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| **1.1.U1** | **According to the cell theory, living organisms are composed of cells.*** State the three parts of the cell theory.
* Outline evidence that supports the cell theory.
* Compare the use of the word theory in daily language and scientific language.
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| **1.1.U2** | **Unicellular organisms carry out all functions of life.*** Outline eight functions of life.
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| **1.1.U3** | **Cell Surface to volume is an important limitation to cell size.*** ​Outline the activities occurring in the volume and at the surface of the cell.
* Calculate the surface area, volume and SA:V ratio of a cube.
* Explain the benefits and limitations of using cubes to model the surface area and volume of a cell.
* Describe the relationship between cell size and the SA:V ratio of the cell.
* Explain why cells are often limited in size by the SA:V ratio.
* List three adaptations of cells that  maximize the SA: volume ratio.
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| **1.1.U4** | **Multicellular organisms have properties that emerge due to the interaction of their cellular components.*** Define and provide an example of unicellular and multicellular organism.
* List characteristics of cells in a multicellular organism.
* Define and give examples of emergent properties.
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| **1.1.U5** | **Specialized tissues can develop by cell differentiation in multicellular organisms.*** Define tissue.​
* Outline the benefits of cell specialization in a multicellular organism.
* Define differentiation.
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| **1.1.U6** | **Differentiation involves the expressions of some genes and not others in a cell’s genome.*** Describe the relationship between cell differentiation and gene expression.
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| **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.*** Define zygote and embryo.
* List 2 key properties of stem cells that have made them on the active areas of research in biology and medicine today.
* Explain why stem cells are most prevalent in the early embryonic development of a multicellular organism.
* Contrast the characteristics of embryonic, umbilical cord and adult somatic stem cells.
* Define totipotent, multipotent and pluripotent.
 |
| **1.1.A1** | **Questioning the cell theory using atypical examples, including striated muscle, giant algae and aseptate fungal hyphae.*** Describe features of striated muscle fibers that make them an atypical example cell.
* Describe features of aseptate fungal hyphae  that make them an atypical example cell.
* Describe features of giant algae that make them an atypical example cell.
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| **1.1.A2** | **Investigation of functions of life in Paramecium and one named photosynthetic unicellular organism.*** Describe characteristics of *Paramecium* that enable it to perform the functions of life.
* Describe characteristics of *Chlamydomonas* that enable it to perform the functions of life
 |
| **1.1.A3** | **Use of stem cells to treat Stargardt’s disease and one other named condition*** Outline the cause and symptoms of Stargardt’s disease.
* Explain how stem cells are used in the treatment of Stargardt’s disease.
* Outline the cause and symptoms of leukemia.
* Explain how stem cells are used in the treatment of leukemia.
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| **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.*** + List the source and mechanism of obtaining stem cells.
	+ Outline the benefits and drawbacks in using embryonic, cord blood and adult stem cells.
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| **1.1.S1** | **Use of a light microscope to investigate the structure of cells and tissues.***Practical 1** Label the names of parts of the microscope.
* Given the magnification of the ocular and objective lenses, calculate the total microscope magnification.
* Measure the field of view diameter of a microscope under low power.
* Calculate the field of view diameter of a microscope under medium or high power.
* Estimate the size of a sample in the microscope field of view.
* Demonstrate how to focus the microscope on  a sample.
* Demonstrate how to make a temporary “wet mount” on a microscope slide.
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| **1.1.S2** | **Drawing of cell structures as seen with the light microscope.*** Demonstrate how to draw cell structures seen with a microscope using sharp, carefully joined lines and straight edge lines for labels.
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| **1.1.S3** | **Calculation of the magnification of drawings and the actual size of structures and ultrastructures shown in drawings or micrographs.*** Define micrograph.
* State why the magnification of a drawing or micrograph is not the same as the magnification of the microscope.
* Use a formula to calculate the magnification of a micrograph or drawing.
* If given the magnification of a micrograph or drawing, use a formula to calculate the actual size of a specimen.
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| **1.1.NOS1** | **Looking for trends and discrepancies- although most organisms conform to cell theory, there are exceptions.*** Define “trend” and “discrepancy.”
* Explain why “trends and discrepancies” are useful in scientific study.
* List features of cells that would be considered a “trend”.
* List examples of cell types or organisms that are “discrepancies” to the cell theory.
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| **1.1NOS2** | **Ethical implications of research- research involving stem cells is growing in importance and raises ethical issues.*** Explain why biological research must take ethical issues into consideration.
