CIEE Global Institute – London

Course name: Introductory Biology I (Lab course)
Course number: (GI) BIOL 2401 LNEN
Programs offering course: London Open Campus Block
Open Campus track: STEM and Society
Language of instruction: English
U.S. semester credits: 4
Contact hours: 45 lecture and 45 laboratory
Term: Fall 2019

Course Description

Introductory Biology I is designed to cover the first semester scope and sequence requirements of a typical two-semester biology course for science majors. The course provides comprehensive coverage of foundational research and core biology concepts through an evolutionary lens. This first semester will cover the chemistry of life, cell structure and function, genetics and basic evolutionary processes.

Learning Objectives

By the end of this course, students will be able to:

- Make proper measurements, understand units and their conversions, and how to quantify uncertainty in measurements.
- Use the scientific method as a basis of inquiry, including observation, hypothesis testing, data collection, analysis and drawing reasonable conclusions.
- Develop problem-solving skills by approaching biological phenomena mathematically, chemically and with physics, as well as intuitively.
- Explain the chemical foundations for life, biological macromolecules and how living things work on a chemical level.
- Describe the cellular structure of prokaryotic and eukaryotic cells, the structure and function of plasma membranes, metabolism, cellular respiration, photosynthesis, cellular communication and cellular reproduction.
- Apply knowledge of cells to understand onset and control of cancer.
- Employ the process of Meiosis and sexual reproduction to explore genetics, examining data to compare Mendellian to modern understandings of genetics.

- Analyze DNA structure and function to describe RNA and DNA replication, repair, protein synthesis, genome mapping and gene expression.

- Apply genetic knowledge to evolution, including the formation of new species, rates of speciation, evolution of populations and phylogenetic relationships between species and groups of species.

- Know and follow proper laboratory safety practices.

- Collect and report data effectively: Use correct laboratory notebook skills, spreadsheets, graphing software and regression analysis.

- Assess how Biology impacts their lives and the lives of local people.

Course Prerequisites

None

Methods of Instruction

The course will be taught using lectures, class discussions, lecture activities, reading assignments, problem sets, presentations, laboratory activities and experiments. In addition, students will visit national universities and industrial facilities, conducting interviews with local biologists and conservationists. Students will work individually and in groups in laboratory and on assigned problem sets. Students are expected to read portions of the textbook before lectures and review laboratory manual instructions before labs. Students will work in groups to present current applications of biology in their lives and in the lives of those in the local community. Students should take full advantage of generous online resources associated with the texts.

Assessment and Final Grade

Weekly Exams (Five)	25 %
Problem Sets	10 %
Laboratory	30 %
Group Presentations (Two)	10 %
Participation	5 %
Final Exam (Comprehensive)	20 %

Course Requirements

Participation

Participation is valued as meaningful contribution in the digital and tangible classroom, utilizing the resources and materials presented to students as part of the course. Meaningful contribution requires students to be prepared in advance of each class session and to have regular attendance. Students must clearly demonstrate they have engaged with the materials as directed, for example, through classroom discussions, online discussion boards, peer-to- peer feedback (after presentations), interaction with guest speakers, and attentiveness on co-curricular and outside-of-classroom activities.

Weekly Exams

Each week, students will take an exam based upon the previous week's material. These exams will include standard exam formats of True/False, Multiple Choice, Short Answer and Problem Solving. Each exam will take approximately 30 minutes and comprise 5% of the final course evaluation.

Problem Sets

Problems located at the end of each chapter of the textbook will be assigned to individuals or groups by the instructor. Student solutions to these problems will be collected and discussed in review sessions. The instructor will work through or give solutions to all problems. Similar problems will appear on weekly quizzes and the final exam. Assessment for problem sets will include timely and correct completion of problems.

Laboratory

Each lab will begin with a short quiz assessing student preparedness. This will cover material in the laboratory manual related to the lab assigned for that day. Each lab will end with a report sheet which must be turned in at the end of the lab period. All lab report sheets must be completed in ink. Report protocol will be covered in the first lab period. Points will be deducted for failing to follow these procedures or if the lab sheet is not neatly presented. A laboratory notebook will be kept, in addition to the manual, and will contain all changes to protocols, data collected and interpretation of data. Some labs will require written lab reports. The style and content of written lab reports will be given in the first lab period.

