BIOLOGY

INTRODUCTION

Biology is the study of life and living systems from the molecular to the biosphere level. Through the study of biology, students are given the opportunity to explore and understand the natural world, the human body and the place of humans in Nature, and to become aware of the impact of biological knowledge on everyday life.

Building on students' prior knowledge and their everyday experiences, the CE Biology syllabus is designed to cover major aspects of biology as well as its relationship with society and technology. Examples of how biology is applied or related to social and technological issues are given in the Science-Technology-Society (STS) activities listed in the Biology Curriculum Guide (S4-5) prepared by the Curriculum Development Council in 2002.

Biology, as a discipline in science, should be studied with an inquiry approach, which involves the application of scientific skills and thinking processes. Upon completion of this course, candidates should be able to demonstrate mastery of basic biological concepts and principles. Furthermore, they are expected to display knowledge of and skills in designing and conducting scientific investigation. These include the ability to identify problems for investigation; formulate hypotheses; design and conduct investigations; gather, analyse and assess scientific information; and propose scientific explanations or solutions to the problems posed.

In view of the diversified needs of candidates, the syllabus is designed to cater for candidates of different abilities and aspirations. The content of this syllabus is divided into two parts: the ***Core*** and the ***Extension***. The Core represents the basic and fundamental components of biology that all candidates should learn. The Extension includes additional and more challenging materials that may place a greater demand on candidates to exercise higher order cognitive abilities. This design allows some candidates to focus on the Core so that more time can be devoted to mastering the basic concepts and principles. For the more able candidates, the challenges provided by the Extension may help them progress further and experience a greater sense of achievement. In the syllabus, the Extension topics are indicated by <u>underlining</u>.

AIMS

The aims set out below describe the educational purposes of following a course based on the HKCE Biology syllabus. Some of these aims are reflected in the assessment objectives; others are not because they cannot be readily translated into measurable objectives. All, however, are essential for the development of a comprehensive and holistic understanding of the living world.

Through the CE Biology course, candidates will :

1. acquire knowledge and understanding of basic biological concepts and principles, and appreciate the relationship between biological science and other disciplines;
2. understand how scientific knowledge is derived, keep abreast with modern advances, appreciate the scientific thoughts and efforts of the individuals who contributed to these advances and the impacts of such advances on humans;
3. apply biological knowledge to daily life, evaluate its impacts on and implications for the living world, and develop a critical mind to make informed judgements and decisions;
4. develop an inquiring mind, the skills and attitudes for scientific investigation, and the ability to apply biological knowledge to solve problems, and to communicate effectively with others using the language of science;
5. develop an interest in the study of biological science and a commitment to a healthy life; and
6. develop an appreciation of the wonders of the living world and a respect for all living things.

ASSESSMENT OBJECTIVES

The objectives of the examination are to test the following abilities:

1. to recognize, recall and show understanding of biological facts, concepts and principles;
2. to apply biological knowledge to explain observations and phenomena;
3. to apply biological knowledge to solve problems, which may involve unfamiliar situations, including those of a personal, social, economic, environmental, and technological nature;
4. to apply biological knowledge in making logical deductions;
5. to draw on existing knowledge to show an understanding of the benefits and drawbacks of the application of biology;

6. to evaluate scientific information and issues and to make informed judgements based on social, economic, environmental and technological considerations;
7. to select and organize relevant information and to present information, ideas and arguments clearly, logically and coherently, using appropriate scientific terms and conventions;
8. to formulate working hypotheses and to design tests for them, using controls where appropriate;
9. to observe and describe objects and phenomena accurately;
10. to process and present information through the appropriate use of graphs, tables, drawings and diagrams, etc.;
11. to interpret and analyse simple biological experimental data and to draw valid conclusions from the available information;
12. to evaluate the conclusions from investigations and to plan for further investigations if necessary;
13. to formulate generalizations from available information; and
14. to detect errors in experiments and to suggest improvements.

