Science Education
Key Learning Area

Biology
Curriculum and Assessment Guide
(Secondary 4 - 6)

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

Recommended for use in schools by the Education Bureau
HKSARG
2007 (with updates in January 2014)

(Blank page)

Contents

(Blank page)

Preamble

The Education and Manpower Bureau (EMB, now renamed Education Bureau (EDB)) stated in its report[1] in 2005 that the implementation of a three-year senior secondary academic structure would commence at Secondary 4 in September 2009. The senior secondary academic structure is supported by a flexible, coherent and diversified senior secondary curriculum aimed at catering for students' varied interests, needs and abilities. This Curriculum and Assessment (C&A) Guide is one of the series of documents prepared for the senior secondary curriculum. It is based on the goals of senior secondary education and on other official documents related to the curriculum and assessment reform since 2000, including the *Basic Education Curriculum Guide* (2002) and the *Senior Secondary Curriculum Guide* (2007). To gain a full understanding of the connection between education at the senior secondary level and the basic education level, and how effective learning, teaching and assessment can be achieved, it is strongly recommended that reference should be made to all related documents.

This C&A Guide is designed to provide the rationale and aims of the subject curriculum, followed by chapters on the curriculum framework, curriculum planning, pedagogy, assessment and use of learning and teaching resources. One key concept underlying the senior secondary curriculum is that curriculum, pedagogy and assessment should be well aligned. While learning and teaching strategies form an integral part of the curriculum and are conducive to promoting learning to learn and whole-person development, assessment should also be recognised not only as a means to gauge performance but also to improve learning. To understand the interplay between these three key components, all chapters in the C&A Guide should be read in a holistic manner.

The C&A Guide is jointly prepared by the Curriculum Development Council (CDC) and the Hong Kong Examinations and Assessment Authority (HKEAA). The CDC is an advisory body that gives recommendations to the HKSAR Government on all matters relating to curriculum development for the school system from kindergarten to senior secondary level. Its membership includes heads of schools, practising teachers, parents, employers, academics from tertiary institutions, professionals from related fields/bodies, representatives from the HKEAA and the Vocational Training Council (VTC), as well as officers from the EDB. The HKEAA is an independent statutory body responsible for the conduct of public assessment, including the assessment for the Hong Kong Diploma of Secondary Education (HKDSE). Its governing council includes members drawn from the school sector, tertiary institutions and government bodies, as well as professionals and members of the business community.

[1] The report is *The New Academic Structure for Senior Secondary Education and Higher Education – Action Plan for Investing in the Future of Hong Kong*, and will be referred to as the *334 Report* hereafter.

The C&A Guide is recommended by the EDB for use in secondary schools. The subject curriculum forms the basis of the assessment designed and administered by the HKEAA. In this connection, the HKEAA will issue a handbook to provide information on the rules and regulations of the HKDSE examination as well as the structure and format of public assessment for each subject.

The CDC and HKEAA will keep the subject curriculum under constant review and evaluation in the light of classroom experiences, students' performance in the public assessment, and the changing needs of students and society. All comments and suggestions on this C&A Guide may be sent to:

Chief Curriculum Development Officer (Science Education)
Curriculum Development Institute
Education Bureau
Room E232, 2/F, East Block
Education Bureau Kowloon Tong Education Services Centre
19 Suffolk Road
Kowloon Tong, Hong Kong

Fax: 2194 0670
E-mail: science@edb.gov.hk

Acronym

AL	Advanced Level
ApL	Applied Learning
ASL	Advanced Supplementary Level
C&A	Curriculum and Assessment
CDC	Curriculum Development Council
CE	Certificate of Education
EC	Education Commission
EDB	Education Bureau
EMB	Education and Manpower Bureau
HKALE	Hong Kong Advanced Level Examination
HKCAA	Hong Kong Council for Academic Accreditation
HKCEE	Hong Kong Certificate of Education Examination
HKDSE	Hong Kong Diploma of Secondary Education
HKEAA	Hong Kong Examinations and Assessment Authority
HKedCity	Hong Kong Education City
HKSAR	Hong Kong Special Administrative Region
IT	Information Technology
KLA	Key Learning Area
KS1/2/3/4	Key Stage 1/2/3/4
LOF	Learning Outcomes Framework
MOI	Medium of Instruction
NOS	Nature of Science
NGO	Non-governmental Organisation
OLE	Other Learning Experiences
P1/2/3/4/5/6	Primary 1/2/3/4/5/6
PDP	Professional Development Programmes
QF	Qualifications Framework
RASIH	Review of the Academic Structure for Senior Secondary Education and Interface with Higher Education

S1/2/3/4/5/6	Secondary 1/2/3/4/5/6
SBA	School-based Assessment
SEN	Special Educational Needs
SLP	Student Learning Profile
SRR	Standards-referenced Reporting
STSE	Science, Technology, Society and Environment
TPPG	Teacher Professional Preparation Grant
VTC	Vocational Training Council

Chapter 1 Introduction

This chapter provides the background, rationale and aims of Biology as an elective subject in the three-year senior secondary curriculum, and highlights how it articulates with the junior secondary curriculum, post-secondary education, and future career pathways.

1.1 Background

The Education Commission's education blueprint for the 21st Century, *Learning for life, learning through life – Reform proposals for the Education System in Hong Kong* (EC, 2000), highlighted the vital need for a broad knowledge base to enable our students to function effectively in a global and technological society such as Hong Kong, and all subsequent consultation reports have echoed this. The *334 Report* advocated the development of a broad and balanced curriculum emphasising whole-person development and preparation for lifelong learning. Besides the four core subjects, Chinese Language, English Language, Mathematics and Liberal Studies, students are encouraged to select two or three elective subjects from different Key Learning Areas (KLAs) according to their interests and abilities, and also to engage in a variety of other learning experiences such as aesthetic activities, physical activities, career-related experiences, community service, and moral and civic education. This replaces the traditional practice of streaming students into science, arts and technical/commercial subjects.

Study of the three different areas of biology, chemistry and physics often complement and supplement each other. In order to provide a balanced learning experience for students studying sciences, the following elective subjects are offered under the Science Education KLA:

Biology, Chemistry and Physics
These subjects are designed to provide a concrete foundation in the respective disciplines for further studies or careers.