Group Presentation 1

Students will investigate how Biology impacts their daily lives and the lives of local people. This will be done in groups using information from various sources, including interviewing each other, local people and online resources. A 15 minute presentation with a demonstration using biological principles will be graded on the overall quality and information in the presentation as well as each student's part in it.

Group Presentation 2

Students measure local natural history museum specimens, between geographical locations or over time, to detect evolution. A 15-minute presentation will summarize their findings. This will include statistical analyses and presentation of trends. The presentation will be graded on the overall quality and information in the presentation as well as each student's part in it.

Final Exam

The final exam is comprehensive. As with quizzes, this exam will include standard exam formats of True/False, Multiple Choice, Short Answer and Problem Solving. It will include material from both lecture and laboratory.

Class Attendance

Regular class attendance is required throughout the program, and all unexcused absences will result in a lower participation grade for any affected CIEE course. Due to the intensive schedules for Open Campus programs, unexcused absences that constitute more than 10% of the total course will result in a written warning.

Students who transfer from one CIEE class to another during the add/drop period will not be considered absent from the first session(s) of their new class, provided they were marked present for the first session(s) of their original class. Otherwise, the absence(s) from the original class carry over to the new class and count against the grade in that class.

For CIEE classes, excessively tardy (over 15 minutes late) students must be marked absent. Attendance policies also apply to any required co-curricular class excursion or event, as well as to Internship, Service Learning, or required field placement. Students who miss class for personal travel, including unforeseen delays that arise as a result of personal travel, will be marked as absent and unexcused. No make-up or re-sit opportunity will be provided.

Attendance policies also apply to any required class excursion, with the exception that some class excursions cannot accommodate any tardiness, and students risk being marked as absent if they fail to be present at the appointed time.

Unexcused absences will lead to the following penalties:

Percentage of Total Course Hours Missed	*Equivalent Number of Open Campus Semester classes*	*Minimum Penalty*
Up to 10%	1 content classes, or up to 2 language classes	Participation graded as per class requirements
10 – 20%	2 content classes, or 3-4 language classes	Participation graded as per class requirements; **written warning**
More than 20%	3 content classes, or 5 language classes	Automatic **course failure**, and possible expulsion

Weekly Schedule

NOTE: this schedule is subject to change at the discretion of the instructor to take advantage of current experiential learning opportunities.

Week 1 The Chemistry of Life

Session 1.1: Students define biology and explore its chemistry. In doing so, they identify shared characteristics of the natural sciences, delineate steps in the scientific method, differentiate inductive vs. deductive reasoning and describe the goals of basic and applied science. They will use concepts of matter and elements to explain ways naturally occurring elements combine to make molecules, cells, tissues, organ systems and organisms. They will further explore four major classes of biological macromolecules: proteins, carbohydrates, nucleic acids and lipids.

Readings: Chapter 1 The Study of Life, Chapter 2 The Chemical Foundation of Life and Chapter 3 Biological Macromolecules, plus assigned problems at ends of chapters, and Szostak, J.W., 2017. The origin of life on Earth and the design of alternative life forms. Molecular Frontiers Journal, 1(02), pp.121-131.

Laboratory 1: Lab Check in, Basic Lab Safety, and Simple Measurement. Introduction to the Scientific Method, Biology from Microscopic to Ecosystem. Lab Notebook protocol will be explained with a post lab check. There will be a sample Pre-Lab Quiz (not graded). Students will review lab protocols, use the scientific method, graphing and statistics to approach a biological investigation, learn to use a dissecting and compound microscope and examine bacteria and protists. Students will walk with the instructor to the local market and explore how bacteria impact our lives in food and drink.

Due: Group Presentation 1

Watch: What is Biology? The Characteristics of Life. The Science Classroom. https://www.youtube.com/watch?v=7nKKoxnmTEA

Homework: Read 10 Applications of Biology in Everyday Life https://www.lifepersona.com/10-applications-of-biology-in-everyday-life and, using internet resources, come up with three additional examples.

