Biology Curriculum (Secondary 4-6)

Supplementary Document

Jointly prepared by the Curriculum Development Council and the Hong Kong Examinations and Assessment Authority

Recommended to be used with the Biology Curriculum and Assessment Guide (Secondary 4-6)

Science Education Section, Education Bureau

2015

Introduction

The purpose of the revision is to provide space for enhancing the effectiveness of learning and teaching of Biology. This document is the result of a number of discussion sessions of the following committees.

- Working Group on the Review of Biology (S4-6) and Combined Science (Biology part) (S4-6) Curricula
- CDC-HKEAA Committee on Biology (Senior Secondary)

It is applicable for the Biology Hong Kong Diploma of Secondary Education (HKDSE) Examination in year 2016 and onwards. The explanatory notes in this document are by no means exhaustive nor intended to dictate the scope of learning and teaching at the classrooms. It is recommended to be used together with the *Biology Curriculum and Assessment Guide (Secondary 4-6)* jointly prepared by the Curriculum Development Council and the Hong Kong Examinations and Assessment Authority.

General Notes

In each topic, there is a table with the following parts:

(1) Students should learn

This part lists the intentions of learning in the content domain of the curriculum. It outlines the major content areas of each topic and also indicates the knowledge and concepts that students should learn. This provides a basic framework upon which the learning and teaching activities can be developed.

(2) Student should be able to

This part lists a range of learning outcomes to be achieved by students, with different levels of ability in the content domain of the curriculum. Whenever learning outcomes which draw on higher cognitive ability (e.g. evaluate, relate) are applicable, other learning outcomes drawing on lower cognitive ability (e.g. state, describe) are not listed. Students are expected to demonstrate the whole range of cognitive abilities and use these learning outcomes as the basis for self-evaluation. Teachers can also use these learning outcomes to set assessment tasks for monitoring the progress of learning.

(3) Suggested Learning and Teaching Activities

This part suggests activities that can be provided for students to enable them to achieve the learning outcomes. The list includes a wide range of activities, such as discussion, debate, practical work, investigations, information searching and projects. It should be seen as a guide for teachers rather than as an exhaustive or mandatory list. Teachers should exercise their professional judgment in selecting activities to meet the interests and abilities of their students. Where possible, the activities should be framed in the context of students' own experience, to enable them to make connections with scientific knowledge, society and the environment around them. Students will then be well equipped to apply scientific concepts, theories, processes, and values to situations in which they have to investigate and solve everyday problems.

(4) Curriculum Emphases

This part comprises Scientific Inquiry, Science–Technology–Society–Environment Connections, and the Nature and History of Biology. It outlines the generic skills, scientific process skills, values and attitudes that are highlighted in the topic. It also helps enhance students' understanding of the nature of scientific inquiry in biology, the interconnections between science, technology, society and the environment, and biology as a dynamic body of knowledge.

(5) Footnotes

This part is to clarify the learning and assessment focuses of certain curriculum contents.

COMPULSORY PART I. Cells and Molecules of Life

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
a. Molecules of life Water and inorganic ions (e.g. nitrogen, magnesium, calcium and iron) Biomolecules[1]: carbohydrates, lipids, proteins and nucleic acids • Building blocks • Functions	• Relate the significance of water, inorganic ions and biomolecules to life.	• Discuss whether life can exist without water, and the possible benefits of drinking mineral water or isotonic drinks. • Perform common biochemical tests (e.g. Benedict's test, iodine test, grease spot test, and different types of test papers) to identify the presence of biomolecules in living tissues.	① Ask relevant questions, identify problems and formulate hypotheses for investigations related to cells and molecules of life. ① Use appropriate instruments and proper techniques for carrying out practical work (e.g. food tests). ② Be aware of the applications of biological knowledge of molecules of life in society. ② Appreciate the role of science and technology in understanding the molecular basis of life.
b. Cellular organisation Discovery of cells	• Appreciate the contribution of the technological development of the microscope to the discovery of cells.	• Read articles about the discovery of cells. • Conduct a project to explore the contribution of the development of the microscope to the understanding of cells.	② Recognise that the development of microscopic technology, computing technology and image analysing technology may lead to the advancement of biological knowledge. ③ Recognise the contributions of various people (e.g. Robert Hooke and Theodor Schwann) to developments in biology.

[1] The following contents are not the learning and assessment focus: optical isomers, linear form of sugar molecules, structural differences of starch, glycogen and cellulose.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Cell membrane • Properties and functions	• Use the fluid mosaic model to explain the properties and functions of cell membrane. • Appreciate the uses and limitations of scientific models.	• Construct a model to represent the structure of cell membrane (e.g. using tank and ping-pong balls).	① Plan and conduct scientific investigations in the area of cellular structures and functions. ① Use appropriate instruments and proper techniques for carrying out practical work (e.g. preparation of temporary mounts and microscopic examination).
Sub-cellular structures and their functions • Nucleus and chromosomes, endoplasmic reticulum, mitochondrion, chloroplast, cell wall and vacuole	• Prepare temporary mounts of specimens for examination, and make observations and drawings under a light microscope. • Identify cell organelles as seen under light and electron microscopes. • Compare the cellular organisation of animal and plant cells.	• Prepare temporary mounts of animal and plant tissues for examination under a light microscope. • Discuss the variations of the number of mitochondria in different tissues and cell types.	① Make careful observations and accurate records (e.g. examine prepared slides or temporary mounts of tissues and make biological drawings). ② Be aware of the applications of biological knowledge of cells in society.
Prokaryotic cells (e.g. bacterial cells) and eukaryotic cells	• Compare the sub-cellular organisation of prokaryotic and eukaryotic cells.	• Examine electron micrographs or live cell images of prokaryotic, eukaryotic cells and sub-cellular structures.	③ Be aware of the dynamic nature of biological knowledge (e.g. the understanding of cell membrane and sub-cellular organelles). ③ Be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses (e.g. fluid mosaic model of cell membrane structure).

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
c. Movement of substances across membrane Diffusion[2], osmosis and active transport[3] Occurrence of phagocytosis in cells	• Account for the movement of substances across membrane using the concepts of diffusion, osmosis and active transport. • Apply the concept of osmosis to explain plasmolysis and haemolysis.	• Perform practical work to study osmosis at cellular, tissue or organ levels. • Examine live cell images of the processes involved in the movement of substances across membrane.	① Make careful observations and accurate records (e.g. examine prepared slides or temporary mounts of tissues and make biological drawings). ① Identify and explain the importance of control variables in scientific investigations (e.g. the study of osmosis).
d. Cell cycle and division Stages of cell cycle[4] • Cell growth, nuclear division and cytoplasmic division Nuclear division • Mitosis • Meiosis[5]	• Recognise the various stages of cell cycle. • Understand the importance of cell division in growth and reproduction. • Outline and compare the processes of mitosis and meiosis.	• Observe and identify the different stages of mitosis and meiosis, using prepared slides, photomicrographs or live cell images.	① Make careful observations and accurate records (e.g. examine prepared slides and make biological drawings). ② Recognise that the development of microscopic technology and imaging technology may lead to the advancement of biological knowledge.