Science
This subject operates in two modes. Mode I, entitled Integrated Science, adopts an interdisciplinary approach to the study of science, while Mode II, entitled Combined Science, adopts a combined approach. The two modes are developed in such a way as to provide space for students to take up elective subjects from other KLAs after taking one or more electives from the Science Education KLA.

Mode I: Integrated Science

This is designed for students wishing to take up one elective subject in the Science Education KLA. It serves to develop in students the scientific literacy essential for participating in a dynamically changing society, and to support other aspects of learning across the school curriculum. Students taking this subject will be provided with a comprehensive and balanced learning experience in the different disciplines of science.

Mode II: Combined Science → Combined Science (Physics, Chemistry)
→ Combined Science (Biology, Physics)
→ Combined Science (Chemistry, Biology)

Students wishing to take two elective subjects in the Science Education KLA are recommended to take one of the Combined Science electives together with one specialised science subject. Each Combined Science elective contains two parts, and these should be the parts that complement the discipline in which they specialise. Students are, therefore, offered three possible combinations:

- Combined Science (Physics, Chemistry) + Biology
- Combined Science (Biology, Physics) + Chemistry
- Combined Science (Chemistry, Biology) + Physics

1.2 Implementation of Science Subjects in Schools

The five separate Curriculum and Assessment Guides for the subjects of Biology, Chemistry, Physics, Integrated Science and Combined Science are prepared for the reference of school managers and teachers, who are involved in school-based curriculum planning, designing learning and teaching activities, assessing students, allocating resources and providing administrative support to deliver the curricula in schools. Arrangements for time-tabling and deployment of teachers are given in Appendix 1

This C&A Guide sets out guidelines and suggestions for the Biology Curriculum. The delivery of the Biology part of Combined Science contributing towards the qualifications of Combined Science (Biology, Physics) and Combined Science (Chemistry, Biology) in the Hong Kong Diploma of Secondary Education will be discussed in the *Combined Science C&A Guide* (CDC & HKEAA, 2007).

1.3 Rationale

This Biology Curriculum serves as a continuation of the Science (S1–3) Curriculum and builds on the strength of the current Biology curricula. It will provide a range of balanced learning experiences so that students develop the necessary scientific knowledge and understanding, skills and processes, and values and attitudes embedded in the "Life and Living" strand and other strands of science education. These are necessary for personal development to enable students to contribute towards a scientific and technological world. The curriculum will prepare students for their tertiary studies, vocational training and careers in various fields of life science.

The emergence of a highly competitive and integrated economy, advanced scientific and technological innovations, and a growing knowledge base will continue to have a profound impact on our lives. In order to meet the challenges posed by these changes, the Biology Curriculum, like other science electives, provides a platform for developing scientific literacy and building up essential scientific knowledge and skills for life-long learning. Through the learning of biology, students will acquire relevant procedural and conceptual knowledge to help them understand many contemporary issues. They will become aware of the interconnections between science, technology, society and the environment. In addition, students will develop a respect for the living world, an attitude of responsible citizenship and a commitment to promote personal and community health.

Biology is a rapidly advancing science incorporating a huge amount of information about living organisms. There is a mistaken impression that it is a subject involving memorisation of numerous unrelated facts. In this curriculum, it is hoped that students will develop a broad, general understanding of biological principles and concepts and at the same time acquire a body of essential facts. In order to make the study of biology exciting and relevant, it is suggested that it should be introduced in real life contexts. The adoption of a wide range of learning and teaching strategies and assessment practices is intended to stimulate interest in and create motivation for learning among students with a range of abilities and aspirations.

1.4 Curriculum Aims

The overarching aim of the Biology Curriculum is to provide biology-related learning experiences that enable students to develop scientific literacy, so that they can participate actively in our rapidly changing knowledge-based society, prepare for further studies or careers in the fields related to life science, and become lifelong learners in science and technology.

The broad aims of the Biology Curriculum are to enable students to:

- develop and maintain an interest in biology, a sense of wonder and curiosity about the living world, and a respect for all living things and the environment;
- construct and apply knowledge of biology, understand the nature of science in biology-related contexts, and appreciate the relationships between biological science and other disciplines;
- develop the ability to make scientific inquiries; think scientifically, critically and creatively; and solve biology-related problems individually and collaboratively;
- understand the language of science and communicate ideas and views on biology-related issues;
- be aware of the social, ethical, economic, environmental and technological implications of biology, and be able to make informed decisions and judgments on biology-related issues; and
- develop an attitude of responsible citizenship, and a commitment to promote personal and community health.

1.5 Interface with the Junior Secondary Curriculum and Post-secondary Pathways

This curriculum draws and builds upon the knowledge and understanding, skills and processes, and values and attitudes developed in the junior secondary science curriculum. It extends the study of the "Life and Living", "Scientific Investigation" and "Science, Technology, Society and Environment (STSE)" strands in science education. Figure 1.1 depicts how the strands in this KLA are inter-related.

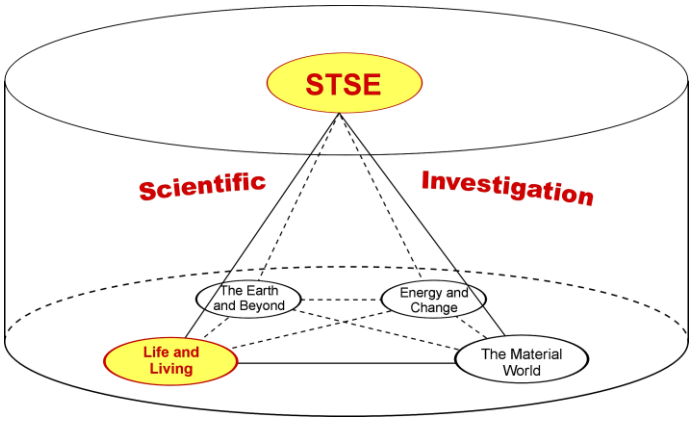


Figure 1.1 Diagrammatic Representation of the Strands in Science Education

Teachers may refer to Chapter 3 for details of the relationship between the Science S1–3 Syllabus and the Biology Curriculum.

