

Programa de estudios de biología

Distribuido en Colombia por:



Topic 1: Cell Biology - 15 Hours for Both SL and HL			VRLab Academy Experiment
Subtopic	Subtopic Number	Points to Understand	
Introduction to cells	1,1	<ul style="list-style-type: none"> • According to the cell theory, living organisms are composed of cells • Organisms consisting of only one cell carry out all functions of life in that cell • Surface area to volume ratio is important in the limitation of cell size • Multicellular organisms have properties that emerge from the interaction of their cellular components • Specialized tissues can develop by cell differentiation in multicellular organisms • Differentiation involves the expression of some genes and not others in a cell's genome • 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 	<p><u>Blood Vessels VR</u></p>
Ultrastructure of cells	1,2	<ul style="list-style-type: none"> • Prokaryotes have a simple cell structure without compartmentalization • Eukaryotes have a compartmentalized cell structure • Electron microscopes have a much higher resolution than light microscopes 	
Membrane structure	1,3	<ul style="list-style-type: none"> • Phospholipids form bilayers in water due to the amphipathic properties of phospholipid molecules • Membrane proteins are diverse in terms of structure, position in the membrane and function • Cholesterol is a component of animal cell membranes 	
Membrane transport	1,4	<ul style="list-style-type: none"> • Particles move across membranes by simple diffusion, facilitated diffusion, osmosis and active transport • The fluidity of membranes allows materials to be taken into cells by endocytosis or released by exocytosis. Vesicles move materials within cells 	
The origin of cells	1,5	<ul style="list-style-type: none"> • Cells can only be formed by division of pre-existing cells 	

		<ul style="list-style-type: none"> • The first cells must have arisen from non-living material • The origin of eukaryotic cells can be explained by the endosymbiotic theory 	
Cell division	1,6	<ul style="list-style-type: none"> • Mitosis is division of the nucleus into two genetically identical daughter nuclei • Chromosomes condense by supercoiling during mitosis • Cytokinesis occurs after mitosis and is different in plant and animal cells • Interphase is a very active phase of the cell cycle with many processes occurring in the nucleus and cytoplasm • Cyclins are involved in the control of the cell cycle • Mutagens, oncogenes and metastasis are involved in the development of primary and secondary tumours 	

Topic 2: Molecular Biology - 21 Hours for Both SL and HL			VRLab Academy Experiment
Subtopic	Subtopic Number	Points to Understand	
Molecules to metabolism	2,1	<ul style="list-style-type: none"> • Molecular biology explains living processes in terms of the chemical substances involved • Carbon atoms can form four covalent bonds allowing a diversity of stable compounds to exist • Life is based on carbon compounds including carbohydrates, lipids, proteins and nucleic acids • Metabolism is the web of all the enzyme-catalysed reactions in a cell or organism • Anabolism is the synthesis of complex molecules from simpler molecules including the formation of macromolecules from monomers by condensation reactions • Catabolism is the breakdown of complex molecules into simpler molecules including the hydrolysis of macromolecules into monomers 	<p><u>Blood Vessels VR</u></p> <p><u>Photosynthesis Experiment</u></p> <p><u>Enzymes Experiment</u></p>
Water	2,2	<ul style="list-style-type: none"> • Water molecules are polar and hydrogen bonds form between them • Hydrogen bonding and dipolarity explain the cohesive, adhesive, thermal and solvent properties of water • Substances can be hydrophilic or hydrophobic 	<p><u>Anatomy VR</u></p>
Carbohydrates and lipids	2,3	<ul style="list-style-type: none"> • Monosaccharide monomers are linked together by condensation reactions to form disaccharides and polysaccharide polymers • Fatty acids can be saturated, monounsaturated or polyunsaturated. • Unsaturated fatty acids can be cis or trans isomers • Triglycerides are formed by condensation from three fatty acids and one glycerol 	