[2] The learning and assessment focus is confined to simple diffusion.
[3] Detailed mechanism of active transport is not the learning and assessment focus.
[4] Details of cell cycle are not the learning and assessment focus.
[5] Crossing over is a feature of meiosis.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
e. Cellular energetics Metabolism: catabolism and anabolism • Occurrence of catabolic and anabolic processes in cells	• Distinguish between catabolic and anabolic processes.		
Enzymes and enzymatic reactions • Properties and roles of enzyme • Active site and specificity • Factors (temperature, pH and inhibitors) affecting the rate of enzymatic reactions[6] • Application of enzyme in everyday life	• Recognise the properties of enzyme and its roles in metabolism. • Explain enzyme specificity in terms of active site. • Explain the effects of factors on the rate of enzymatic reactions.	• Perform practical work to demonstrate the breaking down or building up action of enzymes. • Design and perform investigations to study the effects of temperature, pH or inhibitors on the activities of enzymes, and to find out some commercial applications of enzymes (e.g. bioactive washing powder and meat tenderiser).	① Identify and explain the importance of control variables in scientific investigations (e.g. the study of enzymatic activities). ② Be aware of the applications of biological knowledge of enzymes in society.
Photosynthesis • Site of photosynthesis – Leaves and chloroplasts • Requirements for photosynthesis – light, carbon dioxide, water and chlorophyll	• Understand the significance of photosynthesis. • Relate the structures of leaves and chloroplasts to their functions in photosynthesis.	• Examine the morphology and the internal structure of leaves, and the photomicrographs or live cell images of chloroplasts. • Perform practical work to identify the photosynthetic products.	① Identify and explain the importance of control variables in scientific investigations (e.g. the study of photosynthesis).

[6] Modes and mechanism of enzyme inhibition are not the learning and assessment focus.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
• Photochemical reactions – light absorption[7] – photolysis of water for the generation of NADPH – generation of ATP	• Outline the major steps of photochemical reactions and carbon fixation.	• Design and perform investigations to study the effects of environmental factors (e.g. light intensity and carbon dioxide concentration) on the rate of photosynthesis.	② Recognise that the development of microscopic technology and imaging technology may lead to the advancement of biological knowledge.
• Carbon fixation: Calvin cycle[8] – Carbon dioxide fixation and formation of 3-C compound – Reduction of 3-C compound leading to the formation of glucose – Regeneration of carbon dioxide acceptor	• Understand the dependence of carbon fixation to the photochemical reaction.	• Interpret, analyse and evaluate data relating to investigations on photosynthesis. • Search for information to compare the photosynthetic rates and productivities in different climatic areas, and to understand scientists' work related to photosynthesis.	③ Recognise the contributions of various people (e.g. Melvin Calvin) to developments in biology. ③ Be aware of the dynamic nature of biological knowledge (e.g. the understanding of cellular processes).
• Conversions of photosynthetic products into other biomolecules		• Conduct a project on how a greenhouse works in enhancing plant growth.	
• Factors (light intensity and carbon dioxide concentration) affecting the rate of photosynthesis	• Explain the effects of environmental factors on the rate of photosynthesis.	• Use animations to study the processes of photosynthesis.	

[7] Photosystem is not the learning and assessment focus.
[8] The following contents are not the learning and assessment focus: detailed biochemical reactions, names and structural formula of the intermediate biomolecules, concept of oxidation number.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Respiration[9] • Sites of respiration – Cytoplasm and mitochondrion • Glycolysis – Breakdown of glucose to 3-C compound (triose phosphate) – Oxidation of triose phosphate to pyruvate – Production of NADH and ATP • Aerobic pathway – Conversion of pyruvate to acetyl-CoA – Outline of Krebs cycle ▪ Combination of acetyl-CoA with a 4-C compound to form a 6-C compound ▪ Regeneration of 4-C compound with the release of carbon dioxide ▪ Production of NADH, FADH and ATP	• Understand the significance of respiration. • State the role of ATP in energy transfer. • Outline the major steps of glycolysis, aerobic and anaerobic pathways.	• Examine the photomicrographs or live cell images of mitochondria. • Design and perform investigations to study aerobic and anaerobic respiration in organisms. • Interpret, analyse and evaluate data relating to investigations on respiration. • Discuss the application of anaerobic respiration in the food industry. • Search for information to understand scientists' work related to cellular respiration. • Use animations to study the processes of respiration.	① Identify and explain the importance of control variables in scientific investigations (e.g. the study of respiration). ② Recognise that the development of microscopic technology and imaging technology may lead to the advancement of biological knowledge. ② Be aware of the applications of biological knowledge of cells and molecules of life in society. ③ Recognise the contributions of various people (e.g. Sir Hans Krebs) to developments in biology.

[9] The following contents are not the learning and assessment focus: detailed biochemical reactions, names and structural formula of the biomolecules, concept of oxidation number.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
– Oxidative phosphorylation[10] ▪ Regeneration of NAD and FAD ▪ Formation of ATP • Anaerobic pathway – Formation of lactic acid in muscle cell – Formation of ethanol and carbon dioxide in yeast • Industrial applications of anaerobic respiration	• Be aware of the occurrence of anaerobic respiration during exercise. • Distinguish between aerobic and anaerobic respiration. • Be aware of the interconversions of biomolecules through biochemical pathways. • Compare the processes of respiration and photosynthesis.		

[10] Oxygen as the final acceptor of hydrogen should be mentioned.

COMPULSORY PART II. Genetics and Evolution

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
a. Basic genetics Mendel's laws of inheritance	• Understand the law of segregation and law of independent assortment. • Apply Mendel's laws of inheritance to solve genetic problems[2].	• Read articles about how Gregor Mendel contributed to the study of genetics. • Use computer simulations and other materials (e.g. genetic corn) to study patterns of inheritance.	① Make careful observations and accurate records. ① Use diagrams and physical models as visual representations of phenomena and relationships arising from the data (e.g. genetic diagrams).
Inheritance in humans[1] • Multiple alleles: ABO blood groups • Sex linkage • Sex determination	• Understand the inheritance of ABO blood groups and sex-linked traits. • Recognise the role of sex chromosomes in sex determination of humans.		② Be aware of the application of knowledge of basic genetics in society and its social, ethical and economic implications. ③ Recognise the contributions of various people (e.g. Gregor Mendel) to the understanding of genetics and evolution. ③ Be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses (e.g. Mendel's work).

[1] Codominance, incomplete dominance and linkage are not the learning and assessment focus.
[2] The learning and assessment focus is confined to solving genetic problems involving monohybrid cross.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Pedigree analysis Variations in characteristics • Continuous variation • Discontinuous variation • Causes of variation – hereditary information – environmental factors – mutation	• Analyse pedigree to study the inheritance of characteristics. • Explain the causes of different types of variations in characteristics.	• Construct and/or analyse a pedigree of the inheritance of some human traits (e.g. haemophilia, tongue rolling and ear lobes). • Observe and analyse variations in humans (e.g. height and tongue rolling).	① Classify, collate and display both first and second hand data (e.g. construct a pedigree of the inheritance of some human traits). ① Make careful observations and accurate records (e.g. observe variations in humans).
b. Molecular genetics Chromosomes, genes and nucleic acids Gene expression and protein synthesis • transcription[3] and translation[4]	• Describe the structural and functional relationships of chromosomes, genes and nucleic acids. • Outline the process of protein synthesis.	• Construct models of DNA and RNA. • Read about the work of some biologists (e.g. James Watson and Francis Crick) in the discovery of DNA.	① Use diagrams and physical models as visual representations of phenomena and relationships arising from the data (e.g. DNA model). ② Be aware of the application of knowledge of molecular genetics in society and its social, ethical and economic implications.

