractive - http://www.hhmi.org/biointeractive/
e. PBS Evolution - http://www.pbs.org/wgbh/evolution/
f. Understanding Evolution – http://evolution.berkeley.edu/

g. Darwin – American Museum of Natural History - http://www.amnh.org/exhibitions/darwin/?src=h_h
h. McGraw-Hill Virtual Laboratory - http://www.mhhe.com/biosci/genbio/virtual_labs/
i. Virtual Labs Media Library - http://virtuallabs.stanford.edu/
j. NSF National Center for Case Study Teaching in Science - http://sciencecases.lib.buffalo.edu/cs/
k. Encyclopedia of Life – http://eol.org (http://eol.org/)
l. NOVA - http://www.pbs.org/wgbh/nova/

Instructional Services

OAN Number:
Ohio Transfer 36 TMNS and Transfer Assurance Guide OSC003 and OSC024 (1 of 2 courses, both must be taken)

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