Topic 1: Cell Biology[1]

1.1: Introduction to cells

ESSENTIAL IDEA: The evolution of multicellular organisms allowed cell specialization and cell replacement.

NATURE OF SCIENCE:

1. **Looking for trends and discrepancies--although most organisms conform to cell theory, there are exceptions.**
2. **Ethical implications of research--research involving stem cells is growing in importance and raises ethical issues.**

THEORY OF KNOWLEDGE:

How can we distinguish living from non-living?

Understandings:

DCS Topic Code	Statement	Guidance
1.1.U1	According to the cell theory, living organisms are composed of cells.	
1.1.U2	Organisms consisting of only one cell carry out all functions of life in that cell.	Students will name and briefly explain these functions of life: nutrition, metabolism, growth, response, excretion, homeostasis and reproduction.
1.1.U3	Surface area to volume ratio is important in the limitation of cell size	
1.1.U4	Multicellular organisms have properties that emerge from the interaction of their cellular components.	
1.1.U5	Specialized tissues can develop by cell differentiation in multicellular organisms.	

[1] Note: Practicals shown in red are prescribed by the IB. Practicals in bold black are additional lab investigations.

1.1.U6	Differentiation involves the expression of some genes and not others in a cell's genome.	
1.1.U7	The capacity of stem cells to divide and differentiate along different pathways is necessary in embryonic development and also makes stem cells suitable for therapeutic uses.	
1.1.A1	Questioning the cell theory using atypical examples, including striated muscle, giant algae and aseptate fungal hyphae.	
1.1.A2	Investigation of functions of life in Paramecium and one named photosynthetic unicellular organism.	*Chlorella* or *Scenedesmus* are suitable photosynthetic unicells, but *Euglena* should be avoided as it can feed heterotrophically.
1.1.A3	Use of stem cells to treat Stargardt's disease and one other named condition.	
1.1.A4	Ethics of the therapeutic use of stem cells from specially created embryos, from the umbilical cord blood of a new-born baby and from an adult's own tissues.	
1.1.S1	Use of a light microscope to investigate the structure of cells and tissues, with drawing of cells. Calculation of the magnification of drawings and the actual size of structures and ultrastructures shown in drawings or micrographs. **(PRACTICAL 1)**	Scale bars are useful as a way of indicating actual sizes in drawings and micrographs.

1.2: Ultrastructure of cells

ESSENTIAL IDEA: Eukaryotes have a much more complex cell structure than prokaryotes.

NATURE OF SCIENCE:

1. **Developments in scientific research follow improvements in apparatus--the invention of the electron microscopes led to greater understanding of cell structure.**

THEORY OF KNOWLEDGE:

The world we inhabit is limited by the world that we see. Is there any distinction to be drawn between knowledge claims dependent upon observations made by sense perception and knowledge claims dependent upon observations assisted by technology?

Understanding, Applications, and Skills

DCS Topic Code	Statement	Guidance
1.2.U1	Prokaryotes have a simple cell structure without compartmentalization.	
1.2.U2	Eukaryotes have a compartmentalized cell structure.	
1.2.U3	Electron microscopes have a much higher resolution than light microscopes.	
1.2.A1	Structure and function of organelles within exocrine gland cells of the pancreas and within palisade mesophyll cells of the leaf.	
1.2.A2	Prokaryotes divide by binary fission.	
1.2.S1	Drawing of the ultrastructure of prokaryotic cells based on electron micrographs.	Drawings of prokaryotic cells should show the cell wall, pili and flagella, and plasma membrane enclosing cytoplasm that contains 70S ribosomes and a nucleoid with naked DNA.
1.2.S2	Drawing of the ultrastructure of eukaryotic cells based on electron micrographs.	Drawings of eukaryotic cells should show a plasma membrane enclosing cytoplasm

		that contains 80S ribosomes and a nucleus, mitochondria and other membrane-bound organelles are present in the cytoplasm (RER, Golgi, SER). Some eukaryotic cells have a cell wall.
1.2.S3	Interpretation of electron micrographs to identify organelles and deduce the function of specialized cells.	