[3] Detailed process of transcription is not the learning and assessment focus. Limit to the concepts of template strand and base pairing.
[4] Detailed process of translation is not the learning and assessment focus. Limit to the concepts of codon and anticodon.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Mutation • Chromosome mutation (e.g. Down syndrome) and gene mutation (e.g. Sickle-cell anaemia) • Spontaneous and induced mutation • Causes of mutation (e.g. radiation and chemical)	• Distinguish between chromosome and gene mutation.	• Examine photomicrographs of karyotypes of chromosome mutation. • Search for information on the sources of mutagenic agents and their effects on human health.	③ Be aware of the dynamic nature of biological knowledge (e.g. from basic genetics to molecular genetics). ③ Recognise the contributions of various people (e.g. James Watson, and Francis Crick) to the understanding of genetics.
Biotechnology • Recombinant DNA technology[5] • DNA fingerprinting[6] • Human Genome Project (HGP) and its implications	• Recognise the applications of recombinant DNA technology and DNA fingerprinting. • Recognise the contributions and limitations of the data obtained from the HGP. • Appreciate the joint efforts of scientists in international genomics projects.	• Use audiovisual materials to illustrate the processes of recombinant DNA technology and DNA fingerprinting. • Perform practical work to extract DNA from living tissues (e.g. onion tissues), and to separate DNA fragments by gel-electrophoresis. • Search for information on the use of DNA fingerprinting in forensic science. • Make a chart or create a timeline of the discoveries that have arisen from the HGP.	① Use appropriate instruments and proper techniques for carrying out practical work on molecular genetics (e.g. DNA extraction and gel-electrophoresis). ② Be aware that societal needs have led to technological advances (e.g. recombinant DNA technology and DNA fingerprinting). ② Appreciate the contribution of the Human Genome Project (HGP) and the application of biotechnology to humans and society.

[5] Detailed mechanism of recombinant DNA technology is not the learning and assessment focus. Recombinant DNA technology involves restriction and ligation.
[6] Detailed mechanism of DNA fingerprinting is not the learning and assessment focus.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
			② Explain how the knowledge of biotechnology may lead to the development of new technologies and how new technologies may lead to further understanding of inheritance. ③ Appreciate the advancement of the study of genetics from traditional breeding experiments to molecular experimentation and analysis.
c. Biodiversity and evolution Diversity of life forms Classification of organisms • Need for classification	• Appreciate the existence of various life forms in the world, and the different ways through which organisms adapt to their habitats. • Be aware that modern classification is based on the phylogenetic relationships of organisms. • Recognise the use of classification systems and binomial nomenclature. • Construct and use dichotomous keys to identify unknown organisms.	• Visit a herbarium, country park or special area (e.g. Lions Nature Education Centre, and Tai Po Kau Nature Reserve). • Use specimens, audiovisual materials, games, etc. to study the diversity of organisms, and their ways of life. • Classify organisms into major categories according to a classification system.	① Make careful observations and accurate records (e.g. observe distinguishing features for identifying organisms). ② Appreciate the role of science and technology in understanding the complexity of life forms and their genetics.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
• Classification approaches proposed by Carl Woese – Six kingdoms (Eubacteria, Archaebacteria, Protista, Fungi, Plantae and Animalia) – Three domains (Bacteria, Archaea and Eukarya)	• Classify organisms into six kingdoms. • Appreciate that classification systems are subject to change when new evidence appears.	• Search for information on other classification systems, and binomial naming of some organisms. • Construct and use dichotomous keys to identify organisms from a local habitat. • Read about the work of Carl Linnaeus and his system of naming organisms. • Discuss the advantages and limitations of different classification systems, and why the classification of some organisms has been changed over time.	③ Be aware of the dynamic nature of biological knowledge (e.g. the development of classification systems).
Origins of life	• Appreciate that there are various explanations for the origins of life.	• Read article about the Miller-Urey experiment.	① Formulate and revise scientific explanations and models using logic and evidence (e.g. use of fossil records as evidence for evolution). ② Understand how science has been influenced by societies (e.g. various views on the origins of life and evolution).

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Evolution • Origin of species • Speciation – genetic variation – isolation[7] • Mechanism of evolution – natural selection • Evidence of evolution (e.g. fossil record)	• Relate speciation to evolution. • Outline the mechanism of evolution. • Be aware of the limitations of using fossil record as evidence of evolution, and the presence of other evidence.	• Read about the work of some biologists (e.g. Jean Baptiste Lamarck, Charles Darwin and Sir Alfred Russel Wallace) on evolution. • Use computer simulations or other simulations to model natural selection.	③ Recognise the contributions of various people (e.g. Charles Darwin, Sir Alfred Russel Wallace and Jean Baptiste Lamarck) to the understanding of evolution.

[7] Details of different types of isolation are not the learning and assessment focus.

COMPULSORY PART III. Organisms and Environment

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
a. Essential life processes in plants Nutrition in plants • Plants as autotrophs • Photosynthesis*	• Appreciate the significance of plants as autotrophs.		① Make careful observations and accurate records (e.g. examine prepared slides or temporary mounts of roots, stems and leaves, and make biological drawings). ① Ask relevant questions, identify problems and formulate hypotheses for investigations related to life processes.
• Need for minerals[1]	• Explain the need for minerals in plants.	• Design and perform investigations to study the effects of different minerals on plant growth using potted plants.	① Plan, conduct and write reports on scientific investigations in areas of life processes.
• Absorption of water and minerals	• Relate the structure of roots to their functions in water absorption.	• Examine the structure of the root of young seedlings using live specimens or prepared slides.	① Identify and explain the importance of control variables in scientific investigations (e.g. the study of the effects of different minerals on plant growth).
Gas exchange in plants • Occurrence of gas exchange in different parts of plant • Gas exchange in leaves	• Relate the features of leaves to gas exchange and prevention of water loss. • Explain the effects of light intensity on gas exchange in plants.	• Design and perform investigations to study the effects of light intensity on gas exchange in land or water plants using hydrogencarbonate indicator solution or data loggers.	① Use appropriate instruments and proper techniques for carrying out practical work (e.g. preparation of temporary mounts and microscopic examinations).

* Refer to *Photosynthesis* in topic I Cells and Molecules of Life.
[1] Using nitrogen, phosphorus and magnesium as examples.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Transpiration • Process[2] and significance • Factors (humidity, light intensity and wind) affecting the rate of transpiration Transport of substances in plants • Transport of water[3] and minerals • Translocation of organic nutrients[4] Support in plants • Cell turgidity • Physical nature of xylem	• Make connections between transpiration, absorption and transport of water, and cooling of plants. • Explain the effects of environmental factors on the rate of transpiration. • Describe the path of materials transport in flowering plants. • Compare the means of support in herbaceous and woody dicotyledonous plants.	• Design and perform investigation to compare the distribution of stomata on both sides of a leaf. • Perform practical work to demonstrate the occurrence of transpiration, and to trace the uptake of water in herbaceous plant using eosin solution. • Design and perform investigations to study the effects of environmental factors on the rate of transpiration using potometer. • Examine the cross sections of the leaf, stem and root of a young dicotyledonous plant using temporary mounts or prepared slides.	② Analyse ways in which scientific and technological advancement (e.g. computing technology and image analysing technology) have enhanced our understanding of complex life processes. ③ Understand that science is a human endeavour through the study of essential life processes of plants and interactions with our environment. ③ Be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses (e.g. the study of transpiration pull). ③ Recognise the complexity of the physiological processes of plants. ③ Understand the nature and limitations of scientific activity (e.g. investigations on various physiological processes).