Proteins	2,4	<ul style="list-style-type: none"> • Amino acids are linked together by condensation to form polypeptides • There are 20 different amino acids in polypeptides synthesized on ribosomes • Amino acids can be linked together in any sequence giving a huge range of possible polypeptides • The amino acid sequence of polypeptides is coded for by genes • A protein may consist of a single polypeptide or more than one polypeptide linked together • The amino acid sequence determines the three-dimensional conformation of a protein • Living organisms synthesize many different proteins with a wide range of functions • Every individual has a unique proteome 	
Enzymes	2,5	<ul style="list-style-type: none"> • Enzymes have an active site to which specific substrates bind • Enzyme catalysis involves molecular motion and the collision of substrates with the active site • Temperature, pH and substrate concentration affect the rate of activity of enzymes • Enzymes can be denatured • Immobilized enzymes are widely used in industry 	
Structure of DNA and RNA	2,6	<ul style="list-style-type: none"> • The nucleic acids DNA and RNA are polymers of nucleotides • DNA differs from RNA in the number of strands present, the base composition and the type of pentose • DNA is a double helix made of two antiparallel strands of nucleotides linked by hydrogen bonding between complementary base pairs 	
DNA replication, transcription and translation	2,7	<ul style="list-style-type: none"> • The replication of DNA is semi-conservative and depends on complementary base pairing • Helicase unwinds the double helix and separates the two strands by breaking hydrogen bonds • DNA polymerase links nucleotides together to form a new strand, using the pre-existing strand as a template 	

		<ul style="list-style-type: none"> • Transcription is the synthesis of mRNA copied from the DNA base sequences by RNA polymerase • Translation is the synthesis of polypeptides on ribosomes • The amino acid sequence of polypeptides is determined by mRNA according to the genetic code • Codons of three bases on mRNA correspond to one amino acid in a polypeptide • Translation depends on complementary base pairing between codons on mRNA and anticodons on tRNA
Cell respiration	2,8	<ul style="list-style-type: none"> • Cell respiration is the controlled release of energy from organic compounds to produce ATP • ATP from cell respiration is immediately available as a source of energy in the cell • Anaerobic cell respiration gives a small yield of ATP from glucose • Aerobic cell respiration requires oxygen and gives a large yield of ATP from glucose
Photosynthesis	2,9	<ul style="list-style-type: none"> • Photosynthesis is the production of carbon compounds in cells using light energy • Visible light has a range of wavelengths with violet the shortest wavelength and red the longest • Chlorophyll absorbs red and blue light most effectively and reflects green light more than other colours • Oxygen is produced in photosynthesis from the photolysis of water • Energy is needed to produce carbohydrates and other carbon compounds from carbon dioxide • Temperature, light intensity and carbon dioxide concentration are possible limiting factors on the rate of photosynthesis

Topic 3: Genetics - 15 Hours for Both SL and HL

VRLab Academy Experiment

Subtopic	Subtopic Number	Points to Understand	
Genes	3,1	<ul style="list-style-type: none"> • A gene is a heritable factor that consists of a length of DNA and influences a specific characteristic • A gene occupies a specific position on a chromosome • The various specific forms of a gene are alleles • Alleles differ from each other by one or only a few bases • New alleles are formed by mutation • The genome is the whole of the genetic information of an organism • The entire base sequence of human genes was sequenced in the Human Genome Project 	
Chromosomes	3,2	<ul style="list-style-type: none"> • Prokaryotes have one chromosome consisting of a circular DNA molecule • Some prokaryotes also have plasmids but eukaryotes do not. -Eukaryote chromosomes are linear DNA molecules associated with histone proteins • In a eukaryote species there are different chromosomes that carry different genes • Homologous chromosomes carry the same sequence of genes but not necessarily the same alleles of those genes. -Diploid nuclei have pairs of homologous chromosomes. -Haploid nuclei have one chromosome of each pair • The number of chromosomes is a characteristic feature of members of a species • A karyogram shows the chromosomes of an organism in homologous pairs of decreasing length • Sex is determined by sex chromosomes and autosomes are chromosomes that do not determine sex 	<p><u>Anatomy VR</u></p>