One aim of the senior secondary education is to enable students to pursue higher education or to enter the workplace through a variety of pathways, so that every student has an opportunity to succeed in life. This curriculum will provide students with a solid foundation in biological and life science, so that they can pursue higher levels of study in tertiary or vocational training institutions and enter a wide spectrum of careers related to science, technology and the environment. Furthermore, the development of a logical mind and problem-solving skills through studying biology will prepare students to deal intelligently with everyday problems and make them more competitive in the workplace. Figure 1.2 shows the continuum of learning for students studying biology.

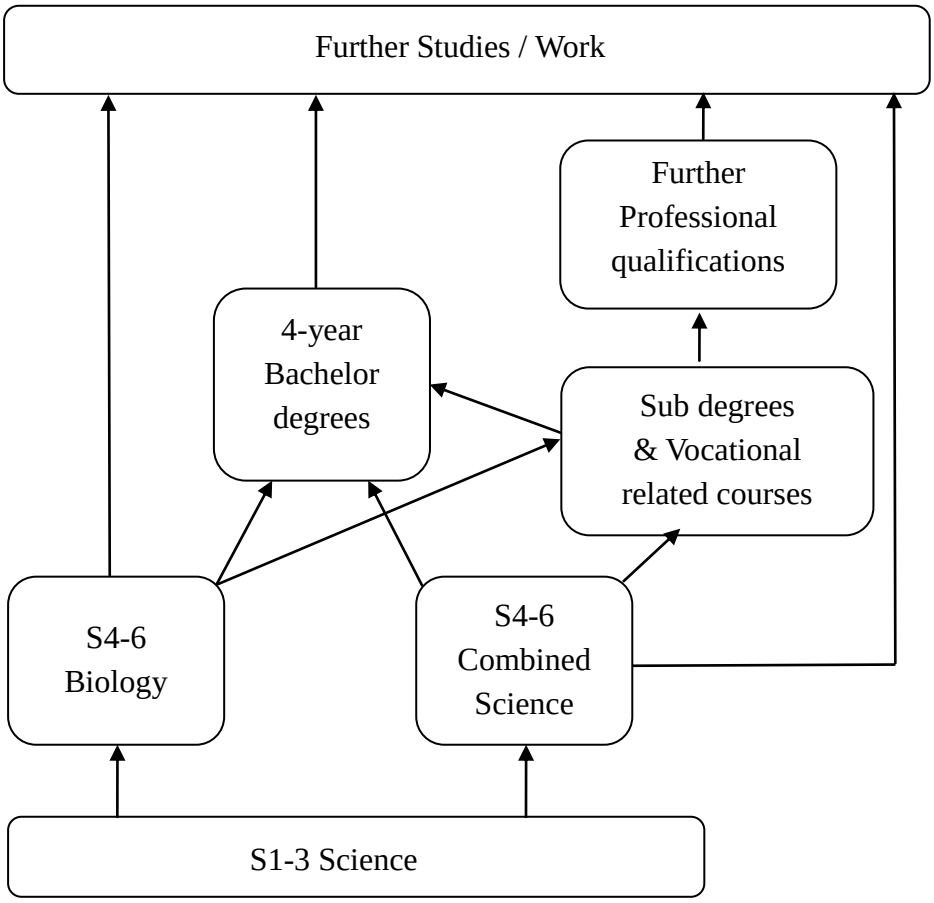


Figure 1.2 Multiple Pathways to Higher Education and the Workplace

(Blank page)

Chapter 2 Curriculum Framework

The curriculum framework for Biology embodies the key knowledge, skills, values and attitudes that students are to develop at senior secondary level. It forms the basis on which schools and teachers can plan their school-based curriculum, and design appropriate learning, teaching and assessment activities.

2.1 Design Principles

The design of this curriculum is founded on the following principles, which are in line with those recommended in Chapter 3 of the *334 Report* and Booklet 1 of the *Senior Secondary Curriculum Guide* (CDC, 2007).

(1) Prior knowledge

This curriculum builds upon the prior knowledge, skills, values and attitudes, that students are expected to have achieved through the Science S1-3 Curriculum. There is a close connection between the topics in the Science S1-3 Curriculum and the Biology Curriculum. Please refer to Chapter 3 for details of their relationships.

(2) Balance between breadth and depth

The Biology Curriculum serves as one of the elective subjects to widen the spectrum of subjects available for student choice. A balanced coverage of topics is selected to broaden the perspective of the students. However, there will be in-depth study in some topics to prepare students for further study in a particular area.

(3) Balance between theoretical and applied learning

Theoretical learning of the conceptual knowledge in this curriculum provides students with a solid foundation in biological principles and concepts. Students are expected to understand the application of biological knowledge through the curriculum emphasis on STSE Connections.

(4) Balance between essential learning and a flexible and diversified curriculum

The compulsory part of this curriculum will provide students with essential knowledge and concepts, whilst the choice provided in the elective part will allow for flexibility to cater for the needs and interests of students.

(5) Learning how to learn and inquiry-based learning

In this curriculum, a wide range of learning activities is suggested to develop students' overall capacity for self-directed and lifelong learning. In addition, it is recommended that teachers adopt a range of learning and teaching strategies, e.g. a contextual approach, scientific investigations, problem-based learning and issue-based learning to enhance students' understanding of various contemporary issues in biology.

(6) Progression

Students can explore their interests through the study of foundation topics within the compulsory part in S4. This will also ensure effective progression to S5 and S6 in their chosen studies.

(7) Smoother articulation to multiple progression pathways

This curriculum enables students to pursue academic and vocational/professional education and training, with articulation to a wide range of post-secondary and university studies or to the workplace.

(8) Greater coherence

There are cross-curricular elements in the curriculum to strengthen the connections with other subjects.

(9) Catering for diversity

There are differences among students in various dimensions such as interests, needs and abilities. This curriculum provides an opportunity for students to choose individual elective topics according to their interests and needs. The curriculum allows students to achieve the learning targets at their own pace in line with their abilities.

