Human Biological Science
Scope and sequence

Human Biological Science: Scope and sequence of content

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HUMAN FORM AND FUNCTION						
Cells, metabolism and regulation	Cells carry out life processes to survive. Cells possess similar features including membranes, nuclei and cytoplasm that perform life processes. The senses allow the body to respond to external stimuli. Dysfunctions occur from the failure of protection from pathogens and foreign materials. Life processes: • respiration, feeding, (including digestion and absorption) excretion, movement, reproduction, responses, growth and differentiation • distinguish between living and non-living • the cell theory • basic cell structure/components and their functions *(nucleus, nucleolus, cell membrane, cytoplasm, endoplasmic reticulum, mitochondria, golgi body, lysosomes, vesicles).* Stimuli: • the senses; touch, taste, smell, sight and hearing • stimuli detected include light, sound, smell, taste, temperature, texture and pressure • simple responses *e.g. pupil size and blinking.* Pathogens and foreign materials: • types of pathogens: bacteria, viruses, parasites, fungi • example of disease caused by each type with emphasis on mode of transmission and entry into body • the body recognises and reacts to foreign materials.	The primary role of the cell cycle is for growth and repair. The body detects and responds to changes in its internal environment that are outside its tolerance limits. Dysfunctions are caused when tolerance limits are exceeded. The cell cycle: • chromosome changes in mitosis (including microscopic examination) • introduction to the differentiation of cells which result in different tissues • basic introduction to stem cells and their uses. Tolerance limits: • conditions resulting from exceeding tolerance limits *e.g. hypothermia, hyperthermia, hypoxia, oxygen toxicity syndrome, dehydration and water intoxication* • individual differences related to tolerance limits *e.g. temperature, oxygen , water, diet, alcohol.*	Metabolic reactions make energy and matter available for use in cells. These reactions are controlled by enzymes which are affected by various factors. Cellular structures provide for exchange of materials, metabolism and cell division (mitosis and meiosis). Efficient functioning of the body requires non-specific protection. Non-specific protection include internal and external methods. Metabolism: • anabolic and catabolic reactions and organelles involved. (word equations only) *e.g. mitochondria and ribosomes* • respiration (aerobic and anaerobic); inputs, outputs and organelles involved • nutrients required and their uses including carbohydrates/simple sugars, proteins/amino acids, lipids/ fatty acids and glycerols, vitamins and minerals • enzyme function including reduction in activation energy, lock and key principle • factors that affect enzyme activity including pH, temperature, cofactors, co-enzymes. Transport: • structure of the cell membrane as it relates to transport of materials (greater detail covered in Unit 3A) • methods of transporting materials including diffusion, facilitated diffusion, osmosis, active transport, endocytosis and exocytosis • factors affecting exchange of materials including SA/Vol ratio , concentration gradients. Mitosis: • function and signifigance of chromosome number in mitosis.	Genes determine a cell's structure and function. Differentiation of stem cells produces different cells and tissues. DNA: • structure of DNA including base pair model • locations in the cell including nucleus and mitochondria • role of DNA in the cell • DNA replication—base pair model. Differentiation: • differentiation forming embryonic germ layers • tissues formed from the primary germ layers • types of stem cells and their potency • importance of stem cells e.g. cord blood • teratogenic effects on stem cells.	Cellular activities are controlled by feedback mechanisms for the maintenance of homeostasis of body temperature, body fluid composition, blood sugar, gas concentrations and blood pressure. Disruption to homeostasis causes dysfunction that can be controlled by physiological, behavioural and medical intervention. Cellular activities: • role of cell membrane structure and function in active transport and as a receptor • DNA controls the production of cellular materials. Homeostasis by feedback systems: • components of a stimulus-response feedback model • homeostatic mechanisms that control body temperature • body fluid composition • blood sugar • gas concentrations • blood pressure • physiological and behavioural mechanisms that influence the maintenance of homeostasis of the above conditions. Disruption of homeostasis: • causes of disruption ▪ hormonal *e.g. insulin—diabetes* ▪ behavioural *e.g. drugs, excessive activity, eating habits* ▪ disease *e.g. emphysema* • treatments for disruption of homeostasis	DNA codes for the production of proteins in cells via a series of processes. Humans have specific resistance mechanisms, in response to an invasion by pathogens. DNA and RNA is involved in: • protein synthesis (including transcription and translation) • cellular control of gene expression including regulator, operator and promoter genes. Specific resistance: • role of B cells, T cells, memory cells and plasma cells • antibody and cell-mediated defence • primary and secondary immune response • passive and active immunity • natural and artificial immunity • role of antibiotics and antivirals.