[2] The explanation of transpiration pull should be linked with the sub-topic *Movement of substances across membrane*. Cohesion-tension theory is not the learning and assessment focus.
[3] Cohesion-tension theory is not the learning and assessment focus.
[4] Mass flow hypothesis of phloem transport is not the learning and assessment focus.

b. Essential life processes in animals Nutrition in humans • Humans as heterotrophs			① Ask relevant questions, identify problems and formulate hypotheses for investigations related to life processes.
• Food requirements and functions of different food substances – Carbohydrates – Lipids – Proteins – Vitamins – Minerals (e.g. calcium and iron) – Dietary fibre	• Explain the effect of age, activity and pregnancy on dietary requirements.	• Perform practical work to identify composition in some common foodstuffs. • Design and perform investigation to compare the amount of vitamin C in different fruits and vegetables.	① Plan, conduct and write reports on scientific investigations in areas of life processes. ① Identify and explain the importance of control variables in scientific investigations (e.g. the study of the action of digestive enzymes). ① Use appropriate instruments and proper techniques for carrying out practical work (e.g. food tests and dissection).
• Balanced diet • Ingestion – Dentition – Mastication	• Relate health problems to improper diet.		② Evaluate the impact of the application of biology to human activities (e.g. dietary requirement).
• Digestion – General plan of the digestive system	• Explain the significance of mechanical and chemical digestion.	• Examine the alimentary canal and its associated glands of a dissected mammal or a human torso.	② Be aware of the application of biological knowledge (e.g. balanced diet) in society.
– Digestion of carbohydrates, proteins and lipids in various parts of the alimentary canal	• Understand the digestion and absorption processes in various parts of the alimentary canal.	• Perform practical work to demonstrate the effect of bile salt on oil.	
• Absorption and assimilation – Structural adaptation of small intestine for food absorption – Role of liver – Fate of absorbed food	• Illustrate the adaptive features of the small intestine for food absorption. • Describe the routes of the transport of absorbed food and their fates in cells and tissues.	• Design and perform investigations to study the action of digestive enzymes (e.g. amylase on starch-agar plate, protease on milk-agar plate or egg white).	③ Understand that science is a human endeavour through the study of essential life processes of animals and interactions with our environment. ③ Recognise the complexity of the physiological processes of animals.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
• Egestion		• Perform practical work to simulate digestion and absorption in the alimentary canal using dialysis tubing.	③ Understand the nature and limitations of scientific activity (e.g. investigations on various physiological processes).
Gas exchange in humans			
• General plan of the breathing system	• Relate the structure of various parts of the breathing system to gas exchange.	• Examine the breathing system of a dissected mammal or a human torso. • Examine a pig's lungs.	① Make careful observations and accurate records (e.g. examine prepared slides and make biological drawings). ① Use appropriate instruments and proper techniques for carrying out practical work (e.g. microscopic examinations and dissections).
• Gas exchange in air sacs • Routes of transport of respiratory gases • Mechanism of ventilation	• Understand the exchange of respiratory gases between the body cells and the external environment.	• Examine the structure of air sacs using prepared slide or photomicrograph. • Perform practical work to compare the differences in composition between inhaled and exhaled air.	
Transport of substances in humans			
• General plan of the circulatory system and lymphatic system • Composition and functions of blood, tissue fluid and lymph • Exchange of materials between blood and body cells • Formation of tissue fluid	• Relate the structure of various components of the circulatory system and lymphatic system to transport. • Describe the exchange of materials and the formation of tissue fluid.	• Perform dissection of a pig's heart and examine its structures. • Examine the capillary flow in a fish's tail fin or frog's web. • Examine the structure of arteries and veins, and the components of blood using prepared slides or photomicrographs.	① Make careful observations and accurate records (e.g. examine prepared slides and make biological drawings). ① Use appropriate instruments and proper techniques for carrying out practical work (e.g. microscopic examinations and dissections).

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
c. Reproduction, growth and development			
Asexual reproduction • Binary fission in bacteria	• Discuss the significance of asexual and sexual reproduction.	• Examine photomicrographs, video clips or live cell images of binary fission of bacteria.	① Make careful observations and accurate records (e.g. examine photomicrographs and make biological drawings). ① Use appropriate instruments and proper techniques for carrying out practical work (e.g. microscopic examinations).
• Vegetative propagation in flowering plants	• Outline with an example, the process of vegetative propagation in flowering plants.	• Cultivate and examine any vegetative propagation organ of flowering plants.	
Sexual reproduction in flowering plants • Floral parts	• Relate the structure of various floral parts to reproduction.	• Examine the adaptive features of insect-pollinated and wind-pollinated flowers.	
• Pollination	• Understand the importance of pollination. • Compare the adaptive features of insect-pollinated flowers and wind-pollinated flowers.		
• Fertilisation • Significance of seed and fruit dispersal	• Outline the process of fertilisation leading to the formation of seed and fruit.		

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Reproduction in humans • General plan of the male and female reproductive systems • Structure of sperm and ovum • Menstrual cycle[5] – Cyclic changes in uterine lining – Ovulation • Fertilisation • Development of embryo and foetus – Placenta – Identical twins and fraternal twins • Birth process • Parental care	• Relate the structure of various parts of the reproductive systems to their functions. • Recognise the roles of sperm and ovum in sexual reproduction. • Describe the transfer of semen during sexual intercourse and the process of fertilisation. • Relate the structure of the placenta to its role in the development of foetus. • Recognise the significance of parental care and the advantages of breast-feeding.	• Examine the male and female reproductive systems of dissected mammals or a human torso. • Examine photomicrographs, video clips or live cell images of sperms and ova. • Use audiovisual materials to study the process of fertilisation. • Examine photos or video clips taken by ultrasound showing different stages of foetal development. • Discuss the harmful effects of drinking and smoking habits of a pregnant woman on the development of the foetus.	① Make careful observations and accurate records (e.g. examine photomicrographs and make biological drawings). ② Evaluate the impact of the application of biology to human activities (e.g. birth control). ② Analyse ways in which scientific and technological advancement (e.g. computing technology and image analysing technology) have enhanced our understanding of complex life processes. ② Be aware of the application of biological knowledge (e.g. birth control) in society and its social, ethical, economic and environmental implications.

[5] Hormonal control of menstrual cycle is included in elective topic V Human Physiology: Regulation and Control.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
• Birth control	• Understand the biological basis of various methods of birth control.	• Search for information on the effectiveness and possible side effects of various birth control methods, *in vitro* fertilisation and termination of pregnancy.	
Growth and development • Concepts of growth and development • Germination of seed and its development into a new plant		• Design and perform investigations to study seed germination and the growth of young seedlings.	① Ask relevant questions, identify problems and formulate hypotheses for investigations related to life processes. ① Plan, conduct and write reports on scientific investigations in areas of life processes.
• Stages of growth in annual plants and humans – Growth curves	• Identify the different stages of growth from growth curves of plants and humans.		① Identify and explain the importance of control variables in scientific investigations.
• Measurement of growth in plants and humans – Growth parameters (e.g. weight, height and area)	• Discuss the advantages and disadvantages of using various parameters to measure growth.		