THE EXAMINATION

The examination will consist of two papers, 1 and 2. Details of the examination are as follows:

		Paper 1	**Paper 2**
Percentage weighting in the subject		60%	40%
Duration		1 hour 45 minutes	1 hour
Paper structure	Section A (60% of paper mark)	• All questions are to be attempted. • Consists of questions set on the Core part of the syllabus.	• All questions are to be attempted. • Consists of questions set on the Core part of the syllabus.
	Section B (40% of paper mark)	• A choice of 2 out of 3 questions. • Consists of questions set on the whole syllabus.	• All questions are to be attempted. • Consists of questions set on the whole syllabus.
Question type		• All are structured questions. • Each question may be subdivided into 2 or more parts.	• All are multiple-choice questions.

NOTES

1. In general, SI units will be used.
2. The booklet 'An English-Chinese Glossary of Terms Commonly Used in the Teaching of Biology in Secondary Schools (2003)' prepared by the Curriculum Development Council is a useful reference for biological terms in Chinese.
3. The CE Biology syllabus builds upon the knowledge and learning experiences acquired by students through studying the biology components of the core part of the CDC Syllabus for Science (Secondary 1-3).

THE SYLLABUS

The syllabus is divided into eight sections. The concepts and principles embodied in the different sections are interrelated and should be studied as integral parts of the whole syllabus instead of as separate entities. The order of presentation of the topics should not be regarded as the recommended teaching sequence.

SECTION 1 THE CELL

This section introduces the concept of the cell as the basic unit of life. This fundamental concept of biology is established through examining and understanding the chemical composition of the cell, its structure and its metabolism. Attention should also be drawn to the underlying similarity of structure and organization of cells from a diversity of tissues. In addition, through the study of the discovery of cells, this section brings out the contribution of other science disciplines to the development of biological knowledge.

Syllabus Topics	*Explanatory Notes*	*Suggested Practical Work and Other Activities*
1.1 Chemicals of life	The inorganic and organic chemical constituents in organisms.	

	The functions of carbohydrates, fats, proteins and DNA in organisms.	Performing common food tests to identify chemicals in some foodstuffs (Refer to Topic 4.2).
	The importance of water to life: its roles in many vital life processes.	
	The presence of minerals in all living cells.	
1.2 Discovery of cells	The contribution of technological developments of microscope to the discovery of cells and cell theory.	
1.3 The basic structure of a cell	The functions of the following cell structures: cell membrane, nucleus, chromosome, cytoplasm and mitochondrion; chloroplast, cell wall and large vacuole in plant cells.	Preparing temporary mounts of animal and plant tissues. Examining animal and plant cells, and identifying nucleus, cytoplasm, cell wall, chloroplast and vacuole.
	The similarities and differences between animal and plant cells.	Comparing animal and plant cells under the microscope.
1.4 Cell activities	Metabolism as the catabolic and anabolic processes taking place within a cell.	

	The properties of enzymes.	Performing practical work to demonstrate the breaking down or building up action of enzymes.
	The roles of enzymes in metabolism.	
	The effects of temperature and pH on enzyme activities.	Performing practical work to study the effects of temperature and pH on the activities of enzymes.
		Designing and performing investigations to compare the activities of enzymes, e.g. bioactive ingredients in commercial washing powder.
	The processes by which substances move across a cell membrane: diffusion, active transport and osmosis.	
	Water movement across selectively permeable cell membrane in terms of water potential.	Performing practical work on osmosis using non-living materials.
		Performing practical work using living materials to study osmosis at cellular, tissue or organ level.
1.5 The cell as a basic unit of life	The cell as the basic structural and functional unit of life.	Examining cell and tissue samples.

	The presence of different types of cells inside a multicellular organism for performing specialized functions.	
	The different levels of organization in a multicellular organism: tissue, organ and system.	Examining an angiosperm, a dissected mammal or a human torso.

SECTION 2 ORGANISMS AND THEIR ENVIRONMENT

This section introduces the concept of classification through a study of the diversity of organisms. Building on knowledge of diversity of life, the interaction of living organisms and their environment is briefly considered. Together with the study of the human impacts on the environment, this section brings out the importance of environmental protection and of respect for living organisms and habitats.

Syllabus Topics	*Explanatory Notes*	*Suggested Practical Work and Other Activities*
2.1 Diversity of organisms	The existence of many different kinds of organisms on Earth.	
2.2 Classification	The need of a classification system for biological studies.	Identifying organisms with simple keys. Classifying organisms found in a local habitat, e.g. old wall, tree trunk, school campus or field.
	The classification of organisms into five kingdoms: Prokaryotes, Protoctists, Fungi, Plants and Animals.	