Week 2 The Cell: Structure, Function, Respiration and Photosynthesis

Session 2.1: Cell Structure and Function. Students will describe the role of cells in organisms using cell theory. They will differentiate characteristics of prokaryotic and eukaryotic cells, plant and animal cells and their organelles. Students will explore the concept of the extracellular matrix and list ways cells communicate. They will describe the cell membrane fluid mosaic model, the phospholipid, protein and carbohydrate functions in membranes and discuss membrane fluidity. They will differentiate passive, active and bulk transport, including endo and exocytosis. Students will also understand cell metabolism, explaining the two types of metabolic pathways and discussing how chemical reactions play a role in energy transfer. They will use concepts of energy and thermodynamics, explaining how energy is released through ATP hydrolysis, as well as describing the role of enzymes in metabolic pathways.

Readings and Problem Sets: Chapter 4 Cell Structure, Chapter 5 Structure and Function of Plasma Membranes and select end of chapter problems.

Laboratory 2: The Function and Property of Cells, Movement of Molecules Across Cell Membranes. Using compound microscopes, students will used prepared and fresh and prepared slides to examine cell structure of prokaryotic, plant, fungal and animal cells. They will use aquatic plant cells to observe diffusion and osmosis. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period.

Session 2.2: Cellular Respiration. ATP as an energy source will begin student investigation into respiration and photosynthesis. Students will describe glycolysis and note net changes in ATP and NADH. They go on to explain the citric acid cycle and further ATP generation, completing the cellular respiration process by describing how electrons move through the electron transport chain in oxidative phosphorylation. Students will also explore alternate carbohydrate metabolism pathways, like metabolism without oxygen and how it may lead to fermentation. Protein, lipid metabolic pathways are also investigated as well as how cellular respiration is regulated.

Readings and Problem Sets: Chapter 6 Metabolism, Chapter 7 Cellular Respiration and assigned problems, and Cavaleri, M.A., et al. 2017. Tropical rainforest carbon sink declines during El Niño as a result of reduced photosynthesis and increased respiration rates. *New Phytologist*, *216*(1), pp.136-149.

Laboratory 3: Cellular Respiration and Photosynthesis. Students will demonstrate that microorganisms perform cellular respiration in the laboratory. They will compare classroom air with exhaled air. Students will measure the effect of exercise on carbon dioxide production, examine alternatives to aerobic respiration and begin fermentation via anaerobic respiration by making their own wine using a local fruit. Students will examine photosynthesis by comparing chlorophyll levels and cells in the leaf epidermis, measuring absorption of carbon dioxide during photosynthesis, and testing leaves for starch. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period.

Session 2.3: Photosynthesis. Students will explore photosynthesis: its importance, main structures involved and key substrates and products. They will examine the light-dependent reactions of photosynthesis, explaining how plants absorb energy from light, why only certain wavelengths will work and how and where photosynthesis takes place in a plant. They will then follow light energy captured to the production of organic molecules.

Readings and Problem Sets: Chapter 8 Photosynthesis and assigned problems.

Weekly Exam 1

Week 3 The Cell: Communication and Reproduction

Session 3.1: Cell Communication. Students will determine which molecules signal cell communication, how they propagate communication, how the cell responds and how this works in single-celled organisms. More specifically, they will describe the four types of signaling mechanisms found in multicellular organisms, compare internal receptors with cell-surface receptors and recognize the relationship between a ligand's structure and its mechanism of action. They will explain the binding of ligands and explain how it initiates signal transduction. They will also describe how signaling pathways direct protein expression, cellular metabolism and cell growth.

Readings: Chapter 9 Cell Communication and assigned problems.

Laboratory 4: Organic Molecules and Nutrition, Factors Affecting Enzyme Activity. Students will employ positive and negative indicator tests to test food samples for different molecules. They will examine a pea seed embryo and how it differs from surrounding endosperm. Students will investigate enzyme activity using demonstrations, examination of enzyme activity in food vacuoles and examine the effects of environmental conditions on protein structure. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period.