Topic 1.5: The origin of cells

ESSENTIAL IDEA: There is an unbroken chain of life from the first cells on Earth to all cells in organisms alive today.

NATURE OF SCIENCE:

1. **Testing the general principles that underlie the natural world--the principle that cells only come from pre-existing cells needs to be verified.**

THEORY OF KNOWLEDGE:

Biology is the study of life, yet life is an emergent property. Under what circumstances is a systems approach productive in biology and under what circumstances is a reductionist approach more appropriate? Do scientists decide between competing approaches?

Understandings, Applications and Skills

DCS Topic Code	Statement	Guidance
1.5.U1	Cells can only be formed by division of pre-existing cells.	Students should be aware that the 64 codons in the genetic code have the same meanings in nearly all organisms, but that there are some minor variations that are likely to have accrued since the common origin of life on Earth.
1.5.U2	The first cells must have arisen from non-living material.	
1.5.U3	The origin of eukaryotic cells can be explained by the endosymbiotic theory.	Evidence for the endosymbiotic theory is expected. The origin of eukaryotic cilia and flagella does not need to be included.

1.5.A1	Evidence from Pasteur's experiments that spontaneous generation of cells and organisms does not now occur on Earth.	

1.3: Membrane Structure

ESSENTIAL IDEA: The structure of biological membranes makes them fluid and dynamic.

NATURE OF SCIENCE:

1. **Using models as representations of the real world--there are alternative models of membrane structure.**
2. **Falsification of theories with one theory being superseded by another--evidence falsified the Davson-Danielli model**

THEORY OF KNOWLEDGE:

Under what circumstances is it important to learn about theories that were later discredited?

Understandings, Applications and Skills

DCS Topic Code	Statement	Guidance
1.3.U1	Phospholipids form bilayers in water due to the amphipathic properties of phospholipid molecules.	Amphipathic phosolipids have HYDROPHOBIC and HYDROPHILIC properties.
1.3.U2	Membrane proteins are diverse in terms of structure, position in the membrane and function.	
1.3.U3	Cholesterol is a component of animal cell membranes.	
1.3.A1	Cholesterol in mammalian membranes reduces membrane fluidity and permeability to some solutes.	
1.3S1	Draw the fluid mosaic model.	Drawings of the fluid mosaic membrane model can be 2-dimensional rather than 3-dimensional. Individual phospholipid

		molecules should be shown using the symbol of a circle with 2 parallel lines attached: 
1.3S2	Analyze evidence from electron microscopy that led to the proprosal of the Davson-Danielli model that led to the Singer-Nicolson model.	
1.3S3	Analyze the falsification of the Davson-Danielli model that led to the Singer-Nicolson model.	

1.4: Membrane Transport

ESSENTIAL IDEA: Membranes control the composition of cells by active and passive transport.

NATURE OF SCIENCE:

1. **Experimental design--accurate quantitative measurement in osmosis experiments are essential.**

Understandings, Skills and Applications

DCS Topic Code	Statement	Guidance
1.4.U1	Particles move across membranes by simple diffusion, facilitated diffusion, osmosis and active transport.	
1.4.U2	The fluidity of membranes allows materials to be taken into cells by endocytosis or released by exocytosis. Vesicles move materials within cells.	
1.4.A1	Structure and function of sodium-potassium pumps for active transport and potassium channels for facilitated diffusion in axons.	
1.4.A2	Tissues or organs to be used in medical procedures must be bathed in a solution with the same osmolarity as the cytoplasm to prevent osmosis.	
1.4S1	Estimation of osmolarity in tissues by bathing samples in hypotonic and hypertonic solutions **(PRACTICAL 2)**	Osmosis experiments are a useful opportunity to stress the need for accurate mass and volume measurements in scientific experiments.