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HUMAN FORM AND FUNCTION						
Body systems	The body is organised from cells to tissues, organs and systems. The major body systems are the digestive, excretory, skeletal, muscular, respiratory, circulatory, nervous, endocrine, immune and reproductive systems and are related to life processes. The human lifecycle occurs in a sequence of stages. Organisation: • hierarchy of organisation in the body • introduction to tissue types and cell organisation • location of organs associated with each body system in the body. Functions: • function of each organ system related to life processes *e.g. digestive system—feeding.* The human life cycle: • from gamete to birth and through to death • systems change during the life cycle • death determination.	Organs within systems are organised for efficient functioning and interaction. Males and females have different body forms and reproductive systems. Systems: • principal organs within the main body systems • structural layout of at least two systems related to efficient functioning • structure and function at cellular level related to tissue and organ levels *e.g. cilia in the lungs* • interaction between systems *e.g. the circulatory system with both the digestive and respiratory systems* • efficient functioning related to different structures in systems *e.g. types of bones and joints in the skeletal system.* Reproduction: • general structural and functional differences between male and female reproductive systems (hormonal details in later units) • differences between males and *females e.g. growth rates, strength and perceptions.*	The respiratory, circulatory, digestive and excretory systems are specialised to control inputs and outputs in supporting metabolism. • Respiratory system. Structure and function related to: ▪ gas exchange including characteristics of respiratory surfaces ▪ maintenance of concentration gradients in lungs including breathing and blood flow. • Circulatory system. Structure and function related to: ▪ role of the heart, arteries, veins and capillaries in the circulation of blood ▪ roles of plasma and erythrocytes in the transport of materials including oxygen, nutrients and wastes ▪ clotting of blood at wound including fibrinogen and platelets ▪ inflammatory response ▪ lymphatics and white blood cells (overview only). • Digestive system. Structure and function related to: ▪ mechanical digestion including teeth, bile, process of peristalsis ▪ chemical digestion of carbohydrates, lipids and proteins including enzymes and the associated glands ▪ absorption of nutrients ▪ elimination.	Reproductive systems are specialised for gamete production, fertilisation and support for pregnancy and birth. Reproduction is controlled by hormones. Environmental factors can influence human development from implantation to infancy. Body systems differentiate, grow and develop at different rates during life from fertilisation. Reproductive systems: • structure and function of male and female reproductive systems • spermatogenesis and oogenesis • hormonal control of menstrual and ovarian cycles and spermatogenesis. Development: • implantation and development of the placenta • significant developments in embryonic and foetal stages • changes to a female during pregnancy • birth process • comparison of foetal and neonate circulation • patterns and milestones of development in infants. Environmental factors: • care of the unborn child *e.g. risks associated with smoking, alcohol and other drug use* • the effect of various types of teratogens. Reproductive technologies related to: • contraception • infertility e.g. IVF, GIFT donors	The endocrine and autonomic nervous systems work together to control the interaction of body systems to maintain homeostasis in a changing external environment. Endocrine system: • types and location of endocrine glands • relationship between the hypothalamus and pituitary • production site, target organ and effect of various hormones • feedback loops involving endocrine activity • hormonal modes of action. Autonomic nervous system: • overview of divisions of the nervous system • nerve impulse generation and propagation • relationship of the Autonomic NS to the body's nervous system • divisions of the Autonomic NS and their effect on various body organs. Comparison of hormones and nerves in terms of: • speed, duration, transmission and specificity.	The nervous system and the musculo-skeletal system interact to provide coordinated actions of the body. Advances in mechanical, chemical and biological technologies can enhance body functions and replace structures to alter the natural course of human development and aid recovery after trauma. Central and peripheral nervous system: • brain (cerebrum, cerebellum, meninges, medulla oblongata, , hypothalamus), spinal cord • afferent and efferent systems • structure of motor, sensory and inter-neurons • the reflex arc including components and their functions in the transmission of messages. • transmission of nerve impulses–generation and propagation • control of movement and balance—areas and types of motor control of the body in the cerebrum and cerebellum • innervation of muscular contraction. Muscles—structure and function related to: • macroscopic including the types, locations and resulting movements • microscopic including myofibrils • molecular including actin and myosin • sliding filament theory of contraction. Skeleton—structure and function related to:

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			• Excretory system. Structure and function related to: ▪ formation of urine in the kidney (details of the processes of filtration, re-absorption and secretion not required) ▪ deamination of amino acids in the liver. • Protection of body systems ▪ body's external defences against disease–of skin, digestive, urogenital, respiratory, eye and ear. Assisted protection of the body: ▪ external *e.g. hygiene, topical preparations and barriers* ▪ internal *e.g. antibiotics and antivirals.*	• conception • maintenance of pregnancy including ultrasound, foetal monitoring and hormonal intervention. • Sexually transmitted infections (STI) ▪ causes, symptoms and treatment.		• macro and microscopic structure of bone and cartilage • structure and functionality of major joint types Including ball and socket, hinge, pivot, gliding, immovable. Medical technologies related to support for trauma recovery and changing function of the musculoskeletal and nervous systems caused by ageing: including osteoporosis, osteoarthritis, Alzheimer's disease and Parkinson's disease. • mechanical: ▪ external *e.g. supports, bionic limbs* ▪ internal *e.g. artificial joints and physiotherapy* • chemical: ▪ dietary supplements ▪ pharmaceuticals *e.g. anti-inflammatories* • biological: ▪ tissue regeneration ▪ grafting and transplantations.