Meiosis	3,3	<ul style="list-style-type: none"> • One diploid nucleus divides by meiosis to produce four haploid nuclei • The halving of the chromosome number allows a sexual life cycle with fusion of gametes • DNA is replicated before meiosis so that all chromosomes consist of two sister chromatids • The early stages of meiosis involve pairing of homologous chromosomes and crossing over followed by condensation • Orientation of pairs of homologous chromosomes prior to separation is random • Separation of pairs of homologous chromosomes in the first division of meiosis halves the chromosome number • Crossing over and random orientation promotes genetic variation • Fusion of gametes from different parents promotes genetic variation 	
Inheritance	3,4	<ul style="list-style-type: none"> • Mendel discovered the principles of inheritance with experiments in which large numbers of pea plants were crossed • Gametes are haploid so contain only one allele of each gene • The two alleles of each gene separate into different haploid daughter nuclei during meiosis • Fusion of gametes results in diploid zygotes with two alleles of each gene that may be the same allele or different alleles • Dominant alleles mask the effects of recessive alleles but co-dominant alleles have joint effects • Many genetic diseases in humans are due to recessive alleles of autosomal genes, although some genetic diseases are due to dominant or co-dominant alleles • Some genetic diseases are sex-linked. The pattern of inheritance is different with sex-linked genes due to their location on sex chromosomes • Many genetic diseases have been identified in humans but most are very rare 	

		<ul style="list-style-type: none"> • Radiation and mutagenic chemicals increase the mutation rate and can cause genetic diseases and cancer 	
Genetic modification and biotechnology	3,5	<ul style="list-style-type: none"> • Gel electrophoresis is used to separate proteins or fragments of DNA according to size • PCR can be used to amplify small amounts of DNA • DNA profiling involves comparison of DNA • Genetic modification is carried out by gene transfer between species • Clones are groups of genetically identical organisms, derived from a single original parent cell • Many plant species and some animal species have natural methods of cloning • Animals can be cloned at the embryo stage by breaking up the embryo into more than one group of cells • Methods have been developed for cloning adult animals using differentiated cells 	

Topic 4: Ecology - 12 Hours for Both SL and HL			VRLab Academy Experiment
Subtopic	Subtopic Number	Points to Understand	
Species, communities and ecosystems	4,1	<ul style="list-style-type: none"> • Species are groups of organisms that can potentially interbreed to produce fertile offspring • Members of a species may be reproductively isolated in separate populations • Species have either an autotrophic or heterotrophic method of nutrition (a few species have both methods) • Consumers are heterotrophs that feed on living organisms by ingestion • Detritivores are heterotrophs that obtain organic nutrients from detritus by internal digestion 	

		<ul style="list-style-type: none"> • Saprotrophs are heterotrophs that obtain organic nutrients from dead organisms by external digestion • A community is formed by populations of different species living together and interacting with each other • A community forms an ecosystem by its interactions with the abiotic environment • Autotrophs obtain inorganic nutrients from the abiotic environment • The supply of inorganic nutrients is maintained by nutrient cycling • Ecosystems have the potential to be sustainable over long periods of time 	
Energy flow	4,2	<ul style="list-style-type: none"> • Most ecosystems rely on a supply of energy from sunlight • Light energy is converted to chemical energy in carbon compounds by photosynthesis • Chemical energy in carbon compounds flows through food chains by means of feeding • Energy released from carbon compounds by respiration is used in living organisms and converted to heat • Living organisms cannot convert heat to other forms of energy. -Heat is lost from ecosystems • Energy losses between trophic levels restrict the length of food chains and the biomass of higher trophic levels 	

