Cell Biology Learning Framework

Topic	Learning Goals (see below for sample Learning Objectives)
Membrane Structure and Function	How do varied membrane composition and the structural features of component macromolecules in different cells contribute to membrane function?
	How do solutes and other materials move across membranes?
Nuclear Structure and Function	How does the structure of the nucleus affect chromosome organization and gene expression?
Cytoskeleton Structure and function	How do the different components of the cytoskeleton support a variety of cell functions, such as cell shape, division, movement, sensing the environment, and cell-cell communication?
Cell cycle and cell division	How do cells conduct, coordinate, and regulate nuclear and cell division?
Cell Communication	How do cells send, receive, and respond to signals from their environment, including other cells?
Matter & Energy Transformation	How do cells transform energy and cycle matter?
Cellular Specialization	How can and why do cells with the same genomes have different structures and functions?
Multicellularity & Cell Connections	How do cells connect to each other and organize to function as a collective entity?
Protein Targeting & Trafficking	How are cellular components targeted and distributed to different regions and compartments of a cell?
Evolutionary History of Cells	How does evolutionary history explain the similarities and differences among cells?
Methods & Tools of Cell Biology	How do the methods and tools of cell biology enable and limit our understanding of the cell?

Topic	Learning Goals	Sample Learning Objectives
Membrane Structure and Function	How do varied membrane composition and the structural features of component macromolecules in different cells contribute to membrane function?	Draw the structure of a lipid and explain how the structure allows a lipid bilayer to spontaneously assemble in an aqueous environment
		Explain the importance of membrane lipid and protein component structural asymmetries in membrane function.
		Describe the process by which membranes grow, are turned over, or are absorbed
		Explain why different membranes have different lipid and protein constituents
	How do solutes and other materials move across membranes?	Given a set of molecules of differing solubility in water, predict their relative rates of diffusion across a membrane bilayer.
		Compare and contrast the properties and functions of channels and carriers.
		Given data about the relative concentrations of solutes on both sides of a membrane, predict the direction of solute flow.
		Design an experiment that distinguishes between different modes of crossing the membrane, such as diffusion, facilitated diffusion, active transport
Nuclear structure and function	How does the structure of the nucleus affect chromosome organization and gene expression?	Describe the arrangement of chromosomal DNA in the nucleus and how it changes during the cell cycle.
		Compare and contrast how the presence of a nucleus in eukaryotes and its absence in prokaryotes alters the dynamics of gene expression.
		Design an experiment to demonstrate the role of the nuclear pore complex.
		From an evolutionary perspective, propose a mechanism that gave rise to the eukaryotic nucleus.
		Diagram where ribosomal components are synthesized and where they are assembled.
Cytoskeleton Structure/function	How do the different components of the cytoskeleton support a variety of cell functions, such as cell shape, division, movement, sensing the environment, and cell-cell communication?	Compare the characteristics and functions of microfilaments, microtubules, and intermediate filaments.
		Compare the structure and dynamic properties of microtubules versus actin and how these properties contribute to the different functions of these polymers in cells
		Explain how motor proteins harness energy to move along cytoskeletal tracks
Cell cycle and cell division (mitosis and meiosis)	How do cells conduct, coordinate, and regulate nuclear and cell division?	Predict how a mutation or other functional alteration in a cytoskeletal protein will affect the progress of nuclear and cytoplasmic division.
		Defend the argument that the presence of a cell wall in plants and fungi requires a different method for dividing the cytoplasm than that used in animals.
		Evaluate the relative contribution of mutations in tumor suppressor genes and proto-oncogenes in the development of cancer
		Assess the usefulness and limitations of information obtained from several experimental techniques (i.e., TEM, atomic force microscopy, fluorescent antibody labeling, and confocal fluorescence time lapse microscopy) in dissecting