(10) Relevance to students' life

Motivation and interests are key considerations for effective and active learning. This curriculum provides means to ensure that learning content and activities are relevant to students' everyday life, especially the events and substances they encounter daily.

2.2 Learning Targets

The learning targets of the curriculum are categorised into three domains: knowledge and understanding, skills and processes, and values and attitudes.

2.2.1 Knowledge and Understanding

Students are expected to:

- acquire knowledge and develop an understanding of biological principles, concepts, terms and facts;
- apply biological knowledge and concepts to familiar and unfamiliar situations;
- show an understanding of the application and uses of biological knowledge in daily life; and
- develop an understanding of current issues and developments in biology.

2.2.2 Skills and Processes

Students are expected to:

- make careful observations, ask relevant questions, identify problems and formulate hypotheses for investigations;
- recognise the importance of evidence in supporting, modifying or refuting proposed scientific theories;
- develop the ability to think scientifically and creatively;
- acquire an analytical mind to critically evaluate biology-related issues;
- identify the pros and cons of the application of biological knowledge for informed decision-making;
- plan and conduct scientific investigations individually or collaboratively with appropriate instruments and methods, collect quantitative and qualitative information with accuracy, analyse data and draw conclusions for problem-solving;
- use information technology to process and present scientific information; and
- communicate ideas and views effectively with others, using the language of science.

2.2.3 Values and Attitudes

Students are expected to:

- show an interest in the study of biology, appreciate the wonders and complexity of Nature, and show respect for all living things and the environment;
- recognise their responsibility for conserving, protecting and maintaining the quality of the environment;
- develop positive values and attitudes towards adopting a healthy lifestyle;
- be aware of the dynamic nature of biological knowledge and appreciate the role of science and technology in understanding the living world; and
- be aware of the application of biological knowledge in society and its social, ethical, economic and environmental implications.

2.3 Curriculum Structure and Organisation

The Biology Curriculum serves as a continuation of the Science (S1-3) Curriculum. With careful consideration of students' prior knowledge and everyday experiences, it is designed to cover major aspects of biology, and to highlight relevance of biology to social, technological and environmental issues. The curriculum framework has three interconnected components: Learning Targets, Curriculum Emphases, and Compulsory and Elective Parts. Figure 2.1 represents the relationships between the various components.

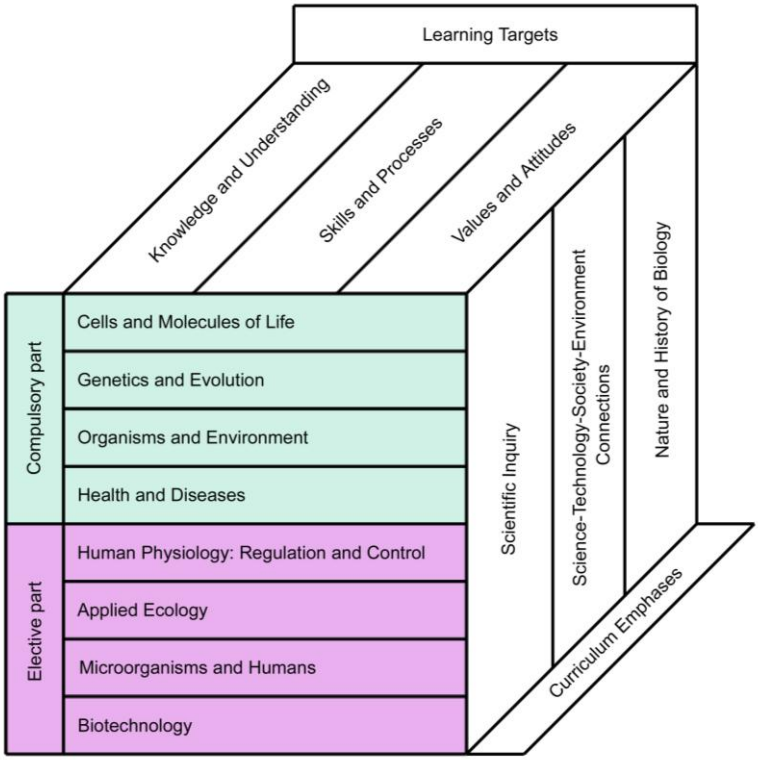


Figure 2.1 Diagrammatic Representation of the Biology Curriculum Framework

The curriculum consists of compulsory and elective parts. The compulsory part covers a range of content that enables students to develop understanding of fundamental biological principles and concepts, and the scientific process skills. There are four topics in the compulsory part – *Cells and Molecules of Life*, *Genetics and Evolution*, *Organisms and Environment*, and *Health and Diseases*.

The elective part is designed to cater for the diverse interests, abilities and needs of students. It aims to provide an in-depth treatment of some of the topics in the compulsory part, an application of essential knowledge and concepts, or an extension of certain areas of study. There are four topics in the elective part – *Human Physiology: Regulation and Control*, *Applied Ecology*, *Microorganisms and Humans*, and *Biotechnology*. Students are required to study any two out of the four topics.

Each topic in the compulsory and elective parts is organised in the following way:

(1) Overview

This part introduces the main theme and focuses of the content for each topic. It suggests the overarching expected learning outcomes of the topic.

(2) 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.

(3) Students should learn and should be able to

(a) The left column of the table lists the intentions of learning (students should learn) 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. For general principles and examples of learning and teaching strategies, please refer to Chapter 4.

(b) The right column of the table lists a range of learning outcomes (students should be able to) 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.

(4) 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. Teachers may refer to Chapter 4 for general principles and examples of learning and teaching strategies.

2.3.1 Curriculum Emphases

Three Curriculum Emphases are designed in the Biology Curriculum and should be applied across the curriculum. They will help to strengthen 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. The following three Curriculum Emphases are identified in the Biology Curriculum:

(1) Scientific Inquiry

This should enable students to:

- make careful observations, ask relevant questions, identify problems and formulate hypotheses for investigations;
- plan, conduct and write reports on scientific investigations;
- select and design appropriate methods of investigations for specific purposes;
- use appropriate instruments and apply proper techniques for carrying out practical work;
- identify and explain the importance of control variables in scientific investigations;
- explain why sample size, random sampling, replicates and repeat procedures are important in scientific investigations;
- classify, collate and display both first and second hand data;
- use diagrams, graphs, flow charts and physical models as visual representations of phenomena and relationships arising from the data;
- analyse and draw conclusions from data;
- understand that the process of scientific investigations includes analysing evidence and providing explanations based upon scientific theories and concepts; and
- formulate and revise scientific explanations and models using logic and evidence.