	The classification of plants into flowering plants and non-flowering plants (mosses, ferns and gymnosperms).	
	The classification of animals into invertebrates and vertebrates (fishes, amphibians, reptiles, birds and mammals).	
	The existence of virus as a non-cellular entity.	
2.3 The ecosystem	Ecosystem as a dynamic system resulting from the interactions of organisms and their environment.	
	The biotic and abiotic factors in an ecosystem.	
2.4 Energy flow within an ecosystem	The Sun as the ultimate source of energy in most ecosystems.	
	Energy flows within an ecosystem via producers and consumers.	
	The uses of food chains, food webs, pyramids of numbers and biomass to represent the feeding relationship of organisms, and the energy flow between different trophic levels in an ecosystem.	Constructing and interpreting food chains, food webs, and pyramids of numbers and biomass.
	<u>The accumulation of toxic substances along a food chain.</u>	

2.5 Cycling of materials	The cycling of carbon in an ecosystem by natural and human activities. The cycling of nitrogen in an ecosystem by natural and human activities. The important role of decomposers in the cycling of materials.	
2.6 Ecological interdependence of organisms	The relationship of organisms in an ecosystem: predation, competition, commensalism, mutualism and parasitism.	Using living/audiovisual materials to show examples on the relationship of organisms in an ecosystem.
2.7 Human impacts on the environment	The increasing effects of human activities on the environment. The effects of pollutants on the environment and human health. The existence of renewable and non-renewable resources. The undesirable effects of over-exploitation of resources: deforestation and over-consumption of fossil fuels.	
2.8 Environmental protection	The need of environmental protection. The concept of sustainable development.	

	Some measures of environmental protection, e.g. preserving biodiversity, protecting endangered species, recycling of used materials and pollution control including sewage treatment.	

SECTION 3 ENERGETICS

This section focuses on the processes by which energy is made available to organisms. The dependence of animals on plants for energy supply and the linkage to the concept of energy flow in the ecosystem should be highlighted.

Syllabus Topics	*Explanatory Notes*	*Suggested Practical Work and Other Activities*
3.1 Photosynthesis	The significance of photosynthesis in converting light energy to chemical energy in plants.	
	The requirements for photosynthesis: light, carbon dioxide, water and chlorophyll.	Designing and performing investigations to study the requirements for photosynthesis.
	The photosynthetic process: the splitting of water by light, the formation of carbohydrate, and the release of oxygen.	Performing practical work to detect the photosynthetic products.
	<u>The effects of environmental factors (light intensity and carbon dioxide concentration) on the rate of photosynthesis.</u>	<u>Designing and performing investigations to study the effects of some environmental factors on the rate of photosynthesis.</u>

	The different ways of utilization of photosynthetic products in plants.	Performing practical work to test for the different types of food stored in plants.
	The structural adaptation of the leaf as a photosynthetic organ.	Examining the morphology and the internal structures of leaves.
3.2 Respiration	The significance of respiration in releasing energy through the controlled oxidative breakdown of food.	
	The processes of aerobic and anaerobic respiration as represented by simple word equations.	Designing and performing investigations to study aerobic and anaerobic respiration in organisms.
	Alcoholic fermentation in yeast and lactic acid production in muscle.	
	The differences between aerobic and anaerobic respiration.	
	The importance of anaerobic respiration.	

SECTION 4 OBTAINING ESSENTIALS FOR LIFE

This section focuses on how organisms satisfy their basic needs of food, oxygen, and water. The life processes of nutrition, gas exchange and transport should be studied in an integrated manner. Contents are organized around the main theme of obtaining essentials for life so as to facilitate better understanding of the structure and functioning of an organism as a whole. Plants and humans are taken as representative organisms in this section.

Syllabus Topics	*Explanatory Notes*	*Suggested Practical Work and Other Activities*
4.1 Nutrition, gas exchange, water relation and transport in plants	Plants as autotrophs obtaining their nutrition by photosynthesis (Refer to Topic 3.1).	
	The importance of minerals (nitrogen and magnesium) for proper growth in plants.	Studying the effects of different minerals on plant growth using potted plants.
	The application of chemical fertilizers in agriculture.	
	The simple histology of a young dicotyledonous plant.	Examining the cross sections of the leaf, stem and root of a young dicotyledonous plant.
	The structural features of leaves in relation to gas exchange and prevention of water loss.	