Carbon cycling	4,3	<ul style="list-style-type: none"> • Autotrophs convert carbon dioxide into carbohydrates and other carbon compounds • In aquatic ecosystems carbon is present as dissolved carbon dioxide and hydrogen carbonate ions • Carbon dioxide diffuses from the atmosphere or water into autotrophs • Carbon dioxide is produced by respiration and diffuses out of organisms into water or the atmosphere • Methane is produced from organic matter in anaerobic conditions by methanogenic archaeans and some diffuses into the atmosphere or accumulates in the ground • Methane is oxidized to carbon dioxide and water in the atmosphere • Peat forms when organic matter is not fully decomposed because of acidic and/or anaerobic conditions in waterlogged soils • Partially decomposed organic matter from past geological eras was converted either into coal or into oil and gas that accumulate in porous rocks • Carbon dioxide is produced by the combustion of biomass and fossilized organic matter • Animals such as reef-building corals and mollusca have hard parts that are composed of calcium carbonate and can become fossilized in limestone 	
Climate change	4,4	<ul style="list-style-type: none"> • Carbon dioxide and water vapour are the most significant greenhouse gases • Other gases including methane and nitrogen oxides have less impact • The impact of a gas depends on its ability to absorb long wave radiation as well as on its concentration in the atmosphere • The warmed Earth emits longer wavelength radiation (heat) • Longer wave radiation is absorbed by greenhouse gases that retain the heat in the atmosphere 	

		<ul style="list-style-type: none">• Global temperatures and climate patterns are influenced by concentrations of greenhouse gases• There is a correlation between rising atmospheric concentrations of carbon dioxide since the start of the industrial revolution 200 years ago and average global temperatures• Recent increases in atmospheric carbon dioxide are largely due to increases in the combustion of fossilized organic matter	
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Topic 5: Evolution and Biodiversity - 12 Hours for Both SL and HL			VRLab Academy Experiment
Subtopic	Subtopic Number	Points to Understand	
Evidence for evolution	5,1	<ul style="list-style-type: none"> • Evolution occurs when heritable characteristics of a species change • The fossil record provides evidence for evolution • Selective breeding of domesticated animals shows that artificial selection can cause evolution • Evolution of homologous structures by adaptive radiation explains similarities in structure when there are differences in function • Populations of a species can gradually diverge into separate species by evolution • Continuous variation across the geographical range of related populations matches the concept of gradual divergence 	
Natural selection	5,2	<ul style="list-style-type: none"> • Natural selection can only occur if there is variation among members of the same species • Mutation, meiosis and sexual reproduction cause variation between individuals in a species • Adaptations are characteristics that make an individual suited to its environment and way of life • Species tend to produce more offspring than the environment can support • Individuals that are better adapted tend to survive and produce more offspring while the less well adapted tend to die or produce fewer offspring • Individuals that reproduce pass on characteristics to their offspring • Natural selection increases the frequency of characteristics that make individuals better adapted and decreases the frequency of other characteristics leading to changes within the species 	<u>Anatomy VR</u>

<p>Classification of biodiversity</p>	<p>5,3</p>	<ul style="list-style-type: none"> • The binomial system of names for species is universal among biologists and has been agreed and developed at a series of congresses • When species are discovered they are given scientific names using the binomial system • Taxonomists classify species using a hierarchy of taxa • All organisms are classified into three domains • The principal taxa for classifying eukaryotes are kingdom, phylum, class, order, family, genus and species • In a natural classification, the genus and accompanying higher taxa consist of all the species that have evolved from one common ancestral species • Taxonomists sometimes reclassify groups of species when new evidence shows that a previous taxon contains species that have evolved from different ancestral species • Natural classifications help in identification of species and allow the prediction of characteristics shared by species within a group 	
<p>Cladistics</p>	<p>5,4</p>	<ul style="list-style-type: none"> • A clade is a group of organisms that have evolved from a common ancestor • Evidence for which species are part of a clade can be obtained from the base sequences of a gene or the corresponding amino acid sequence of a protein • Sequence differences accumulate gradually so there is a positive correlation between the number of differences between two species and the time since they diverged from a common ancestor • Traits can be analogous or homologous. • Cladograms are tree diagrams that show the most probable sequence of divergence in clades • Evidence from cladistics has shown that classifications of some groups based on structure did not correspond with the evolutionary origins of a group or species 	