(2) Science–Technology–Society–Environment Connections

This should enable students to:

- develop sensitivity and responsibility in striking a balance between the needs of humans and a sustainable environment;
- appreciate the role of science and technology in understanding the living world;
- be aware of the application of biological knowledge in society and its social, ethical, economic and environmental implications;
- analyse ways in which scientific and technological advancement have influenced our lives, society and the environment;
- understand how biological knowledge is used in technological applications;
- explain how scientific knowledge may lead to the development of new technologies and how new technologies may lead to scientific discovery;
- be aware that societal needs have led to technological advances; and
- understand how science has been influenced by societies.

(3) Nature and History of Biology

This should enable students to:

- be aware of the dynamic nature of biological knowledge and understand that science is a human endeavour;
- recognise the contributions of various people to understanding and applying biology;
- be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses; and
- understand the nature and limitations of scientific activity.

2.3.2 Time Allocation

A total of 250 hours[Δ] should be allocated to cover the Biology Curriculum. Within this, 20 hours are allocated for scientific investigations to further develop students' skills and attitudes in scientific inquiry. An estimate of the number of hours required for each topic is shown below to provide some guidance on the weighting to be placed on individual topics:

	Suggested lesson time (Hours)
Scientific Investigations	20
Compulsory Part (200 hours)	
I. Cells and Molecules of Life	44
a. Molecules of life*	
b. Cellular organisation*	
c. Movement of substances across membrane*	
d. Cell cycle and division*	
e. Cellular energetics*	
II. Genetics and Evolution	38
a. Basic genetics*	
b. Molecular genetics*	
c. Biodiversity and evolution*	

[Δ] The The lesson time for Liberal Studies and each elective subject is 250 hours (or 10% of the total allocation time) for planning purpose, and schools have the flexibility to allocate lesson time at their discretion in order to enhance learning and teaching effectiveness and cater for students' needs.

"250 hours" is the planning parameter for each elective subject to meet local curriculum needs as well as requirements of international benchmarking. In view of the need to cater for schools with students of various abilities and interests, particularly the lower achievers, "270 hours" was recommended to facilitate schools' planning at the initial stage and to provide more time for teachers to attempt various teaching methods for the NSS curriculum. Based on the calculation of each elective subject taking up 10% of the total allocation time, 2500 hours is the basis for planning the 3-year senior secondary curriculum. This concurs with the reality check and feedback collected from schools in the short-term review, and a flexible range of 2400±200 hours is recommended to further cater for school and learner diversity.

As always, the amount of time spent in learning and teaching is governed by a variety of factors, including whole-school curriculum planning, learners' abilities and needs, students' prior knowledge, teaching and assessment strategies, teaching styles and the number of subjects offered. Schools should exercise professional judgement and flexibility over time allocation to achieve specific curriculum aims and objectives as well as to suit students' specific needs and the school context.

[*] Part of these topics is included in the biology part of Combined Science (Biology, Physics) and Combined Science (Chemistry, Biology).

III. Organisms and Environment 84

a. Essential life processes in plants*
b. Essential life processes in animals*
c. Reproduction, growth and development*
d. Coordination and response *
e. Homeostasis*
f. Ecosystems*

IV. Health and Diseases 14

a. Personal health*
b. Diseases*
c. Body defence mechanisms

Elective Part (50 hours, any 2 out of 4)

V. Human Physiology: Regulation and Control 25

a. Regulation of water content (osmoregulation)
b. Regulation of body temperature
c. Regulation of gas content in blood
d. Hormonal control of reproductive cycle

VI. Applied Ecology 25

a. Human impact on the environment
b. Pollution control
c. Conservation
d. Global issues

VII. Microorganisms and Humans 25

a. Microbiology
b. Use of microorganisms
c. Microbial genetics
d. Harmful effects of microorganisms

VIII. Biotechnology 25

a. Techniques in modern biotechnology
b. Applications in biotechnology
c. Bioethics

Total lesson time: 250

The sequence of presentation of topics in the curriculum framework should not be regarded as a fixed order of learning and teaching. Teachers have autonomy to decide on the arrangement that suits their students and their circumstances. Individual topics should be studied as integral parts of the whole curriculum and not as separate entities. The biological structures and processes, for example, should be considered and understood in the context of the whole organism and not in isolation. Please refer to Chapter 3 for suggestions regarding the sequence of learning and teaching.

SCIENTIFIC INVESTIGATIONS

Scientific inquiry is one of the curriculum emphases which recur throughout the curriculum. It is expected that students will further develop skills in planning and conducting investigations, communicating information and understanding, scientific thinking and problem-solving as well as working individually and in teams.

In order to facilitate the incorporation of scientific investigation into the learning and teaching of biology, time for conducting simple investigations and practical work has already been included in the suggested lesson time for each topic. In addition, there are 20 hours allocated for arranging relatively large-scale or cross-topic investigations to provide students with opportunities to develop the full range of skills and appreciate the nature of science. Teachers could make their own judgments on the best use of this 20-hour lesson time to provide an opportunity for students to design and conduct individual or group investigative projects.

COMPULSORY PART

I. Cells and Molecules of Life

Overview

Cells and biomolecules are fundamental units of life. Organisms are built up of these fundamental units which function as an integrated whole. The study of the structure and function of cells will lay the foundation for students to understand and relate cellular processes to the essential life processes of organisms. The study of the discovery of cells will enable students to appreciate the contribution of technology to the advancement of science and the dynamic nature of biological knowledge.

Scientific Inquiry

This should enable students to:

- ask relevant questions, identify problems and formulate hypotheses for investigations related to cells and molecules of life;
- plan and conduct scientific investigations in the area of cellular structures and functions;
- use appropriate instruments and proper techniques for carrying out practical work (e.g. food tests, preparation of temporary mounts and microscopic examination);
- make careful observations and accurate records (e.g. examine prepared slides or temporary mounts of tissues and make biological drawings); and
- identify and explain the importance of control variables in scientific investigations (e.g. the study of enzymatic activities, osmosis, photosynthesis and respiration).