Gas exchange in leaves and its relationship with light intensity.	Investigating the effect of light intensity on gas exchange in land or water plants using hydrogencarbonate indicator solution or data logger.
The process of transpiration and its possible roles in absorption of minerals and cooling.	Performing practical work to demonstrate the occurrence of transpiration.
	Designing and performing an investigation to compare the distribution of stomata on both sides of a leaf.
The effects of environmental factors on the rate of transpiration.	Designing and performing investigations to study the effects of environmental factors on the rate of transpiration using potometer.
The absorption of water and minerals in roots.	
The adaptive features of roots in relation to water absorption.	Examining the roots of young seedlings.
The transport of water and minerals in flowering plants.	Performing practical work to trace the uptake of eosin solution in a herbaceous plant.

	The path of transport of organic nutrients in flowering plants. The significance of support in plants for obtaining light. The importance of cell turgidity in supporting young dicotyledonous plants. The importance of the physical nature of xylem in the support of woody stems.
4.2 Nutrition, gas exchange and transport in humans	Humans as heterotrophs obtaining their nutrition by taking in organic substances. The food requirements of humans and the effects of deficiency in vitamins (A, C and D), minerals (calcium and iron) and dietary fibre. The functions of carbohydrates, fats, proteins, vitamins, minerals and dietary fibre. The food sources of carbohydrates, fats, proteins, vitamins (A, C and D), minerals (calcium and iron) and dietary fibre.

The methods for detecting glucose, reducing sugar, starch, fat, protein and vitamin C in common foodstuffs.	Performing common food tests [test for glucose using Clinistix paper, Benedict's test for reducing sugar, iodine test for starch, grease spot test for fat, test for protein using Albustix paper, test for vitamin C using DCPIP (dichlorophenol indophenol) solution] on some common foodstuffs to compare their food components. Designing and performing investigations to compare the amount of vitamin C in different fruits and vegetables.
The importance of water to humans.	
The need for a balanced diet.	
The variation in dietary requirements in relation to age, activity and pregnancy.	
The health problems resulting from an improper diet.	
The human dentition.	
The types and functions of teeth, and their structures.	

Oral health.	
Causes and prevention of tooth decay.	Investigating the change in pH in the mouth before and after eating candies.
Periodontal disease and its prevention.	
The need for digestion.	
The general plan of the digestive system.	Examining the alimentary canal and its associated glands of a dissected mammal or a human torso.
The functions of different parts of the alimentary canal and its associated glands.	
The mechanical and chemical digestion of food.	Designing and performing investigations on the action of digestive enzymes, e.g. amylase on starch-agar plate, protease on milk-agar plate or egg white.
	Investigating the effect of bile salt on oil.
The absorption of food.	
The structural adaptation of the small intestine for food absorption.	Performing practical work to simulate digestion and absorption in the alimentary canal using dialysis tubing.
The transport of absorbed food and their fates in cells and tissues.	

The role of liver in relation to food assimilation.	
The process of egestion.	
The general plan of the human breathing system.	Examining the breathing system of a dissected mammal or a human torso. Examining the lung of a pig.
The process of gas exchange in the air sacs.	
The adaptive features of the air sacs in gas exchange.	Examining the air sacs of a mammal.
The mechanism of ventilation.	Investigating the differences in composition between inhaled and exhaled air.
The transport of respiratory gases.	
The relation of exercises to energy requirement, rate of cellular respiration and ventilation.	Studying the change in breathing rate during exercise using breath volume kit or data logger.
The general plan of the human circulatory system.	

The structure of various components of the human circulatory system in relation to their functions.	Dissecting and examining the heart of a pig. Examining the capillary flow in a fish's tail fin or frog's web. Examining the sections of an artery and a vein.
The structure, composition and functions of blood.	Examining a blood smear. Performing practical work to detect the presence of glucose in plasma.
The formation of tissue fluid.	
The exchange of materials between blood and body cells.	Performing practical work to study the effects of oxygen and carbon dioxide on citrated blood of a chicken.
An outline of the lymphatic system and its functions.	