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| **1.2.U1** | **Prokaryotes have a simple cell structure without compartmentalization.*** Outline the major differences between prokaryotic and eukaryotic cells.
* List the functions of the following structures of a prokaryotic cell:  cell membrane, nucleoid, plasmid, cytoplasm, ribosome, cell wall, pili, capsule, and flagella.
* Define extracellular.
* Contrast the size of eukaryotic and prokaryotic ribosomes.
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| **1.2.U2** | **Eukaryotes have a compartmentalized cell structure.*** State the meaning and advantages of eukaryotic cells being  “compartmentalized.”
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| **1.2.U3** | **Prokaryotes divide by binary fission.*** Define asexual reproduction.
* Outline the four steps of binary fission.
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| **1.2.U4** | **Electron microscopes have a much higher resolution than light microscopes.*** Define resolution.
* Compare the maximum resolutions of a light microscope with those of an electron microscope.
* List three example structures that are visible with electron microscopes but not with a light microscope.
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| **1.2.A1** | **Structure and function of organelles within exocrine gland cells of the pancreas.*** State the function of an exocrine gland cell.
* Describe the function of the following structures in an exocrine gland cell:  plasma membrane, nucleus, mitochondria, Golgi apparatus, lysosomes, vesicles and endoplasmic reticulum.
 |
| **1.2.A2** | **Structure and function of organelles within palisade mesophyll cells of the leaf.*** State the function of a palisade mesophyll cell.
* Describe the function of the following structures in a palisade mesophyll cell:  cell wall, plasma membrane, chloroplasts, vacuole, nucleus, and mitochondria.
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| **1.2.S1** | **Drawings of the ultrastructure of prokaryotic cells based on electron micrographs.*** Explain why the ultrastructure of prokaryotic cells must be based on electron micrographs.
* Draw the ultrastructure of E.coli, including the cell wall, pili, flagella, plasma membrane, cytoplasm, 70s ribosomes, and nucleoid with naked DNA.
 |
| **1.2.S2** | **Drawings of the ultrastructure of eukaryotic cells based on electron micrographs.*** Recognize features and identify structures in micrographs of eukaryotic cells (inclusive of the plasma membrane, cytoplasm, free 80s ribosomes, nucleus, rough endoplasmic reticulum, Golgi apparatus, lysosome, mitochondria, chloroplast, vacuoles, vesicles, centrioles, microtubules, cilia, flagella and cell wall).
* Given a micrograph, draw and label the ultrastructure of a eukaryotic cell.
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| **1.2.S3** | **Interpretations of electron micrographs to identify organelles and deduce the function of specialized cells.*** Explain why cells with different functions will have different structures.
* Identify ultrastructures visible in a micrograph of a eukaryotic cell.
* Given a micrograph of a cell, deduce the function of the cell based on the structures present.
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| **1.2****NOS** | **Developments in scientific research follows improvements in apparatus- the invention of the electron microscopes led to greater understanding of cell structure.*** With reference to a specific example, explain how an improvement in apparatus allowed for greater understanding of cell structure.
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| **1.3.U1** | **Phospholipids form bilayers in water due to the amphipathic properties of phospholipid molecules.*** Draw a simplified diagram of the structure of the phospholipid, including a phosphate-glycerol head and two fatty acid tails.
* Define hydrophilic and hydrophobic.
* Define amphipathic and outline the amphipathic properties of phospholipids.
* Explain why phospholipids form bilayers in water, with reference to hydrophilic phosphate heads and two hydrophobic hydrocarbon tails.
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| **1.3.U2** | **Membrane proteins are diverse in terms of structure, position in the membranes and function.*** State the primary function of the cell membrane.
* Contrast the structure of integral and peripheral proteins.
* List at least four functions (with example) of membrane bound proteins.
* Contrast the two types of transport proteins:  pumps and channels.
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| **1.3.U3** | **Cholesterol is a component of animal cell membranes.*** Identify the structure of cholesterol in molecular diagrams.
* Describe the structural placement of cholesterol within the cell membrane.
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| **1.3.A1** | **Cholesterol in mammalian membranes reduces membrane fluidity and permeability to some solutes.*** Describe the function of cholesterol molecules in the cell membrane.
