Core Learning Outcomes

These are the BIG IDEAS that you should walk away with and hold on to by the time class is over.

Specifically, at the end of this course, you should be able to:

1. Design and conduct experiments to predict and explain simple chemical and biological principles.
2. Explain how the first and second laws of thermodynamics predict the interactions of molecules.
3. Describe life's underlying chemical composition, including the basic features of atomic structure and bonding, the importance of water in living systems, and the general structure and function of carbohydrates, phospholipids, proteins, enzymes and nucleic acids.
4. Compare & contrast cells of the three domains: Bacteria, Archaea and Eukarya Correlate the molecular composition of cells with their cell structures; explain the structure and function of eukaryotic organelles.
5. Describe the physical structures of phospholipid bilayer membranes and their associated proteins in cells, and explain the various mechanisms by which small molecules interact with or traverse cell membranes to change cell behavior.
6. Describe the properties and processes common to all cells, including exchange with the external environment, transport across selectivity permeable membranes, homeostasis, and the enzymatic promotion of chemical reactionse.
7. Explain the concept that cells transform energy and recycle matter; specifically, that photosynthesis transforms light energy to chemical energy that is then accessible to all cells through cellular respiration. Diagram energetic coupling and the energetics and metabolism of cells and organisms.
8. Describe how one cell becomes two. Explain the roles of cellular reproduction in living cells, including the processes and outcomes of DNA replication, mitosis and meiosis.
9. Describe the structure and heritable nature of genetic material. Explain how genotype controls phenotype in simple Mendelian and non-Mendelian inheritance patterns. Use the principles of independent assortment and segregation of alleles to predict the results of genetic crosses involving two or more traits when the genes involved are linked or unlinked.
10. Use the Central Dogma to explain how a gene encodes for a protein. Diagram the structure and regulation of DNA and RNA, and the information flow that results in a protein. Explain how gene expression is regulated and how this idea relates to cellular differentiation.
11. Explain the biological basis of biotechnology tools and how they are used to engineer solutions to biological problems.
12. Discuss basic ideas of the theory of evolution, including mutation, variation, and natural selection.
13. Analyze scientific data and apply quantitative skills to biological situations.

Course Materials

Required Text: OpenStax Biology, 2e – free! -
https://openstax.org/details/books/biology-2e
We discuss chapters 1-18 in CBEN110

Course Learning Objectives

These are SPECIFIC CONCEPTS and IDEAS that we go over during the semester.

1. Use statistics to analyze quantitative data.
2. Describe the scientific method used by biologists to design experiments and solve problems in real-life situations.
3. Explain the value of order of magnitude approaches in biology.
4. Recall metric prefixes (e.g., giga, milli, micro, nano) and their values.
5. Calculate first-order magnitude estimates, such as the density of data storage of a virus.
6. Compare and provide examples of nonpolar covalent bonds, polar covalent bonds, ionic bonds, and hydrogen bonds.
7. Use the pH scale to compare acids and bases, and explain how buffers maintain a relatively constant pH.
8. Analyze data and draw conclusions from scatter plots.
9. Identify the seven major functional groups, their structural formulas, and basic properties.
10. Explain how biomolecules are built up and broken down by dehydration and hydrolysis reactions.
11. Compare and contrast the structures and functions of monosaccharides, disaccharides, and polysaccharides.
12. Compare and contrast the structures and functions of fats, lipids, and steroids.
13. Draw an amino acid and describe how side chains affect its function and structure.
14. Describe the four levels of protein structure, including stabilizing bonds, and predict how environmental conditions can denature proteins.
15. Determine the best techniques for studying cell structure and function.
16. Identify the size-scale of different cell types.
17. Describe the structures and functions of cellular components.
18. Predict the consequences of organelle malfunctions in cells.
19. Explain how cells traffic proteins to specific locations.
20. Describe the three steps common to all signaling pathways.
21. Describe how epinephrine triggers glycogenolysis via a signaling pathway.
22. Predict how signal transduction pathways can be affected by stimuli.
23. Sketch a phospholipid's molecular structure and explain why phospholipids form bilayers in water.
24. Predict the fluidity and permeability of a plasma membrane based on various factors.