Session 3.2: Cellular Reproduction. Students investigate cellular reproduction by describing the genome structure of prokaryotic and eukaryotic cells, distinguish between chromosomes, genes, alleles and traits and describe chromosome compaction, the cell cycle, what controls the cell cycle and describe cancer as uncontrolled cell growth. Students then explore meiosis and sexual reproduction, investigating reduction division in eukaryotic cells.

Readings: Chapter 10 Cell Reproduction, Chapter 11 Meiosis and Sexual Reproduction and assigned problems.

Laboratory 5: Mitosis and Asexual Reproduction. Students will use stained onion cells to observe how mitosis works, paying close attention to identifying its different stages. They will estimate the duration of the cell cycle, as well. Students will go into the forest to study asexual reproduction in plants, how it changes with elevation and rainfall and discuss reasons why asexual reproduction is sometimes preferred. There will be a pre-lab quiz, post-lab notebook check and full laboratory report due the following lab period.

Session 3.3: Mendel's Experiments and Heredity. Students study Mengel's experiments and describe the scientific reasons they worked. In doing so, they describe the expected outcomes of mono and dihybrid crosses with dominant and recessive alleles. They apply the sum and product rules and Punnett squares to calculate probabilities of phenotypes. They also identify non-Mendellian inheritance patterns, such as incomplete dominance, codominance, recessive alleles, multiple alleles and sex linkage. Students explain Mendel's law of segregation and independent assortment in terms of genetics and events of meiosis, and the phenotypic outcomes of epistatic effects between genes. The instructor will provide a conceptual review and lead a discussion of major concepts so far, including a problem-solving workshop.

Readings: Chapter 12 Mendel's Experiments and Heredity with assigned problems.

Weekly Exam 2

Week 4 Genetics: DNA, Genes and Proteins

Session 4.1: Modern Understandings of Inheritance. Students will articulate Sutton's Chromosomal Theory of Inheritance, describe genetic linkage, explain the process of homologous recombination, describe chromosome creating and calculate the distance between genes on a chromosome. They will describe how a karyogram is created, explain how nondisjunction leads to disorders in chromosomal number, compare disorders that aneuploidy causes and describe how errors in chromosome structure occur through inversions and translocations.

Readings and Problem Sets: Chapter 13 Modern Understandings of Inheritance and assigned problems.

Laboratory 6: Connecting Meiosis and Genetics. Students begin by building a pair of chromosomes. They then demonstrate how homologous chromosomes separate in meiosis to form gametes. They will examine genotypes and look at phenotypic differences to describe how traits are passed through generations. Emphasis will be place on practicing genetic problems. A completed genetics problem set will be due at the end of the laboratory period.

Session 4.2: DNA Structure and Function. DNA transformation will be explored, and students will describe key experiments that helped identify DNA as the genetic material. They will state and explain Chargaff's rules. Students describe the structure of DNA, explain the Sanger method of DNA sequencing and compare DNA from prokaryotic and eukaryotic cells. They will apply their knowledge of DNA structure to its replication process and describe the Meselson and Stahl experiments. They will explain DNA replication in prokaryotic and eukaryotic cells, discussing the role of different enzymes and proteins. Finally, students will describe DNA mutations and explain different DNA repair mechanisms.

Readings and Problem Sets: Chapter 14 DNA Structure and Function, and assigned problems, and Pomerantz, A. et al. 2018. Real-time DNA barcoding in a rainforest using nanopore sequencing: opportunities for rapid biodiversity assessments and local capacity building. *GigaScience*, *7*(4), 033.

Laboratory 7: Introduction to Molecular Genetics. Students will remove DNA from cells while learning its biochemistry. They will build a model of a DNA molecule and describe the steps of protein synthesis, finally building a real protein. A prelab quiz and post-lab notebook check will be graded.