STSE Connections

This should enable students to:

- be aware of the applications of biological knowledge of cells and molecules of life in society;
- appreciate the role of science and technology in understanding the molecular basis of life; and
- recognise that the development of microscopic technology, computing technology and image analysing technology may lead to the advancement of biological knowledge.

Nature and History of Biology

This should enable students to:

- be aware of the dynamic nature of biological knowledge (e.g. the understanding of cell membrane, sub-cellular organelles and cellular processes);
- recognise the contributions of various people (e.g. Robert Hooke, Theodor Schwann, Melvin Calvin and Sir Hans Krebs) to developments in biology; and
- 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
a. Molecules of life	
Water and inorganic ions (e.g. nitrogen, magnesium, calcium and iron) Biomolecules: carbohydrates, lipids, proteins and nucleic acids • Building blocks • Functions	• Relate the significance of water, inorganic ions and biomolecules to life.
b. Cellular organisation	
Discovery of cells Cell membrane • Properties and functions Sub-cellular structures and their functions • Nucleus and chromosomes, endoplasmic reticulum, mitochondrion, chloroplast, cell wall and vacuole Prokaryotic cells (e.g. bacterial cells) and eukaryotic cells	• Appreciate the contribution of the technological development of the microscope to the discovery of cells. • Prepare temporary mounts of specimens for examination, and make observations and drawings under a light microscope. • Use the fluid mosaic model to explain the properties and functions of cell membrane. • Appreciate the uses and limitations of scientific models. • Compare the cellular organisation of animal and plant cells. • Identify cell organelles as seen under light and electron microscopes. • Compare the sub-cellular organisation of prokaryotic and eukaryotic cells.
c. Movement of substances across membrane	
Diffusion, osmosis and active transport 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.
d. Cell cycle and division	
Stages of cell cycle • Cell growth, nuclear division and cytoplasmic division	• Understand the importance of cell division in growth and reproduction. • Recognise the various stages of cell cycle.

Students should learn	Students should be able to
Nuclear division • Mitosis • Meiosis	• Outline and compare the processes of mitosis and meiosis.
e. Cellular energetics	
Metabolism: catabolism and anabolism • Occurrence of catabolic and anabolic processes in cells	• Distinguish between catabolic and anabolic processes. • Recognise the properties of enzyme and its roles in metabolism.
Enzymes and enzymatic reactions • Properties and roles of enzyme • Active site and specificity • Factors (temperature, pH and inhibitors) affecting the rate of enzymatic reactions • Application of enzyme in everyday life	• Explain enzyme specificity in terms of active site. • Explain the effects of factors on the rate of enzymatic reactions.
Photosynthesis • Site of photosynthesis – Leaves and chloroplasts • Requirements for photosynthesis – light, carbon dioxide, water and chlorophyll • Photochemical reactions – light absorption – photolysis of water for the generation of NADPH – generation of ATP • Carbon fixation: Calvin cycle – 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 • Conversions of photosynthetic products into other biomolecules • Factors (light intensity and carbon dioxide concentration) affecting the rate of photosynthesis	• Understand the significance of photosynthesis. • Relate the structures of leaves and chloroplasts to their functions in photosynthesis. • Outline the major steps of photochemical reactions and carbon fixation. • Understand the dependence of carbon fixation to the photochemical reaction. • Explain the effects of environmental factors on the rate of photosynthesis.

Students should learn	Students should be able to
Respiration • 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 – Oxidative phosphorylation ▪ 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	• Understand the significance of respiration. • State the role of ATP in energy transfer. • Outline the major steps of glycolysis, aerobic and anaerobic pathways. • Be aware of the occurrence of anaerobic respiration during exercise. • Distinguish between aerobic and anaerobic respiration. • Compare the processes of respiration and photosynthesis. • Be aware of the interconversions of biomolecules through biochemical pathways.

Suggested Learning and Teaching Activities

a. Molecules of 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.

b. Cellular organisation

- 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.
- Discuss the variations of the number of mitochondria in different tissues and cell types.
- Prepare temporary mounts of animal and plant tissues for examination under a light microscope.
- Examine electron micrographs or live cell images of prokaryotic, eukaryotic cells and sub-cellular structures.
- Construct a model to represent the structure of cell membrane (e.g. using tank and ping-pong balls).

c. Movement of substances across membrane

- 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.

d. Cell cycle and division

- Observe and identify the different stages of mitosis and meiosis, using prepared slides, photomicrographs or live cell images.

e. Cellular energetics

- Perform practical work to demonstrate the breaking down or building up action of enzymes; and to identify the photosynthetic products.
- Design and perform investigations to study the effects of temperature, pH or inhibitors on the activities of enzymes; to find out some commercial applications of enzymes (e.g. bioactive washing powder and meat tenderiser); to study the effects of environmental factors (e.g. light intensity and carbon dioxide concentration) on the rate of photosynthesis; and to study aerobic and anaerobic respiration in organisms.
- Examine the morphology and the internal structure of leaves, and the photomicrographs or live cell images of chloroplasts and mitochondria.
- Search for information to compare the photosynthetic rates and productivities in different climatic areas; and to understand scientists' work related to photosynthesis and cellular respiration.
- Conduct a project on how a greenhouse works in enhancing plant growth.
- Discuss the application of anaerobic respiration in the food industry.
- Interpret, analyse and evaluate data relating to investigations on photosynthesis and respiration.
- Use animations to study the processes of photosynthesis and respiration.

COMPULSORY PART

II. Genetics and Evolution

Overview

Through the study of basic genetics, students will acquire knowledge and develop an understanding of concepts of genes and their roles in the life of organisms. The study of molecular genetics will lay the foundation for students to study further in the field of biotechnology and be aware of its impact on society.