SECTION 5 COORDINATION AND RESPONSE

This section examines the ability of organisms to detect and to respond to environmental changes. Sight and locomotion are used to exemplify these two abilities in humans. The section also provides an understanding of nervous and hormonal coordination in humans and introduces the growth responses of plants.

Syllabus Topics	*Explanatory Notes*	*Suggested Practical Work and Other Activities*
5.1 Detecting environmental conditions	The five senses: sight, hearing, taste, touch and smell.	
	The role of sense organs and receptors in the nervous system.	
	The structure of the human eye, and functions of its major parts.	Dissecting and examining an ox's eye.
	The functions of rods and cones in the retina.	
	The presence of three types of cones for colour vision.	
	The control of the amount of light entering the eye.	
	The accommodation of the eye.	

	The causes of long sight, short sight and colour blindness.	
	The correction of long sight and short sight.	
5.2 Nervous coordination in humans	The general plan of the nervous system.	
	The role of the skull and vertebrae in protecting the central nervous system.	
	The role of the central nervous system in linking the receptors and the effectors.	
	The basic structure of a neurone.	
	The types of neurones: sensory neurone, interneurone and motor neurone.	
	The basic structure of the spinal cord and a simple account of a spinal reflex arc.	
	The functions of the main parts of the brain: cerebrum, cerebellum and medulla.	Examining a human brain model.
	The differences between reflex and voluntary actions.	

5.3 Hormonal coordination in humans	The nature of hormonal coordination.	
	Ovaries, testes and pancreas as examples of endocrine glands.	
	The feedback mechanism of hormonal control as illustrated by insulin secretion by the pancreas.	
	The general effects of insulin and glucagon.	
	The similarities and differences between hormonal and nervous coordination.	
5.4 Locomotion in humans	The roles of the skeleton, muscles, joints, tendons and ligaments in locomotion.	
	Muscles as the body's principal effectors.	
	The action of opposing muscle pairs in movement.	
	The differences in the degree of movement between hinge joints (e.g. elbow joint/knee joint) and ball-and-socket joints (e.g. shoulder joint/hip joint).	Examining an arm model.

5.5 Growth responses of plants	The growth responses of roots and shoots to light, gravity and water.	Designing and performing an investigation on the phototropic response of shoots.
	The role of auxins in phototropic and geotropic responses.	Using clinostats to study the geotropic response of roots.
		Designing and performing an investigation on the relative effects of gravity and water on the growth response of plants.

SECTION 6 REGULATION AND DEFENCE

This section focuses on how humans regulate their internal body environment within a fairly stable range, and how they defend themselves against diseases. The concept of homeostasis can be established through the study of excretion and osmoregulation, regulation of body temperature and regulation of blood glucose level. The role of the feedback mechanism in homeostatic control is also highlighted. In addition, the section introduces the different protective mechanisms of the body against infections.

Syllabus Topics	*Explanatory Notes*	*Suggested Practical Work and Other Activities*
6.1 Concept of homeostasis	The importance of maintaining a constant internal environment.	
	The role of feedback mechanism in homeostasis.	
6.2 Osmoregulation and excretion	The general plan of the urinary system and the functions of various parts.	Examining the urinary system of a dissected mammal or a human torso.

	The structure of the kidney and its osmoregulatory and excretory functions.	Examining a kidney model or the longitudinal section of a dissected mammalian kidney.
	The structure of a nephron.	
	The process of ultrafiltration and reabsorption in the formation of urine.	
6.3 Regulation of body temperature	The principle of body temperature regulation.	
	The structure of skin, and its role in temperature regulation.	Examining a skin model or a section of the mammalian skin.
6.4 Regulation of glucose level in blood	The role of liver, pancreas, insulin and glucagon in regulating blood glucose level.	
6.5 Defence against diseases	The physical and chemical barriers for preventing the entry of pathogens.	
	The roles of phagocytes and lymphocytes in defending against pathogens.	
	The principle of vaccination: an induced production of antibodies and phagocytes.	

SECTION 7 REPRODUCTION AND GROWTH

This section deals with processes necessary for the perpetuation of species and growth. The understanding of these processes is linked to the concepts of cell division. Asexual reproduction is illustrated by binary fission and vegetative propagation. Flowering plants and humans are used as examples to illustrate sexual reproduction. In addition, the changes taking place after fertilization and the concept of growth and development are presented.