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
d. Coordination and response Stimuli, receptors and responses • Light as stimulus: the human eye – Major parts of the eye – Rod cells and cone cells – Colour vision – Eye accommodation	• Understand the roles of sense organs and receptors in detecting changes in the environment. • Relate the structure of major parts of the eye to vision.	• Examine model of the human eye. • Perform dissection of an ox's eye and examine its structures.	① Use appropriate instruments and proper techniques for carrying out practical work (e.g. dissections). ① Ask relevant questions, identify problems and formulate hypotheses for investigations related to life processes.
– Eye defects (long sight, short sight and colour blindness)	• Explain the causes of eye defects. • Describe how long sight and short sight are corrected with glasses. • Be aware of the surgical methods for eyesight correction.	• Search for information on how modern technology helps in rectifying eye defects (e.g. short/long sight, astigmatism, cataract or glaucoma).	① Plan, conduct and write reports on scientific investigations in areas of life processes. ① Identify and explain the importance of control variables in scientific investigations.
• Light as stimulus: phototropic response in plants – Responses of root and shoot – Role of auxins	• Recognise the significance of phototropism. • Understand the mechanism of phototropic responses in root and shoot.	• Design and perform investigations on the phototropic responses of roots and shoots.	③ Be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses (e.g. the study of tropism).
• Sound as stimulus: the human ear[6] – Major parts of the ear	• Relate the structure of major parts of the ear to hearing.	• Examine model of the human ear.	

[6] Mechanism of hearing is not the learning and assessment focus.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Nervous coordination in humans • General plan of the nervous system • Central nervous system – Functions of main parts of the brain: cerebrum, cerebellum and medulla oblongata – Functions of spinal cord – Neurone: sensory neurone, interneurone and motor neurone – Synapse[7] • Reflex arc and reflex action • Voluntary actions	• Recognise the role of the central nervous system. • Distinguish different types of neurones in terms of structure and function. • Describe the transmission of nerve impulses across a synapse. • Compare the nature of reflexes and voluntary actions with examples.	• Examine model of the human brain. • Perform practical work of a reflex action (e.g. knee jerk reflex).	② Analyse ways in which scientific and technological advancement (e.g. computing technology and image analysing technology) have enhanced our understanding of complex life processes. ③ Recognise the complexity of the physiological processes in humans. ③ Understand the nature and limitations of scientific activity (e.g. investigations on various physiological processes).
Hormonal coordination in humans • Nature of hormonal coordination • General plan of the endocrine system	• Understand the nature of hormonal coordination. • Use an example to illustrate hormone mediated response. • Compare hormonal and nervous coordination.		③ Recognise the complexity of the physiological processes in humans.

[7] Specific names of neurotransmitters are not the learning and assessment focus.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Movement in humans • Components of the musculo-skeletal system[8]: skeleton, muscles, joints, tendons and ligaments • Joints: hinge joints (e.g. elbow/knee) and ball-and-socket joints (e.g. shoulder/hip) • Action of opposing muscle pairs • Initiation of muscle contraction by nerve impulse	• Understand the roles of different components of the musculo-skeletal system. • Compare the degree of movement between hinge joints and ball-and-socket joints. • Describe how a nerve impulse transmits across the neuromuscular junction leading to muscle contraction. • Explain coordination in terms of stimulus, receptor, coordination system, effector and response.	• Examine model of the human arm. • Perform practical work to observe the contraction of teased muscle from the leg of a pithed frog.	③ Be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses.
e. Homeostasis Concept of homeostasis • Importance of homeostasis • Feedback mechanism[9]	• Appreciate that the internal environment of the human body is maintained by the nervous system and the endocrine system.	• Construct a flow chart to illustrate the feedback mechanism.	③ Recognise the complexity of the physiological processes in humans.

[8] Types of lever system are not the learning and assessment focus.
[9] The learning and assessment focus is confined to negative feedback mechanism.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Parameters of the internal environment • Glucose level and gas content in blood, water content and body temperature Regulation of blood glucose level • Roles of liver, pancreas, insulin and glucagon	• Explain the principle of feedback mechanism with reference to the regulation of blood glucose level.	• Search for information about the physiological consequences of hormonal imbalance (e.g. insulin) and the remedies, especially through modern advances in science and technology.	
f. Ecosystems Levels of organisation • Species, population, community, ecosystem, biome and biosphere Major ecosystem types • Freshwater stream, rocky shore, mangrove, grassland and woodland	• Be aware that organisms and their environment are studied at different levels of organisation. • Appreciate the existence of a variety of ecosystems in the local environment.	• Visit nature reserves, country parks, marine parks, field study centres and other local habitats.	③ Recognise the complexity of the environment.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Components of an ecosystem • Abiotic factors • Biotic community – Niche and habitat – Species diversity and dominant species	• Identify the abiotic factors of a habitat and explain their effects.		③ Understand that science is a human endeavour through the study of essential life processes of animals and interactions with our environment.
– Relationships between organisms ▪ Predation, competition, commensalism, mutualism and parasitism	• Describe the different types of relationships between organisms in a habitat.	• Use live or audiovisual materials to show the relationships of organisms in an ecosystem.	
– Ecological succession ▪ Primary and secondary succession ▪ Climax community	• Outline the process of ecological succession.		
Functioning of an ecosystem • Energy flow – Source of energy – Energy flow between different trophic levels – Feeding relationships of organisms	• Use food chains, food webs, pyramids of numbers and biomass to represent the feeding relationships of organisms and energy flow between different trophic levels. • Understand the efficiency of energy transfer in an ecosystem.	• Construct and interpret food chains, food webs, and pyramids of numbers and biomass.	① Use diagrams, graphs, flow charts and physical models as visual representations of phenomena and relationships arising from the data (e.g. use food chains, food webs, and pyramid of numbers to represent relationships between organisms in ecosystems and distribution of organisms).
• Materials cycling – Carbon and nitrogen cycles	• Understand the cycling of materials in an ecosystem.		

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
• Roles of producers, consumers and decomposers in energy flow and materials cycling	• Be aware of the interactions between the biotic community and the abiotic factors of an ecosystem.		
Conservation of ecosystem			
• Impacts of human activities	• Recognise the need for conservation.		② Evaluate the impact of the application of biology to human activities (e.g. pollution control). ② Develop sensitivity and responsibility in striking a balance between the needs of humans and a sustainable environment. ② Be aware of the application of biological knowledge (e.g. sewage treatment) in society and its social, ethical, economic and environmental implications.
Study of a local habitat • Distribution and abundance of organisms – Sampling methods ▪ Quadrats ▪ Line and belt transects • Measurement of abiotic factors (e.g. light intensity, pH, wind,	• Conduct and report an ecological study of a local habitat.	• Conduct an ecological study of a local habitat (e.g. freshwater stream and rocky shore).	① Ask relevant questions, identify problems and formulate hypotheses for investigations related to ecosystems. ① Plan, conduct and write reports on scientific investigations of ecosystems. ① Select and design appropriate methods of investigations for specific purposes

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
temperature, oxygen, humidity and salinity)			(e.g. use transects and quadrats to collect samples in field studies). ① Explain why sample size, random sampling, replicates and repeat procedures are important in scientific investigations (e.g. field studies). ① Use appropriate instruments and proper techniques for carrying out practical work (e.g. field study techniques). ③ Be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses (e.g. field ecology). ③ Understand the nature and limitations of scientific activity (e.g. investigations on ecosystems).