		cytoskeletal roles in nuclear and cell division.
		Compare different methods used to coordinate cell division in different cell types.
		Compare and contrast organization of the mitotic spindle in animal, fungal, and plant cells and discuss the evolutionary and functional relevance.
Cell Communication	How do cells send, receive, and respond to signals from their environment, including other cells?	Explain how a cell's interactions with its environment can influence cell morphology, behavior, division, or survival.
		Compare and contrast the molecular mechanisms of membrane receptor-mediated and nuclear receptor-mediated signal transduction.
		Describe different mechanisms by which a membrane-bound receptor can affect cell physiology or behavior.
		Choose an everyday human experience and explain how it is mediated by cellular changes due to an external signal.
		Describe how the presence of gap junctions alters cellular responses to extracellular signals.
Matter & Energy Transformation	How do cells transform energy and cycle matter?	list the types of energy used by cells and give examples of when / in what cells / situations the different energy sources are used
		explain why energy transformations are necessary in the cell
		Diagram the energy transformations used in glycolysis, respiration and photosynthesis in a plant cell
		Explain how cyanide, an electron transport chain inhibitor, impacts oxygen consumption within animal cells
Cell Specialization	How can and why do cells with the same genomes have different structures and functions?	Describe the role of differential gene regulation causes cell differentiation.
		Compare and contrast the structure and function of different cell types.
		Predict how a drug with a known target would affect the function of a specific cell type (e.g., a neuron).
		Evaluate the strength and limitations of pieces of evidence in support of the claim that a particular inherited diseases affects a specific cell type.
		Evaluate the benefits of cell specialization in organisms with varying degrees of complexity.
		Evaluate evidence in support of the claim stem cells have great potential in the treatment of a variety of human diseases.
Multicellularity & Cell Connections	How do cells connect to each other and organize to function as a collective entity?	Differentiate the ways plant, animal and fungal cells are connected to each other and exchange materials independent of membrane transport.
		Evaluate the claim that colonial organisms are multicellular.
		Compare and contrast cell communication in unicellular and multicellular organisms in response to pathogens, symbionts, and physical and chemical signals.
		Evaluate the importance of cell-cell communication in coordinating function in multicellular organisms.

		Given an example of apoptosis, analyze its potential effect on fitness of the organism.
Protein Targeting & Trafficking	How are cellular components targeted and distributed to different regions and compartments of a cell?	Discuss the differences in structure of a protein occupying its target destination in the cell and immediately after translation from the mRNA
		Explain the mechanism and function of the unfolded protein response and its value to the cell.
		Compare the general mechanisms that allow some newly synthesized proteins to be released into the cytoplasm, whereas others are directed into other cellular compartments
		Identify the different cellular compartments in a eukaryotic cell and their main functions in the cell
		Analyze data to determine the path taken by a protein that normally resides in an organelle/compartment or is secreted from the cell from its site of synthesis to its final destination
		Given data on effects of drugs and other functional manipulations on entry of various molecules and particles into the cell, determine what pathway is used for entry
		Compare the molecular recognition events and mechanisms required for movement of proteins through different uptake and secretion pathways
Evolutionary History of Cells	How does evolutionary history explain the similarities and differences among cells?	Evaluate data about the evolutionary relatedness among eukaryotes, archae, and bacteria, including caveats or limitations
		Evaluate the case for cytoskeleton evolution from bacterial components.
		Describe the major types of genomic changes that are important in cellular and organism evolution
		Compare and contrast cellular structure and function in eubacteria, archae and eukaryotes in the context of their evolutionary history.
		Construct an explanation for the interrelatedness of photosynthesis and respiration in an evolutionary context.
Methods & Tools	How do the methods and tools of cell biology enable and limit our understanding of the cell?	Assess the usefulness and limitations of information obtained different types of microscopy.
		Describe different strategies to break open cells and isolate cellular organelles.
		Give an example of how the study of temperature-sensitive mutants was instrumental in elucidating the details of a cellular pathway.