Session 4.3: Genes and Proteins. By the end of this session, students will be able to explain the “central dogma” of DNA-protein synthesis and describe the genetic code and how the nucleotide sequence prescribes the amino acid and the protein sequence. They will list the different steps in prokaryotic and eukaryotic transcription, discuss the role of promoters in prokaryotic transcription, describe how and when transcription is terminated, discuss the role of RNA polymerases and explain the significance of transcription factors. Students will explore RNA processing in eukaryotes by describing the different steps in RNA processing, delineating exons, introns and splicing for mRNAs and explain how tRNAs and rRNAs are processed. They will also describe different steps in protein synthesis and the role of ribosomes in protein synthesis.

Readings and Problem Sets: Chapter 15 Genes and Proteins, and assigned problems

Weekly Exam 3

Week 5 Gene Expression

Session 5.1: Gene Expression, Biotechnology and Genomics. Students discuss why every cell does not express all of its genes all of the time, describe how prokaryotic gene regulation occurs at the transcriptional level and discuss how eukaryotic gene regulation occurs at the epigenetic, transcriptional, post-transcriptional, translational and post-translational levels. They will describe steps in prokaryotic gene regulation, explaining activators, inducers and repressors in gene regulation. For eukaryotes, students will explain how chromatin remodeling controls transcriptional access, describe how access to DNA is controlled by histone modification and describe how DNA methylation is related to epigenetic gene changes. They will go on to discuss the role of transcription factors in gene regulation and explain how enhancers and repressors regulate gene expression. Students will understand RNA splicing and explain its role in regulating gene expression and describe the importance of RNA stability in gene regulation.

Moreover, students will understand the process of translation and discuss its key factors, describe how the initiation complex controls translation and explain the different ways post-translational control of gene expression takes place. Finally, students will describe how changes to gene expression can cause cancer, explain how changes to gene expression at different levels can disrupt the cell cycle and discuss how understanding regulation of gene expression can lead to better drug design.

Readings and Problem Sets: Chapter 16 Gene Expression

Laboratory 8: Human Genetics. Students will use various human phenotypic characters to link phenotype to genotype in the classroom population and their family lineages. They will see which traits are sex-linked and learn why. They will examine theoretical family histories to explore codominance and sickle-cell disease, extending this to codominance with multiple alleles. Students will use online sources to investigate and give genetic explanations for hemophilia, albinism and other human conditions. There will be a pre-lab quiz and post-lab homework check.

Session 5.2: Biotechnology and Genomics. Students will begin by describing gel electrophoresis, explain molecular and reproductive cloning and describe biotechnology uses in medicine, agriculture and conservation. They will define genomics, describe genetic and physical maps and use genomic mapping methods. They will describe three types of sequencing and define whole-genome sequencing. Students will investigate different ways genomics is applied, including pharmacogenomics. Special emphasis will be placed on the application of genomics to biodiversity conservation.

Readings and Problem Sets: Chapter 17 Biotechnology and Genomics and assigned problems, with Nicholls, H., 2015. De-extinction: A behemoth revived *Nature*, *521*(7550), p.30.

Laboratory 9: Applications of Genomics. Students will use online resources to investigate and report on genomic applications to ecology and conservation, human health and agriculture. They will present case studies highlighting new technology and associated methodology to address human caused problems and challenges. A final essay on the ethics, cost and likelihood of success will be turned in by the end of the laboratory period.

Session 5.3: Evolution and the Origin of the Species. Students will describe how scientists formulated our present theory of evolution. To do so, they will define adaptation, explain convergent and divergent evolution, describe homologous and vestigial characters and discuss misconceptions about the theory of evolution. They will define species and describe how scientists delineate species, describe genetic variables that lead to speciation, identify prezygotic and postzygotic reproductive barriers, explain allopatric and sympatric speciation and describe adaptive radiation. Students will also describe pathways of species evolution in hybrid zones and explain two major theories on rates of speciation.

Readings and Problem Sets: Chapter 18 Evolution and Origin of Species and assigned problems.