COMPULSORY PART IV. Health and Diseases

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
a. Personal health Meaning of health	• Recognise the meaning of health.		② Be aware of the application of biological knowledge in maintaining a healthy community and its social, ethical, economic and environmental implications.
b. Diseases Types of diseases • Infectious diseases • Non-infectious diseases	• Understand the concept of disease. • Distinguish between infectious and non-infectious diseases.		① Make careful observations and accurate records (e.g. examine prepared slides or photomicrographs of pathogens and make biological drawings).
Infectious diseases (e.g. Cholera, dengue fever, hepatitis B, influenza and tuberculosis)	• Understand how infectious diseases are transmitted.	• Conduct a project on infectious diseases (e.g. Cholera, dengue fever, hepatitis B, influenza and tuberculosis) with reference to their ways of transmission, symptoms, treatments and ways of prevention.	① Identify questions and carry out appropriate studies to understand various infectious and non-infectious diseases in our society. ① Classify, collate and display both first and second hand data (e.g. collect information from the Centre for Health Protection or the Internet).
• Causes • Ways of transmission – Water, air, droplets, food, body fluids, vector and direct contact	• Discuss how to reduce the spread of some common infectious diseases.	• Examine photomicrographs, prepared slides or live cell images of some pathogens (e.g. viruses, bacteria, fungi and protists).	① Understand that the process of scientific investigations includes analysing evidence and providing explanations based upon scientific theories and

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
• Treatment – Antibiotics ▪ Action of antibiotics ▪ Indiscriminate use – Other drugs[1] (e.g. sulpha drugs)	• Be aware of the various ways of disease treatment. • Discuss the consequences of indiscriminate use of antibiotics.	• Read stories about how scientists (e.g. Sir Alexander Fleming, Ernst Boris Chain and Sir Howard Florey) contributed to the discovery and development of penicillin. • Use audiovisual materials to illustrate the effects of antibiotic discs on a bacterial lawn.	concepts (e.g. treatment and prevention of infectious diseases). ② Be aware of the application of biological knowledge in maintaining a healthy community and its social, ethical, economic and environmental implications.
Non-infectious diseases • Cancer	• Discuss the causal relationships between the incidence of various non-infectious diseases and certain lifestyles.	• Conduct a study on the incidence of liver cancer and lung cancer in relation to lifestyles. • Conduct a project on the incidences of various types of cancer in Hong Kong. • Design a poster, leaflet or web page to advise how to reduce the chances of developing one form of cancer.	② Analyse ways in which societal needs have led to technological advances (e.g. treatment and prevention of diseases). ② Appreciate how modern technological advances and scientific discoveries contribute to the detection, diagnosis, treatment, prevention and monitoring of diseases (e.g. cancer and tuberculosis). ② Be aware of personal responsibility in preventing disease transmission.
• Cardiovascular diseases (e.g. coronary heart disease)		• Suggest ways to reduce the incidence of cardiovascular diseases.	
• Diabetes – Forms of diabetes (insulin-dependent diabetes and non-insulin-dependent diabetes) – Control of diabetes	• Outline the biological principles in the control of insulin-dependent diabetes.	• Search for information on the types, symptoms, risk factors, diagnosis, management and control of diabetes.	③ Appreciate the contributions of various people in advancing the application of biology (e.g. the development of vaccines and the discovery of antibiotics).

[1] Specific example and action of drugs are not the learning and assessment focus.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Prevention of diseases • Vaccination: principle of vaccination • Immunisation programme • Healthy lifestyle • Community health	• Outline the principle of vaccination and evaluate the advantages and risks of its application. • Be aware of personal responsibility in preventing disease transmission and the importance of community health.	• Read stories about how scientists (e.g. Edward Jenner, Louis Pasteur and Jonas Salk) contributed to the development of vaccination. • Search for information on the relation of immunisation programmes to the control of infectious diseases (e.g. whooping cough and tuberculosis), and the major outbreaks of infectious diseases in Hong Kong. • Study a personal immunisation record to find out the types of diseases that are covered by the local immunisation programme.	③ Be aware that biological knowledge and theories related to the prevention and control of diseases are developed through observations, hypotheses, experimentations and analyses. ③ Understand the nature and limitations of scientific activity (e.g. the causes and transmission of some diseases are not yet known).
c. Body defence mechanisms Non-specific defence mechanisms • Skin, mucus and other secretions, cilia, phagocytes, blood clotting and inflammatory responses	• Understand the non-specific and specific defence mechanisms.	• Examine prepared slides or models to identify features of mammalian skin that are related to body defence. • Use audiovisual materials, prepared slides, photomicrographs or live cell images to observe phagocytes and lymphocytes.	① Understand that the process of scientific investigations includes analysing evidence and providing explanations based upon scientific theories and concepts (e.g. body defence mechanisms).

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Specific defence mechanism • Immune response • Antigen and antibody • Lymphocytes (B and T cells)	• Outline the principles of immune response.	• Use audiovisual materials or animations to demonstrate the production of antibodies in response to an antigen, and the antigen-antibody reactions.	③ Be aware of the dynamic nature of biological knowledge related to body defence mechanism and diseases, and understand that science is a human endeavour.
• Primary and secondary responses	• Compare primary and secondary responses.		
• Active and passive immunity	• Distinguish between active and passive immunity.	• Discuss why breast feeding may confer passive immunity on a child.	

ELECTIVE PART V. Human Physiology: Regulation and Control

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
a. Regulation of water content (osmoregulation) Importance of regulation of water content Regulation of water content • General plan of the urinary system • Structure and function of nephron • Processes in urine formation[1] – Ultrafiltration – Reabsorption • Action of antidiuretic hormone (ADH) • Biological principles of the dialysis machine (kidney machine)	• Recognise the excretory function of the kidney. • Relate the structure of nephron to its function in regulation of water content. • Understand the action of ADH.	• Examine a dissected mammalian kidney or a kidney model. • Examine the urinary system of a dissected mammal or a human torso.	① Ask relevant questions, identify problems and formulate hypotheses for investigations related to nervous and hormonal control of the human body. ② Be aware of the significance of knowledge in human physiology to improve the quality of life and maintain a healthy community. ② Be aware that societal needs have led to technological advances (e.g. dialysis machines). ② Appreciate the role of science and technology in understanding the human body. ③ Be aware of the dynamic nature of biological knowledge in human physiology, and understand that science is a human endeavour. ③ Be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses.

[1] Countercurrent multiplier is not the learning and assessment focus.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
b. Regulation of body temperature Importance of body temperature regulation Mechanisms of temperature regulation • Skin • Regulatory centre (hypothalamus) • Circulation • Hormone (thyroxine) • Muscle • Behavioural methods	• Understand the structural, physiological and behavioural mechanisms of body temperature regulation.	• Search for information on human physiological conditions under extreme hot and cold environments. • Construct a concept map to show the mechanism of temperature regulation. • Examine prepared slides or photomicrographs to identify features of mammalian skin that are related to temperature regulation.	① Ask relevant questions, identify problems and formulate hypotheses for investigations related to nervous and hormonal control of the human body. ① Make careful observations and accurate records. ② Appreciate the role of science and technology in understanding the human body. ③ Be aware of the dynamic nature of biological knowledge in human physiology, and understand that science is a human endeavour. ③ Be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses.
c. Regulation of gas content in blood Importance of regulation of gas content in blood Control of rate and depth of breathing • Nervous control	• Understand the control mechanism of breathing.		① Ask relevant questions, identify problems and formulate hypotheses for investigations related to nervous and hormonal control of the human body. ① Plan, conduct and write a report on a scientific investigation (e.g. study the