The study of biodiversity will help students to recognise its complexity and the adaptations of different groups of organisms to their environment. Moreover, a phylogenetic approach to the classification system is adopted, which helps them to understand the development of the classification system with evidence gathered from molecular genetics. This will enable students to appreciate the phenomena of evolution and develop their curiosity about the origins of life. In addition to Darwin's theory, students are encouraged to explore other scientific explanations for the origins of life and evolution, to help illustrate the dynamic nature of scientific knowledge.

Scientific Inquiry

This should enable students to:

- make careful observations and accurate records (e.g. observe distinguishing features for identifying organisms, and variations in humans);
- use appropriate instruments and proper techniques for carrying out practical work on molecular genetics (e.g. DNA extraction and gel-electrophoresis);
- classify, collate and display both first and second hand data (e.g. construct a pedigree of the inheritance of some human traits);
- use diagrams and physical models as visual representations of phenomena and relationships arising from the data (e.g. genetic diagrams and DNA model); and
- formulate and revise scientific explanations and models using logic and evidence (e.g. use of fossil records as evidence for evolution).

STSE Connections

This should enable students to:

- be aware of the application of knowledge of basic and molecular genetics in society and its social, ethical and economic implications;
- be aware that societal needs have led to technological advances (e.g. recombinant DNA technology and DNA fingerprinting);
- appreciate the contribution of the Human Genome Project (HGP) and the application of biotechnology to humans and society;
- appreciate the role of science and technology in understanding the complexity of life forms and their genetics;
- understand how science has been influenced by societies (e.g. various views on the origins of life and evolution); and
- 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.

Nature and History of Biology

This should enable students to:

- be aware of the dynamic nature of biological knowledge (e.g. from basic genetics to molecular genetics, and the development of classification systems);
- recognise the contributions of various people (e.g. Gregor Mendel, James Watson, Francis Crick, Charles Darwin, Sir Alfred Russel Wallace and Jean Baptiste Lamarck) to the understanding of genetics and evolution;
- appreciate the advancement of the study of genetics from traditional breeding experiments to molecular experimentation and analysis; and
- be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses (e.g. Mendel's work).

Students should learn	Students should be able to
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.
Inheritance in humans • 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.
Pedigree analysis	• Analyse pedigree to study the inheritance of characteristics.
Variations in characteristics • Continuous variation • Discontinuous variation • Causes of variation – hereditary information – environmental factors – mutation	• Explain the causes of different types of variations in characteristics.
b. Molecular genetics	
Chromosomes, genes and nucleic acids	• Describe the structural and functional relationships of chromosomes, genes and nucleic acids.
Gene expression and protein synthesis • transcription and translation	• Outline the process of protein synthesis.
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. • 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 effort of scientists in international genomics projects.
Biotechnology • Recombinant DNA technology • DNA fingerprinting • Human Genome Project (HGP) and its implications	

Students should learn	Students should be able to
c. Biodiversity and evolution	
Diversity of life forms Classification of organisms • Need for classification • Classification approaches proposed by Carl Woese – Six kingdoms (Eubacteria, Archaebacteria, Protista, Fungi, Plantae and Animalia) – Three domains (Bacteria, Archaea and Eukarya) Origins of life Evolution • Origin of species • Speciation – genetic variation – isolation • Mechanism of evolution – natural selection • Evidence of evolution (e.g. fossil record)	• 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. • Appreciate that classification systems are subject to change when new evidence appears. • Recognise the use of classification systems and binomial nomenclature. • Construct and use dichotomous keys to identify unknown organisms. • Classify organisms into six kingdoms. • Appreciate that there are various explanations for the origins of life. • Be aware of the limitations of using fossil record as evidence of evolution, and the presence of other evidence. • Relate speciation to evolution. • Outline the mechanism of evolution.

Suggested Learning and Teaching Activities

a. Basic genetics

- 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.
- Observe and analyse variations in humans (e.g. height and tongue rolling).
- Construct and/or analyse a pedigree of the inheritance of some human traits (e.g. haemophilia, tongue rolling and ear lobes).

b. Molecular genetics

- 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.
- Examine photomicrographs of karyotypes of chromosome mutation.
- Search for information on the sources of mutagenic agents and their effects on human health.
- 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.

c. Biodiversity and evolution

- 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.
- Discuss the advantages and limitations of different classification systems, and why the classification of some organisms has been changed over time.
- 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; the different explanations for the origins of life; and 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.

COMPULSORY PART

III. Organisms and Environment

Overview

Organisms are an integral part of the environment. Their ways of life and living are closely related to the environment where they live in. Based on this perspective, students will gain knowledge and understanding of organisms and their environment.

Firstly, students will study how organisms obtain their basic needs for oxygen, water and food from the environment. Life processes, such as nutrition, gas exchange, and transport involved, will be studied in an integrated manner so as to enhance understanding of the structures and functions of an organism as a whole. Secondly, students will study reproduction, growth and development to understand how organisms perpetuate and proliferate in the environment. The human is used as a model for students to understand the essential life processes of animals. Thirdly, students will examine how organisms detect changes in the environment and make appropriate responses for their survival, and how humans maintain a steady internal environment. Students will then explore how organisms interact with each other and with their environment as a whole. Finally, the dynamic nature of the ecosystems that involves energy flow and materials cycling will also be investigated. Students are expected to develop an awareness of the impact of human activities on the ecosystems and recognise the need for conservation.

Scientific Inquiry

This should enable students to:

- make careful observations and accurate records (e.g. examine prepared slides or temporary mounts of roots, stems and leaves, and make biological drawings);
- ask relevant questions, identify problems and formulate hypotheses for investigations related to life processes and ecosystems;
- plan, conduct and write reports on scientific investigations in areas of life processes and ecosystems;
- select and design appropriate methods of investigations for specific purposes (e.g. use transects and quadrats to collect samples in field studies);
- identify and explain the importance of control variables in scientific investigations (e.g. the study of the effects of different minerals on plant growth, and the action of digestive enzymes);
- explain why sample size, random sampling, replicates and repeat procedures are important in scientific investigations (e.g. field studies);

- use appropriate instruments and proper techniques for carrying out practical work (e.g. food tests, preparation of temporary mounts, microscopic examinations, dissections and field study techniques); and
- 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).