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| **1.3.S1** | **rawing of the fluid mosaic model.*** Draw and label the structure of membranes.  Include:
	+ Phospholipid bilayer
	+ Integral proteins shown spanning the membrane
	+ Peripheral proteins on membrane surface
	+ Protein channels with a pore
	+ Glycoproteins with a carbohydrate side chain
	+ Cholesterol between phospholipids in the hydrophobic region
	+ An indication of thickness (10nm)
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| **1.3.S2** | **Analysis of evidence from electron microscopy that led to the proposal of the Davson-Danielli model.*** Describe the observations and conclusions drawn by Davson and Danielli in discovering the structure of cell membranes.
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| **1.3.S3** | **Analysis of the falsification of the Davson-Danielli model that led to the Singer-Nicolson model.*** Describe conclusions about cell membrane structure drawn from freeze-etched electron micrograph images of the cell membrane.
* Describe conclusions about cell membrane structure drawn from cell fusion experiments.
* Describe conclusions about cell membrane structure drawn from improvements in techniques for determining the structure of membrane proteins.
* Compare the Davson-Danielli model of membrane structure with the Singer-Nicolson model.
 |
| **1.3.****NOS1** | **Using models as representations of the real world-there are alternative models of membrane structures.*** Explain what models are and their purposes in science.
* Describe the observations and conclusions drawn by Gorter and Grendel in discovering the structure of cell membranes.
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| **1.3.****NOS2** | **Falsification of theories with one theory being superseded by another-evidence falsified the Davson-Danielli model.*** Describe why the understanding of cell membrane structure has changed over time.
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| **1.4.U1** | **Particles move across membranes by simple diffusion, facilitated diffusion, osmosis and active transport.*** Describe simple diffusion.
* Explain two example of simple diffusion of molecules into and out of cells.
* Outline factors that regulate the rate of diffusion.
* Describe facilitated diffusion.
* Describe one example of facilitated diffusion through a protein channel.
* Define osmosis.
* Predict the direction of water movement based upon differences in solute concentration.
* Compare active transport and passive transport.
* Explain one example of active transport of molecules into and out of cells through protein pumps.
 |
| **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.*** Describe the fluid properties of the cell membrane and vesicles.
* Explain vesicle formation via endocytosis.
* Outline two examples of materials brought into the cell via endocytosis.
* Explain release of materials from cells via exocytosis.
* Outline two examples of materials released from a cell via exocytosis.
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| **1.4.U3** | **Vesicles move materials within cells.*** List two reasons for vesicle movement.
* Describe how organelles of the endomembrane system function together to produce and secrete proteins (rough ER, smooth ER, Golgi and vesicles).
* Outline how phospholipids and membrane bound proteins are synthesized and transported to the cell membrane.
 |
| **1.4.A1** | **Structure and function of the sodium-potassium pumps for active transport and potassium channels for facilitated diffusion in axons.*** Describe the structure of the sodium-potassium pump.
* Describe the role of the sodium-potassium pump in maintaining neuronal resting potential.
* Outline the six steps of sodium-potassium pump action.
* Describe the structure of the potassium channel.
* Describe the mechanism of potassium movement through the potassium channel.
* Explain the specificity of the potassium channel.
* Describe the action of the “votage gate” of the potassium channel.
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| **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.*** Explain what happens to cells when placed in solutions of the same osmolarity, higher osmolarity and lower osmolarity.
* Outline the use of normal saline in medical procedures.
 |
| **1.4.S1** | **Estimation of osmolarity in tissues by bathing samples in hypotonic and hypertonic solutions. (Practical 2)*** Define osmolarity, isotonic, hypotonic and hypertonic.
* Calculate the percentage change between measurement values.
* Calculate the mean value of a data set.
* Calculate the standard deviation value of a data set.
* State that the term standard deviation is used to summarize the spread of values around the mean, and that 68% of the values fall within one standard deviation of the mean.
* Explain how the standard deviation is useful for comparing the means and the spread of data between two or more samples.
* Determine the correct type of graph to represent experimental results.
* State that error bars are a graphical representation of the variability of data.
* Accurately graph mean and standard deviation of data sets.
* Determine osmolarity of a sample given changes in mass when placed in solutions of various tonicities.
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| **1.4.****NOS** | **Experimental design- accurate quantitative measurements in osmosis experiments are essential.*** Define quantitative and qualitative.
* Determine measurement uncertainty of a measurement tool.
* Explain the need for repeated measurements (multiple trials) in experimental design.
* Explain the need to controlled variables in experimental design.
 |
| **1.5.U1** | **Cells can only be formed by division of preexisting cells.*** Discuss two implications of all cells being formed from preexisting cells.