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
– Respiratory centre and chemoreceptors – Effects of carbon dioxide concentration in blood Control of cardiac output • Heart rate and stroke volume • Pacemaker and cardiac cycle • Nervous control – Vagus nerve and sympathetic nerves • Hormonal control – Adrenaline	• Outline the major events during the cardiac cycle. • Understand the nervous and hormonal control of cardiac output.		change in heart rate and breathing rate before and after exercise). ① Use appropriate instruments and proper techniques for carrying out practical work (e.g. measuring breathing rate and heart rate). ① Make careful observations and accurate records. ② Appreciate the role of science and technology in understanding the human body.
Effects of exercise • Rate and depth of breathing • Oxygen debt • Cardiac output	• Explain how the gas content in blood is regulated during and after exercise.	• Design and perform investigations to study the changes in heart rate and breathing before and after exercise using data loggers or other methods.	③ Be aware of the dynamic nature of biological knowledge in human physiology, and understand that science is a human endeavour. ③ Be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
d. Hormonal control of reproductive cycle Interaction of hormones in the menstrual cycle Use of hormones as contraceptives and in the treatment of infertility	• Understand the significance of hormonal control of the menstrual cycle. • Explain how hormones can be used as contraceptives and in the treatment of infertility.	• Interpret graphs showing the fluctuation of hormones and the changes of the uterine lining of the menstrual cycle. • Conduct a project on the causes of infertility and its treatment.	① Ask relevant questions, identify problems and formulate hypotheses for investigations related to nervous and hormonal control of the human body. ① Classify, collate and display both first and second hand data (e.g. hormonal change in the menstrual cycle). ② Be aware that societal needs have led to technological advances (e.g. the use of contraceptives). ② Appreciate the role of science and technology in understanding the human body. ③ Be aware of the dynamic nature of biological knowledge in human physiology, and understand that science is a human endeavour. ③ Be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses.

ELECTIVE PART VI. Applied Ecology

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
a. Human impact on the environment Human population growth • Impact of rapid human population growth on the environment • Need for population control Use of resources • Types of resources: renewable and non-renewable resources • Fisheries and agriculture • Impacts – Overexploitation (e.g. in fisheries) – Environmental degradation (e.g. chemical pollution in agriculture) Effects of urbanisation and industrialisation • Land clearance and reclamation • Health problems related to pollution	• Evaluate the impact and control of rapid human population growth. • Recognise the impacts of malpractices in fisheries and agriculture. • Account for the accumulation of toxic substances along a food chain. • Explain the ecological impacts of land clearance and reclamation.	• Conduct a project on the effects of human population growth on the environment and the quality of life.	① Make careful observations, ask relevant questions, identify problems and formulate hypotheses for investigations related to pollution. ① Identify and explain the importance of control variables in scientific investigations related to pollution. ① Explain why sample size, random sampling, replicates and repeat procedures are important in ecological investigations. ① Classify, collate, display, analyse and draw conclusions from both first and second hand data (e.g. collect field data, obtain data from the Environmental Protection Department, Agriculture, Fisheries and Conservation Department or the Internet). ② Be aware of the application of ecological knowledge in society and its social, ethical, economic and environmental implications.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
– Air pollution (e.g. respiratory illnesses) – Water pollution (e.g. gastroenteritis)	• Recognise the effects of air and water pollution on the environment and human health. • Design and perform investigation to study air or water pollution.	• Design and perform investigations to study the lichen distribution as an indication of air pollution by sulphur dioxide. • Identify areas in Hong Kong in which air pollution is most serious, based on the available information from the Environmental Protection Department, and discuss the possible causes. • Design and perform investigations to compare the oxygen content of clean and polluted water using data loggers or other means, and to study the types, sources and effects of pollutants on a freshwater stream or a shore habitat.	② Analyse ways in which scientific and technological advancement have influenced our lives, society and the environment (e.g. pollution resulting from industrialisation and urbanisation). ③ Be aware of the dynamic nature of biological knowledge in ecology and understand that science is a human endeavour. ③ Be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses (e.g. study of the impact of pollution on the local environment. ③ Understand the nature and limitations of scientific activity.
b. Pollution control Reduce, reuse, recycle and replace	• Recognise strategies for pollution control.	• Search for information on the joint efforts of governments to control regional air pollution problems. • Develop action plans to reduce environmental pollution.	② Explain how biological knowledge is used in technological application for management of the environment (e.g. sewage treatment).

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Sewage treatment	• Describe the biological principles of sewage treatment.	• Visit a sewage treatment plant.	
c. Conservation Importance of biodiversity	• Understand the need for conservation.		① Classify, collate, display, analyse and draw conclusions from second hand data (e.g. obtain data from the Environmental Protection Department, Agriculture, Fisheries and Conservation Department or the Internet).
Conservation of species • Endangered species in Hong Kong[1] • Measures to protect endangered species	• Recognise measures to preserve biodiversity. • Be aware of the economic, ecological, aesthetic and moral issues related to conservation. • Discuss the roles of individuals and government in conservation.	• Discuss the conservation of an endangered species with regard to population size, reasons for concern, measures introduced and international cooperation required; and the existing government policies on environmental conservation.	
Conservation of habitats • Conservation areas (e.g. Sites of Special Scientific Interest (SSSI), country parks, marine parks and the Ramsar site) • Ecological restoration of damaged land		• Visit a conservation area in Hong Kong (e.g. Sites of Special Scientific Interest (SSSI), country parks, marine parks and the Ramsar site). • Search for information on the work on conservation done by environmental concern groups and the government. • Debate on the dilemma between urbanisation, industrialisation and conservation.	

[1] Refer to the "Information on Endangered Species" of the Agriculture, Fisheries and Conservation Department (AFCD) for examples of endangered species in Hong Kong.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
d. Global issues • Sustainable development • Management of resources: fisheries and agriculture • Global warming • Acid rain • Eutrophication and algal boom	• Recognise the causes and problems of global issues. • Use local examples to illustrate how resources are managed.	• Conduct a project on the issues related to global warming and acid rain. • Research into some local examples which illustrate the conflicting interests between economic development and environmental conservation.	② Be aware of the application of ecological knowledge in society and its social, ethical, economic and environmental implications. ② Develop sensitivity and responsibility in striking a balance between the needs of humans and a sustainable environment.

ELECTIVE PART VII. Microorganisms and Humans

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
a. Microbiology Viruses • Multiplication of viruses	• Describe how a virus reproduces by infecting a living cell.		① Make careful observations, ask relevant questions, identify problems and formulate hypotheses for investigations related to the study of microorganisms.
Diversity of microorganisms • Representative organisms of Bacteria, Protista and Fungi	• Distinguish different groups of microorganisms based on group features.		① Plan, conduct and write a report on an investigation (e.g. study of optimal conditions for fermentation).
Growth of microorganisms (e.g. yeast) • Growth requirement – Temperature, pH, carbon and nitrogen sources, oxygen and water availability • Stages of growth • Measurement of growth – Cell counts, biomass and optical methods	• Discuss the effects of environmental factors on the growth of microorganisms. • Measure and identify the different stages of growth of microorganisms in culture.	• Design and perform investigations to study the growth of microorganisms (e.g. yeast).	① Use appropriate instruments and proper techniques for carrying out practical work (e.g. aseptic techniques, and measuring the growth of yeast). ① Identify and explain the importance of control variables in scientific investigations related to microbiology.
Aseptic techniques • Principles • Precautions and risk assessment	• Outline the principle of aseptic techniques. • Use aseptic techniques and follow safety procedures in handling,	• Perform practical work to demonstrate aseptic techniques, and to grow yeast in liquid culture and on agar.	② Analyse ways in which scientific and technological advancement (e.g. aseptic techniques) have enhanced our understanding in microbiology. ③ Be aware of the dynamic nature of biological knowledge related to