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HUMAN DIVERSITY AND CHANGE						
Inheritance	DNA carries the genetic information that determines the characteristics of a person (DNA structure is not required in this unit). People can be identified by their DNA. DNA: • and its relationship to the terms gene, chromosome and nucleus • carries information about the individual • is passed from one generation to the next in reproduction • determines some features of the offspring • can be used, for example, to: ▪ *establish family links* ▪ *identify people* ▪ *determine certain diseases or a predisposition to certain diseases* ▪ *trace ancestry.*	Genes are the fundamental units of heredity. The gene concept: • a gene is a section of DNA • genes influence characteristics • in sexual reproduction, offspring contain chromosomes from both parents.	Principles of Mendelian genetics are used to predict variations in offspring. Inheritance: • dominant, recessive, co-dominant, autosomal and sex linked inheritance • sex determination • monohybrid crosses using punnet squares and simple probabilities.	Changes in DNA (mutations) are caused by a variety of factors. Mutations affect cellular and body functions. Genetic counselling uses information from pedigrees, genetic testing to provide an analysis of the risk associated with some of these mutations. Mutations: • causes of mutations • changes in the DNA sequence • conditions caused by mutations including somatic *e.g. cancer* and germ line *e.g. PKU* • chromosomal mutations including analysis of karyotypes. Pedigrees: • construction and interpretation of pedigrees for autosomal and sex-linked conditions • probabilities of producing affected offspring for autosomal and sex linked inheritance • inheritance of mitochondrial DNA. Genetic testing of parents and offspring for: • gene and chromosomal abnormalities. Human Genome Project: • information provided by the Human Genome Project • range of possible uses for this information.	Variations in characteristics can be the result of polygenes and multi-allelic (polymorphic) genes. Variation can arise from gene expression. Gene expression: • the effect of the environment on gene expression *e.g. effect of UV light exposure on melanin production and effect of diet on adipose tissue* • role of epigenetics. Modes of inheritance and variation: • polygenic inheritance (no dihybrid crosses) • multi-allelic (polymorphic) inheritance.	Biotechnological techniques are being developed and used for a range of applications including: • identification of hereditary diseases by ▪ DNA sequencing ▪ profiling techniques ▪ PCR (polymerase chain reaction) ▪ genetic probes • production of human proteins, hormones and vaccines by DNA recombinant techniques (including restriction and ligase enzymes*) e.g. to produce insulin, Human Growth Hormone, Factor VIII* • treatment of genetic disorders by gene therapy *e.g. cystic fibrosis* • cell replacement therapy and tissue engineering by the cloning of stem cells *e.g. repair of injured tissues, treating degenerative nerve diseases.*

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HUMAN DIVERSITY AND CHANGE						
Variation and evolution	Variations occur between individuals. Families can show different genetic traits. Variation: • offspring resemble their parents in many ways • genetically identical twins can be used to study difference between nature and nurture (influence of genes and environment) • characteristics run through families: ▪ physical features ▪ predisposition to diseases.	Phenotype is affected by the environment and genotype. Biological classification of humans (as vertebrates, mammals, primates and hominins) is based on a variety of features. Classification systems are dynamic. Relationship between genotype and phenotype: • genes alone or environment alone or genes and environment together contribute to phenotype • phenotype can be used to deduce genotype • examples of characteristics determined by genetics only, environment only and both • the phenotype of offspring is limited by genes of the offspring's parents. Classification • characteristics of vertebrates, mammals, primates and hominins • reasons for classification of organisms • problems with classification • changes in classification schemes.	New genetic combinations are made as a result of meiosis and fertilisation, giving rise to unexpected variations. Meiosis: • function and signifigance of chromosome changes in meiosis • compare mitosis and meiosis. Variation from meiosis: • crossing over • random assortment • non-disjunction. Variation from fertilisation: • random fertilisation.	The changing environment influences survival of genetic variations. Variations and the environment: • new variations due to mutations may be advantageous or disadvantageous to survival • differential survival of genotypes/phenotypes *e.g. lethal recessives* • teratogens: the range of actions and their effects.	