Weekly Exam 4

Week 6 Evolutionary Processes

Session 6.1: The Evolution of Populations. We will begin by defining population genetics and describe how scientists use population genetics to study evolutionary trends in populations. Students will define the Hardy-Weinberg principle and discuss its importance. They will describe different types of variation in a population, explain why only natural selection can act upon heritable variation, describe genetic drift and the bottleneck effect and explain how each evolutionary force can influence a population's allele frequency. Students will then explain the different ways natural selection can shape populations and describe how these different forces can lead to different outcomes in terms of population variation.

Readings and Problem Sets: Chapter 19 The Evolution of Populations, and assigned problems, and Johnson, M.T. and Munshi-South, J., 2017. Evolution of life in urban environments. *Science*, *358*(6363), p.8327.

Laboratory 10: Evolution lessons from museums. Students will investigate evolution between species at the local natural history museum. Students will summarize museum displays on key aspects of evolution. They will examine and measure museum specimens between locations or over time. They will statistically analyze data, reporting their findings to other groups at the end of the lab period using PowerPoint.

Due: Group Presentations

Session 6.2: Phylogenies and the History of Life. Students will analyze how life is organized using phenotypic and genetic information. To begin, students will discuss the need for a comprehensive classification system, list the different levels of the traditional taxonomic classification system, describe how systematics and taxonomy related to phylogeny and discuss a phylogenetic tree's components and purpose. They will compare homologous and analogous traits, discuss the purpose of cladistics and describe maximum parsimony. Students will describe horizontal gene transfer, illustrate how prokaryotes and eukaryotes transfer genes horizontally. They will then identify the web and ring models of phylogenetic relationships and describe how they differ from the original phylogenetic tree concept.

Readings and Problem Sets: Chapter 20. Phylogenies and the History of Life, with assigned problems and Krienitz, L., Huss, V.A. and Bock, C., 2015. Chlorella: 125 years of the green survivalist. *Trends in plant science*, *20*(2), pp.67-69.

Laboratory 11: Constructing a Phylogeny. Students will use genetic data to construct a phylogenetic web and ring of a taxon of their choosing. This will be constructed using freeware online and will include statistical estimates of confidence. Several trees will be constructed, and students will choose the one that statistically best describes the relationship. Students will then add additional genetic information and see how that changes hypothesized relationships. A formal lab report will be due at the end of the laboratory period.

Weekly Exam 5

Session 6.3: Comprehensive Review, Problem Set Workshop and Final Exam

Course Materials

Textbooks

Biology, Second Edition. 2018. M.A. Clark, J. Choi and M. Douglas, OpenStax College

Thinking about Biology: An Introductory Laboratory Manual 2015. M. Bres and A. Weisshaar, Pearson Education, Inc.

Readings

Cavaleri, M.A., Coble, A.P., Ryan, M.G., Bauerle, W.L., Loescher, H.W. and Oberbauer, S.F., 2017. Tropical rainforest carbon sink declines during El Niño as a result of reduced photosynthesis and increased respiration rates. *New Phytologist*, *216*(1), pp.136-149.

Johnson, M.T. and Munshi-South, J., 2017. Evolution of life in urban environments. *Science*, *358*(6363), p.8327.

Krienitz, L., Huss, V.A. and Bock, C., 2015. Chlorella: 125 years of the green survivalist. *Trends in plant science*, *20*(2), pp.67-69.

Nicholls, H., 2015. De-extinction: A behemoth revived. *Nature*, *521*(7550), p.30.

Pomerantz, A., Peñafiel, N., Arteaga, A., Bustamante, L., Pichardo, F., Coloma, L.A., Barrio-Amorós, C.L., Salazar-Valenzuela, D. and Prost, S., 2018. Real-time DNA barcoding in a rainforest using nanopore sequencing: opportunities for rapid biodiversity assessments and local capacity building. *GigaScience*, *7*(4), p. giy033.

Szostak, J.W., 2017. The origin of life on Earth and the design of alternative life forms. *Molecular Frontiers Journal*, *1*(02), pp.121-131.

Online Resources

Biology Student Resources. 2018. Openstax. Rice University
https://d3bxy9euw4e147.cloudfront.net/oscms-prodcms/media/documents/openstax_getting_started_guide_student.pdf