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
	culturing and disposing of microorganisms.		microorganisms and understand that the development of microbiology is a human endeavour.
b. Use of microorganisms Food processing[1] (e.g. beer-brewing) Vaccines Antibiotics Industrial enzymes (e.g. biological washing powder, and pectinase for extracting fruit juice) Sewage treatment Biogas production	• Be aware of the wide applications of microorganisms. • Outline the process of food production involving the use of microorganisms in fermentation. • Understand the roles of microorganisms in sewage treatment.	• Visit a food production plant. • Perform practical work on the application of the fermentation process (e.g. bread-making, fruit juice fermenting, beer-brewing and wine-making). • Design and perform investigations to study the optimal conditions necessary for fermentation by yeast in bread-making or beer-brewing. • Conduct a project on the applications of microorganisms. • Design and perform investigations to study the content and effectiveness of biological and non-biological washing powder. • Visit a sewage treatment plant.	① Make careful observations, ask relevant questions, identify problems and formulate hypotheses for investigations related to the study of microorganisms. ① Plan, conduct and write a report on an investigation (e.g. study the optimal conditions for fermentation). ① Use appropriate instruments and proper techniques for carrying out practical work. ① Identify and explain the importance of control variables in scientific investigations related to microbiology. ② Explain how biological knowledge is used in technological application (e.g. the use of microorganisms in sewage treatment). ③ Recognise the contributions of various people in advancing the application of biology (e.g. the development of

[1] Details of the manufacturing processes are not the learning and assessment focus.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
			vaccines and the discoveries of antibiotics).
c. Microbial genetics Genetically modified microorganisms (e.g. bacteria and yeast)	• Be aware of the significance and potential hazards of the application of genetically modified microorganisms.	• Search for information on the wide application of genetically modified microorganisms.	② Be aware of the applications of microorganisms and their social, economic and environmental implications (e.g. the use of bacteria in biotechnology). ② Analyse ways in which scientific and technological advancement have enhanced our understanding in microbiology.
d. Harmful effects of microorganisms Diseases caused by microorganisms[2] • Food-borne infection and food poisoning	• Outline the principles of how microorganisms cause diseases in humans. • Recognise the causes of food-borne infection and food poisoning.	• Search for information on the incidence of food poisoning in Hong Kong.	① Classify, collate and display both first and second hand data (e.g. collect data from the Centre for Health Protection, and the World Health Organisation).
Microbial deterioration	• Recognise the problems of microbial deterioration to our daily lives.	• Conduct a project on the prevention of microbial deterioration.	② Be aware of the influences of various types of microorganisms on society and the environment (e.g. as pathogens, decomposers).
Control of growth of microorganisms	• Discuss how to control and eliminate the harmful effects of microorganisms.		

[2] Refer to the sub-topic *Infectious diseases* of topic IVb for diseases caused by microorganisms.

ELECTIVE PART VIII. Biotechnology

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
a. Techniques in modern biotechnology Process of recombinant DNA technology • the production of insulin[1] Polymerase chain reaction (PCR) and its application DNA fingerprinting[2] and its application Genetically modified organisms • Principles of producing genetically modified microorganisms, animals and plants	• Outline the principle of recombinant DNA technology. • Outline the principle of PCR. • Recognise the wide application of PCR. • Outline the principle of DNA fingerprinting. • Outline the principle of constructing genetically modified organisms. • Discuss the benefits and hazards of genetic engineering.	• Use diagrams, audiovisual materials or animations to illustrate the processes of recombinant DNA technology, PCR, DNA fingerprinting and cloning. • Perform practical work to amplify DNA fragments using PCR; and to separate DNA fragments by gel electrophoresis. • Examine cases or discuss the use of DNA fingerprinting in forensic science. • Read articles about the contributions of scientists which have led to the development in genetic engineering (e.g. Kary Mullis, Alec Jeffreys, Herbert Boyer and Stanley Cohen).	① Use appropriate instruments and proper techniques for carrying out practical work (e.g. separation of DNA fragments by gel-electrophoresis and amplification of DNA fragments by PCR). ① Analyse and draw conclusions from data (e.g. DNA fingerprinting). ② Explain how scientific knowledge may lead to the development of new technology and how new technology may lead to scientific discovery (e.g. understanding of the characteristics of enzymes leading to the invention of PCR technology). ③ Recognise the contributions of various people in biotechnology (e.g. Herbert Boyer and Stanley Cohen - development of recombinant DNA technology, Kary

[1] Use the production of insulin as an example to illustrate the process of recombinant DNA technology.
[2] Use VNTR as an example to illustrate the major steps involved in DNA fingerprinting.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Animal cloning • Major steps in cloning of mammals (e.g. Dolly the sheep)	• Outline the principle of cloning of mammals.	• Search for information on animal or plant cloning.	Mullis - invention of the PCR technique, and Alec Jeffreys - development of DNA fingerprinting).
Plant cloning • Major steps in plant tissue culture	• Outline the principle of plant tissue culture. • Be aware of the advantages, disadvantages, applications and limitations of cloning in animals and plants.		
b. Applications in biotechnology			② Appreciate the role of science and technology in understanding the inheritance of humans.
Production of pharmaceutical products (e.g. Insulin, human growth hormone, vaccine and monoclonal antibodies)	• Understand the role of bacteria in the production of pharmaceutical products.	• Search for information on the application of biotechnology in the pharmaceutical industry.	② Be aware that societal needs have led to technological advances (e.g. the production of genetically modified crops to solve food shortage problem).
Gene therapy[3] • Somatic cell gene therapy	• Recognise the possible benefits and hazards of gene therapy.	• Read articles about the treatment of severe combined immunodeficiency disease (SCID) by means of gene therapy.	

[3] Detailed procedures of gene therapy are not the learning and assessment focus.

Students should learn	Students should be able to	Suggested Learning and Teaching Activities	Curriculum Emphases ①Scientific Inquiry ②STSE Connections ③Nature and History of Biology
Stem cell therapy • Nature of stem cells	• Recognise the potential application of stem cells in medicine.		② Understand how science has been influenced by societies (e.g. debates on human cloning and human stem cell research).
Transgenic animals and plants	• Recognise the use of transgenic animals and plants in scientific research, food industry and agriculture.	• Search for information on the uses of transgenic plants in agriculture. • Compare traditional breeding and genetic engineering in crop production.	
c. Bioethics Ethical, legal, social, economic and environmental issues	• Be aware of the potential impact of biotechnology on society.	• Debate on the issues related to genetically modified food, animal and plant cloning, HGP, gene therapy and stem cell therapy.	② Be aware of the wide application of biotechnology and its social, ethical, economic and environmental implications (e.g. issues related to stem cell therapy, gene therapy, animal cloning and genetically modified food).
Areas of current concern in biotechnology • Genetically modified food • Animal and plant cloning • Human Genome Project • Gene therapy • Stem cell therapy	• Discuss the issues related to one of the areas of concern in biotechnology.	• Search for information on the ways in which scientists inform the public and debate their discoveries in cloning.	③ Appreciate the joint efforts of scientists in the development of biotechnology (e.g. the scientists in the US, the UK, France, Germany, Japan and China have contributed to the HGP).