25. Predict how substances will cross a selectively permeable membrane based on their properties and concentrations.
26. Predict how water will move via osmosis across a membrane.
27. Define the difference between passive and active transport, providing examples of each.
28. Describe the structure and function of DNA and RNA.
29. Write the complementary sequence of a DNA molecule.
30. Explain the steps involved in DNA replication and how errors are corrected.
31. Evaluate experimental designs and analyze data identifying DNA as the genetic information molecule.
32. Estimate the size and length of DNA through experimental approaches.
33. Calculate replication times given the speed of DNA polymerase.
34. Describe differences between bacterial and eukaryotic transcription.
35. Describe the central dogma of molecular biology and explain how transcription and RNA processing occur.
36. Transcribe a DNA sequence into an mRNA sequence.
37. Analyze gel electrophoresis data.
38. Calculate the rate of transcription based on experimental data.
39. Explain how proteins are translated from mRNA and apply the genetic code to deduce the protein encoded by mRNA.
40. Predict the causes and impacts of DNA mutations on protein structure and function.
41. Explain how gene expression is regulated and how cells in a multicellular organism express different genes.
42. Predict the outcomes of regulatory events on gene expression.
43. Explain the four phases of the eukaryotic cell cycle and the events of mitosis.
44. Analyze flow cytometry data to predict consequences of aberrations during mitosis.
45. Describe and illustrate the changes in a cell during meiosis and compare them with mitosis.
46. Explain contributions of independent assortment, crossing over, and fertilization to genetic variation.
47. Predict how errors in meiosis may lead to non-disjunctions.
48. Explain Mendel’s principles of segregation and independent assortment.
49. Calculate expected genotype and phenotype frequencies in monohybrid and dihybrid crosses using Punnett squares.
50. Compare dominant and recessive alleles and their roles in incomplete dominance, codominance, epistasis, and X-linked genes.
51. Analyze crosses and pedigrees to determine if phenotypes are autosomal or X-linked, and dominant or recessive.
52. Define evolution and apply the four mechanisms of evolution to various scenarios.
53. Use evidence to support the theory that life evolved from abiotic forces.
54. Explain how abiotic vesicles can grow, compete, and store energy, and analyze data confirming their dynamic behaviors.

55. Explain steps to produce a recombinant vector and design one for specific purposes.
56. Explain how PCR works and how genetically modified organisms are produced.
57. Evaluate the pros and cons of genetically modified crops.
58. Explain how CRISPR works to edit genomes and predict its effects on cells or organisms.
59. Use BLAST to compare nucleic acid and protein sequences and analyze sequence information.
60. Describe types of changes that can occur to entire genomes and analyze dot plots for genome sequence similarities and differences.
61. Recall the inputs and outputs of cellular respiration and relate them to energy extraction.
62. Compare the relative energy provided by various molecules and compute the efficiency of energy extraction by cells.
63. Predict how energy output scales with the mass of an organism.
64. Define energy and describe its major forms.
65. Explain in mathematical terms and plain English how changes in entropy and potential energy determine reaction spontaneity.
66. Compare and contrast exergonic and endergonic reactions.
67. Explain the role of enzymes in chemical reactions, the importance of active sites, and how enzymes are regulated.
68. Analyze genetic circuits and interpret their functions.
69. Explain how potential energy in fatty acids, proteins, and carbohydrates is converted into 2-carbon molecules and reduced electron carriers.
70. Explain how cellular respiration produces ATP from high potential energy molecules.
71. Describe the steps of cellular respiration, including reactants, products, and electron transfers.
72. Explain how the energy in food molecules generates the H+ gradient used to make ATP.
73. Predict the effects of interference in cellular respiration steps.
74. Explain how plants capture energy from sunlight and convert it into potential energy.
75. Describe the steps of photosynthesis, including reactants, products, and electron transfers, and predict the effects of interference.