Gene pools are affected by evolutionary mechanisms including natural selection and chance occurrences. The main evidence for evolution comes from comparative studies in anatomy and biochemistry, and the fossil record. Gene pools: • changes in allele frequencies due to: ▪ mutation ▪ natural selection ▪ random genetic drift including Founder effect ▪ migration. ▪ barriers to gene flow *e.g. geographical and cultural,* ▪ incidence of genetic diseases in various populations *e.g. Tay-Sachs disease.* Speciation: Theory of evolution by natural selection Evidence for evolution: • comparative studies of DNA, protein sequences, anatomy including embryology, homologous structures and vestigial organs • the fossil record: ▪ fossil formation ▪ geological dating and its limitations ▪ relative dating including stratigraphy, index fossils and fluorine dating ▪ absolute dating including C-14 dating. • awareness of problems with the fossil record.	Within the classification system, primate and hominin groups show evolutionary trends. Human evolution is the result of interaction of evolutionary mechanisms and the environment. Primate evolutionary trends: • relative size of cerebral cortex • olfactory/optical shift • gestation time and parental care • mobility of the digits • teeth shape and dental arrangements. Hominin evolutionary trends: • bipedalism—feet adaptations, hip and knee joints • relative size of cerebral cortex • prognathism and dentition • spine and pelvis shape. Interaction of evolutionary mechanisms and the environment: • effects of environment on early hominin evolution • significant cultural advances changing the importance of the environment in human evolution.

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THE PRACTICE OF HUMAN BIOLOGY						
Approaches to investigating and communicating human biology	• given a relevant contextual research question, use a prescribed format to plan and conduct a safe investigation • use simple equipment to collect reliable data presented in simple tables and graphs • make valid conclusions using appropriate terminology. *Research, for example:* • *history of a medical technique, an instrument or an infectious disease* • *twin studies.* *Investigate, for example:* • *microbial investigation of bacteria and fungi* • *variations in senses e.g. sight, hearing and taste tests.*	• given a relevant contextual research question, use a prescribed format to plan and conduct a safe and ethical investigation • use simple equipment to collect reliable data presented in tables and graphs that can be used to make valid conclusions • use simple concepts in scientific explanations • provide a list of resources. *Research, for example:* • *tolerance limits* • *classification schemes* • *dysfunctions of a particular system.* *Investigate, for example:* • *effect of the environmental aspects on body function* • *range of variations in humans.*	• plan and conduct a safe investigation on a question of choice developed from a given contextual problem • use a prescribed format and trial a range of techniques to collect data • collect valid and reliable data • analyse data using rates, percentages and frequencies • refer to possible bias and experimental error • use scientific terminology and appropriate abstract concepts in discussions. *Research, for example:* • *lifestyle choices affecting metabolism* • *genetic patterns in family trees.* *Investigate, for example:* • *factors affecting metabolism* • *effectiveness of methods of assisting non-specific body defences e.g. testing effectiveness of soap, antiseptic cream on growth of micro-organisms* • *genetic variations in families.*	• plan and conduct a safe investigation on a question of choice, developed from a given contextual problem • trial a range of techniques to collect data • analyse data using rates, percentages and frequencies • present information using appropriate symbols, terminology and conventions • consider experimental errors and the ramifications of results that support or disprove hypotheses • discuss different perspectives of a problem. *Research, for example:* • *effect of mutagenic and teratogenic agents* • *pregnancy rates and survival rates of offspring.* *Investigate, for example:* • *probabilities of genetic inheritance.*	• use a problem identified by the student to formulate an hypothesis • plan and conduct a safe and ethical investigation incorporating two different methods to collect data • simple analysis of results including factors that influence the investigation, rates, percentages and frequencies • refer to other researchers' findings to analyse and report data using a variety of sources of supporting evidence and scientific concepts. *Research, for example:* • *homeostasis malfunctions and treatments* • *control of gene expression* • *evidence for human evolution.* *Investigate, for example:* • *behaviour and homeostasis* • *modelling natural selection.