Syllabus Topics	*Explanatory Notes*	*Suggested Practical Work and Other Activities*
7.1 Types of cell division	The replication of genetic material taking place before cell division.	
	An outline of mitotic and meiotic cell division.	Examining the processes of mitotic and meiotic cell division.
	The significance of mitotic and meiotic cell division in growth and reproduction.	
7.2 Asexual reproduction	The occurrence of asexual reproduction in bacteria.	Examining binary fission in bacteria.
	Asexual reproduction in flowering plants by means of vegetative propagation.	Cultivating any vegetative propagating organ of flowering plants.
	An outline of the process of vegetative propagation.	Examining one vegetative propagating organ of flowering plants and identifying the parts in vegetative propagation.

7.3 Sexual reproduction in flowering plants	The structure and functions of various floral parts.	Examining flowers to relate the structure and functions of various floral parts.
	Insect pollination and wind pollination.	
	The adaptive features of insect-pollinated flowers and wind-pollinated flowers.	Examining the adaptive features of insect-pollinated flowers and wind-pollinated flowers.
	The process of fertilization.	
	The formation of fruits and seeds after fertilization.	
	The advantages and disadvantages of sexual reproduction as compared with asexual reproduction.	
7.4 Sexual reproduction in humans	The general plans of male and female reproductive systems and the functions of various parts.	Examining the male and female reproductive systems of dissected mammals or a human torso.

The structure of sperm and ovum.	Examining photomicrographs/video clips of sperms and ova.
The development of secondary sexual characteristics as induced by sex hormones.	
The menstrual cycle: the periodic changes in uterine lining in relation to the time of ovulation.	
The transfer of semen during sexual intercourse and the process of fertilization.	
The formation of identical twins and fraternal twins.	
The development of the fertilized ovum into an embryo.	Examining photos/video clips taken by ultrasound showing different stages of foetal development.
The nutrition, gas exchange and excretion of the foetus in relation to the placenta.	
The protection of the foetus by the uterus, amniotic fluid and the placenta.	

	The birth process.	
	Parental care and its significance.	
	The advantages of breast-feeding.	
	The biological basis of various methods of birth control.	
7.5 Growth and development	The concept of growth and development as illustrated by seed germination into a new plant.	Designing and performing investigations to study seed germination.
	The various methods used in the measurement of growth.	Designing and performing investigations to study the growth of young seedlings.

SECTION 8 GENETICS AND EVOLUTION

This section introduces the concept of genes and their role in inheritance. It then focuses on the pattern of inheritance of monohybrid crossing and describes the causes and significance of variations. It further introduces basic knowledge of genetic engineering. The applications of gene manipulation, and the related social and ethical issues should be highlighted. When studying the concept of evolution, linkage to the idea of variations within a species and the existence of a diverse range of life forms should be established.

Syllabus Topics	*Explanatory Notes*	*Suggested Practical Work and Other Activities*
8.1 Genes and inheritance	The structural relationship between DNA, genes and chromosome.	Examining photomicrographs of human chromosomes.

	The expression of gene, which controls the types of protein produced. Down syndrome, colour blindness, G6PD (glucose-6-phosphate dehydrogenase) deficiency as examples of inherited disorders in humans. An awareness of the Human Genome Project.	
8.2 The pattern of inheritance	Monohybrid inheritance. Phenotypes, genotypes and alleles. Dominance and recessiveness. Homozygotes and heterozygotes. Sex determination in humans. Pedigree.	Solving simple Mendelian genetic problems and analysing pedigree.
8.3 Variations	The occurrence of variations within a species. Continuous and discontinuous variations. The causes of variations.	Observing and analysing variations in humans; e.g. height variation, tongue rolling.

	The effects of ionising radiations and chemicals on the chance of the occurrence of mutation.	
8.4 Genetic engineering	The variations caused by human manipulation of genes.	
	The use of genetically modified plants and animals in food production, and its implications.	
	The use of genetically modified bacteria in the production of insulin, and its implications.	
8.5 Evolution	Fossil records as one of the clues revealing different life forms once appeared on Earth.	Examining fossil records.
	The concept of evolution: • organisms evolving from simple to complex life forms, • the significance of variations within a species, and • the role of natural selection.	