Topic 6: Human Physiology - 20 Hours for Both SL and HL			VRLab Academy Experiment
Subtopic	Subtopic Number	Points to Understand	
Digestion and absorption	6,1	<ul style="list-style-type: none"> • The contraction of circular and longitudinal muscle of the small intestine mixes the food with enzymes and moves it along the gut • The pancreas secretes enzymes into the lumen of the small intestine • Enzymes digest most macromolecules in food into monomers in the small intestine • Villi increase the surface area of epithelium over which absorption is carried out • Villi absorb monomers formed by digestion as well as mineral ions and vitamins • Different methods of membrane transport are required to absorb different nutrients 	<p><u>Blood Vessels VR</u></p> <p><u>Enzymes Experiment</u></p> <p><u>Anatomy VR</u></p>
The blood system	6,2	<ul style="list-style-type: none"> • Arteries convey blood at high pressure from the ventricles to the tissues of the body • Arteries have muscle cells and elastic fibres in their walls • The muscle and elastic fibres assist in maintaining blood pressure between pump cycles • Blood flows through tissues in capillaries. Capillaries have permeable walls that allow exchange of materials between cells in the tissue and the blood in the capillary • Veins collect blood at low pressure from the tissues of the body and return it to the atria of the heart • Valves in veins and the heart ensure circulation of blood by preventing backflow • There is a separate circulation for the lungs • The heart beat is initiated by a group of specialized muscle cells in the right atrium called the sinoatrial node • The sinoatrial node acts as a pacemaker • The sinoatrial node sends out an electrical signal that stimulates 	

		<p>contraction as it is propagated through the walls of the atria and then the walls of the ventricles</p> <ul style="list-style-type: none"> • The heart rate can be increased or decreased by impulses brought to the heart through two nerves from the medulla of the brain • Epinephrine increases the heart rate to prepare for vigorous physical activity 	
Defense against infectious disease	6,3	<ul style="list-style-type: none"> • The skin and mucous membranes form a primary defense against pathogens that cause infectious disease • Cuts in the skin are sealed by blood clotting • Clotting factors are released from platelets • The cascade results in the rapid conversion of fibrinogen to fibrin by thrombin • Ingestion of pathogens by phagocytic white blood cells gives non-specific immunity to diseases • Production of antibodies by lymphocytes in response to particular pathogens gives specific immunity • Antibiotics block processes that occur in prokaryotic cells but not in eukaryotic cells • Viruses lack a metabolism and cannot therefore be treated with antibiotics. Some strains of bacteria have evolved with genes that confer resistance to antibiotics and some strains of bacteria have multiple resistance 	
Gas exchange	6,4	<ul style="list-style-type: none"> • Ventilation maintains concentration gradients of oxygen and carbon dioxide between air in alveoli and blood flowing in adjacent capillaries • Type I pneumocytes are extremely thin alveolar cells that are adapted to carry out gas exchange • Type II pneumocytes secrete a solution containing surfactant that creates a moist surface inside the alveoli to prevent the sides of the alveolus adhering to each other by reducing surface tension 	

		<ul style="list-style-type: none"> • Air is carried to the lungs in the trachea and bronchi and then to the alveoli in bronchioles • Muscle contractions cause the pressure changes inside the thorax that force air in and out of the lungs to ventilate them • Different muscles are required for inspiration and expiration because muscles only do work when they contract 	
Neurons and synapses	6,5	<ul style="list-style-type: none"> • Neurons transmit electrical impulses. • The myelination of nerve fibres allows for saltatory conduction • Neurons pump sodium and potassium ions across their membranes to generate a resting potential • An action potential consists of depolarization and repolarization of the neuron • Nerve impulses are action potentials propagated along the axons of neurons • Propagation of nerve impulses is the result of local currents that cause each successive part of the axon to reach the threshold potential • Synapses are junctions between neurons and between neurons and receptor or effector cells • When presynaptic neurons are depolarized they release a neurotransmitter into the synapse • A nerve impulse is only initiated if the threshold potential is reached 	
Hormones, homeostasis and reproduction	6,6	<ul style="list-style-type: none"> • Neurons transmit electrical impulses. • The myelination of nerve fibres allows for saltatory conduction • Neurons pump sodium and potassium ions across their membranes to generate a resting potential • An action potential consists of depolarization and repolarization of the neuron • Nerve impulses are action potentials propagated along the axons of neurons • Propagation of nerve impulses is the result of local currents that cause each successive part of the axon to reach the threshold potential 	

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