*	• use a personally identified problem to formulate an hypothesis • select methodology to plan and conduct a safe and ethical investigation into various aspects of the problem • mathematically justify results and use others' results to support findings • justify conclusions taking into account errors and limitations in data • prepare and present a balanced report, including discussion of limitations and biases, using information from scientifically reliable sources as well as own data. *Research, for example:* • *impacts of technology on quality of life* • *development of vaccines and their success rates* • *CNS-skeletal muscle changes associated with ageing* • *evolutionary changes in hominins e.g. skulls* • *influence of chemicals on synaptic transmission.* *Investigate, for example:* • *CNS actions and reactions e.g. learning and reflexes* • *biotechnological techniques e.g. modelling PCR and DNA sequencing.*

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THE PRACTICE OF HUMAN BIOLOGY						
The relevance of human biology to everyday life	Human biological science knowledge is evolving at a rapid rate due to technological advances, increasing the amount and type of information available about ourselves. This impacts on areas such as human survival rates, and risks ethical concerns and benefits of medical interventions and also helps to explain variations. Support and diagnosis: • medical systems to support organs *e.g. dialysis* • imaging techniques and resulting information *e.g. X-rays, CAT MRI procedures.* Survival: • changes in survival rates *e.g. over generations, in different countries* • changing life span of humans • historical development of knowledge of the causes of disease and treatments • risks, ethical concerns and benefits of common medical procedures *e.g. appendectomy and pharmaceuticals such as taking antibiotics.*	Interest in the human body has often resulted from explaining body dysfunction; in maintaining health; and trying to improve human performance. Modern medical methods and alternative therapies differ in their effectiveness and each has its risks, ethical concerns and benefits. Body dysfunction: • types of dysfunctions *e.g. cancer, infections,* • requirements for maintaining health *e.g. diet, exercise and hygiene.* Improve performance: • changes in training practices *e.g. individuals → Australian Institute of Sport* • other performance enhancing techniques *e.g. drugs, oxygen therapy and blood doping*. Alternative medicines: • types of alternative therapies • benefits, ethical concerns and risks associated with their use.	Lifestyle choices can compromise body functioning in the short-term and affect future health. Individual differences influence the technologies used to inform the diagnoses of different medical conditions. Lifestyle choices that compromise health: • active or sedentary lifestyle • personal hygiene • use of drugs including alcohol and smoking • diet. Individual differences: • diagnosis depends upon individual differences in body form, stature and disease progression • genetic disorders linked to particular populations *e.g. Tay-Sachs, sickle cell anaemia and thalassemia.*	The rate of change in human biology means that there is a range of alternative treatments available. Each treatment has its risks, ethical concerns and benefits based on individual variations and the condition being treated. Health choices can be based on myths or misconceptions about human biology. Medical technologies: • sex selection of embryo to avoid genetic disease • birth control methods • stem cell collection for future use *e.g. cord blood banks* • treatment for various genetic diseases. Health choices: • pregnant women *e.g. warnings on food labels, drugs, alcohol and smoking* • performance enhancing *e.g. steroid use* • parent's choice for infants *e.g. diet and immunisation choices.*	Human intervention can occur during stages of life by manipulation of life processes. This enables control of normal function or development and treatment of dysfunction to influence the quality of life for individuals and the society. Control of homeostatic dysfunction and hormone replacement therapies to assist treatment of: • hyper/hypothyroidism • control of reproduction and menopause • diabetes • risks, ethical concerns and benefits associated with interventions.	The human genome can be used for individualising medical interventions. Human lifespan is increasing causing issues associated with an ageing population. Potential treatment related to individual variations: • information from the Human Genome providing new interventions for common dysfunctions/ disorders • gene therapy • tissue regeneration. Risks, ethical concerns and benefits: • production and use of vaccines and hormones • medical technologies for treating the effects of ageing • informed debate about human origins. Human life span: • diseases and treatment of an ageing population • euthanasia and quality of life issues.