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| **1.5.U2** | **The first cells must have arisen from non-living material.*** Outline the four processes needed for the spontaneous origin of cells on Earth.
* Outline the experiments of Miller and Urey into the origin of organic compounds.
* Define polymerization, monomer and polymer.
* Outline two properties of RNA that would have allowed it to play a role in the origin of life.
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| **1.5.U3** | **The origin of eukaryotic cells can be explained by the endosymbiotic theory.*** State the endosymbiosis theory.
* Outline the major events in the origin of eukaryotic cells.
* Describe the evidence for the endosymbiotic theory.
 |
| **1.5.A1** | **Evidence from Pastuer’s experiments that spontaneous generation of cells and organisms does not now occur on Earth.*** Define spontaneous generation.
* Describe Pasteur’s experiments about spontaneous generation.
* Explain why Pasteur’s experiments did not support the idea of spontaneous generation.
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| **1.5.****NOS** | **Testing the general principles that underline the natural world- the principles that cells only come from pre-existing cells needs to be verified.*** Explain historical thinking about spontaneous generation (what did people think and why did they think it?).
* Define conformity bias and give an example of conformity bias in the historical study of life.
* Outline the experiments of Redi and Spallanzani.
* List reasons why biologists now universally accept that cells only come from preexisting cells.
 |
| **1.6.U1** | **Mitosis is division of the nucleus into two genetically identical daughter nuclei.*** State the function of mitosis.
* List four processes which involve mitosis.
* State the names of the four phases of mitosis.
* Draw typical eukaryotic cells as they would appear during the interphase and the four phases of mitosis.
* Outline four events that occur during prophase.
* Outline the process of metaphase, inclusive of the role of microtubules and the kinetochore.
* Outline the process of anaphase.
* Outline four events that occur during telophase.
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| **1.6.U2** | **Chromosomes condense by supercoiling during mitosis.*** Describe the structure of a replicated chromosome, include the centromere and sister chromatids.
* Explain why chromosomes must condense during mitosis.
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| **1.6.U3** | **Cytokinesis occurs after mitosis and is different in plants and animal cells.*** Define cytokinesis.
* State the difference between mitosis and cytokinesis.
* Contrast cytokinesis in plant and animal cells.
* Describe the formation of the cleavage furrow in animal cell cytokinesis.
* Describe the formation of the middle lamella and cell wall in plant cell cytokinesis.
 |
| **1.6.U4** | **Interphase is a very active phase of the cell cycle with many processes occurring in the nucleus and cytoplasm.*** List example metabolic reactions occurring during cell interphase.
* Outline events of G1, S, G2 and G0 phases of interphase.
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| **1.6.U5** | **Cyclins are involved in the control of the cell cycle.*** Explain the role of cyclin and cyclin-CDK complexes in controlling the cell cycle.
* State the role of cyclins D, B, A and E in the cell cycle.
 |
| **1.6.U6** | **Mutagens, oncogenes and metastasis are involved in the development of primary and secondary tumors.*** Define tumor, benign, malignant, metastasis, cancer, mutagen and carcinogen.
* Describe why mutagens are not necessarily carcinogens.
* Describe how cancer arises, referring to accumulation of mutations over time.
* Explain the relationship between oncogenes, tumor suppressor genes and cancer.
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| **1.6.A1** | **The correlation between smoking and incidence of cancers.*** Explain the use of correlations to determine the relationship between two variables (inclusive of positive and negative correlations).
* Explain why the existence of a correlation does not necessitate a causal relationship between two variables.
* Calculate a correlation coefficient using Pearson's R.
* Determine if a correlation coefficient value is significant.
* Define significant as related to the relationship between two variables.
* Use epidemiological case study information to outline the relationships between smoking and cancer.
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| **1.6.S1** | **Identification of phases of mitosis in cells viewed with a microscope or in a micrograph.*** Determine the phase of mitosis of a cell viewed in a micrograph or with a microscope.
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| **1.6.S2** | **Determination of a mitotic index from a micrograph*** State the formula for calculation of a mitotic index.
* Calculate the mitotic index of a tissue as seen in a micrograph.
* Outline the use of mitotic index calculations in diagnosis and treatment of cancer
 |
| **1.6.****NOS** | **Serendipity and scientific discoveries- the discoveries of cyclins was accidental.*** Outline the discovery of cyclins including the role of serendipity.
 |