STSE Connections

This should enable students to:

- evaluate the impact of the application of biology to human activities (e.g. dietary requirement, birth control and pollution control);
- analyse ways in which scientific and technological advancement (e.g. computing technology and image analysing technology) have enhanced our understanding of complex life processes;
- develop sensitivity and responsibility in striking a balance between the needs of humans and a sustainable environment; and
- be aware of the application of biological knowledge (e.g. balanced diet, birth control, and sewage treatment) in society and its social, ethical, economic and environmental implications.

Nature and History of Biology

This should enable students to:

- understand that science is a human endeavour through the study of essential life processes of organisms and interactions with our environment;
- be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses (e.g. the study of tropism, transpiration pull and field ecology);
- recognise the complexity of the physiological processes of organisms and the environment; and
- understand the nature and limitations of scientific activity (e.g. investigations on various physiological processes and ecosystems).

Students should learn	Students should be able to
a. Essential life processes in plants	
Nutrition in plants • Plants as autotrophs • Photosynthesis* • Need for minerals • Absorption of water and minerals	• Appreciate the significance of plants as autotrophs. • Explain the need for minerals in plants. • Relate the structure of roots to their functions in water absorption.
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.
Transpiration • Process and significance • Factors (humidity, light intensity and wind) affecting the rate of transpiration	• Make connections between transpiration, absorption and transport of water, and cooling of plants. • Explain the effects of environmental factors on the rate of transpiration.
Transport of substances in plants • Transport of water and minerals • Translocation of organic nutrients	• Describe the path of materials transport in flowering plants. • Compare the means of support in herbaceous and woody dicotyledonous plants.
Support in plants • Cell turgidity • Physical nature of xylem	
b. Essential life processes in animals	
Nutrition in humans • Humans as heterotrophs • 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. • Relate health problems to improper diet. • Explain the significance of mechanical and chemical digestion. • Understand the digestion and absorption processes in various parts of the alimentary canal. • Illustrate the adaptive features of the small intestine for food absorption.

* Refer to *Photosynthesis* in topic I Cells and Molecules of Life

Students should learn	Students should be able to
• Balanced diet • Ingestion – Dentition – Mastication • Digestion – General plan of the digestive system – Digestion of carbohydrates, proteins and lipids in various parts of the alimentary canal • Absorption and assimilation – Structural adaptation of small intestine for food absorption – Role of liver – Fate of absorbed food • Egestion	• Describe the routes of the transport of absorbed food and their fates in cells and tissues.
Gas exchange in humans • General plan of the breathing system • 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. • Relate the structure of various parts of the breathing system to gas exchange.
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.
c. Reproduction, growth and development	
Asexual reproduction • Binary fission in bacteria • Vegetative propagation in flowering plants	• Outline with an example, the process of vegetative propagation in flowering plants. • Relate the structure of various floral parts to reproduction.
Sexual reproduction in flowering plants • Floral parts • Pollination • Fertilisation	• Understand the importance of pollination. • Compare the adaptive features of insect-pollinated flowers and wind-pollinated flowers.

Students should learn	Students should be able to
• Significance of seed and fruit dispersal	• Outline the process of fertilisation leading to the formation of seed and fruit. • Discuss the significance of asexual and sexual reproduction.
Reproduction in humans • General plan of the male and female reproductive systems • Structure of sperm and ovum • Menstrual cycle – Cyclic changes in uterine lining – Ovulation • Fertilisation • Development of embryo and foetus – Placenta – Identical twins and fraternal twins • Birth process • Parental care • Birth control	• 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. • Understand the biological basis of various methods of birth control.
Growth and development • Concepts of growth and development • Germination of seed and its development into a new plant • Stages of growth in annual plants and humans – Growth curves • 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. • Identify the different stages of growth from growth curves of plants and humans.
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.

Students should learn	Students should be able to
– Eye defects (long sight, short sight and colour blindness) • Light as stimulus: phototropic response in plants – Responses of root and shoot – Role of auxins • Sound as stimulus: the human ear – Major parts of the ear	• 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. • Recognise the significance of phototropism. • Understand the mechanism of phototropic responses in root and shoot. • Relate the structure of major parts of the ear to hearing.
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 • 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.
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.
Movement in humans • Components of the musculo-skeletal system: 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.

Students should learn	Students should be able to
e. Homeostasis	
Concept of homeostasis • Importance of homeostasis • Feedback mechanism	• Explain the principle of feedback mechanism with reference to the regulation of blood glucose level. • Appreciate that the internal environment of the human body is maintained by the nervous system and the endocrine system.
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	
f. Ecosystems	
Levels of organisation • Species, population, community, ecosystem, biome and biosphere	• 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.
Major ecosystem types • Freshwater stream, rocky shore, mangrove, grassland and woodland	
Components of an ecosystem • Abiotic factors • Biotic community – Niche and habitat – Species diversity and dominant species – Relationships between organisms ▪ Predation, competition, commensalism, mutualism and parasitism – Ecological succession ▪ Primary and secondary succession ▪ Climax community	• Identify the abiotic factors of a habitat and explain their effects. • Describe the different types of relationships between organisms in a habitat. • Outline the process of ecological succession. • 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. • Understand the cycling of materials in an ecosystem. • Be aware of the interactions between the biotic community and the abiotic factors of an ecosystem.

Students should learn	Students should be able to
Functioning of an ecosystem • Energy flow – Source of energy – Energy flow between different trophic levels – Feeding relationships of organisms • Materials cycling – Carbon and nitrogen cycles • Roles of producers, consumers and decomposers in energy flow and materials cycling	
Conservation of ecosystem • Impacts of human activities	• Recognise the need for conservation.
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, temperature, oxygen, humidity and salinity)	• Conduct and report an ecological study of a local habitat.

Suggested Learning and Teaching Activities

a. Essential life processes in plants

- Design and perform investigations to study the effects of different minerals on plant growth using potted plants; to study the effects of light intensity on gas exchange in land or water plants using hydrogencarbonate indicator solution or data loggers; to compare the distribution of stomata on both sides of a leaf; and 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; and the structure of the root of young seedlings using live specimens or prepared slides.
- Perform practical work to demonstrate the occurrence of transpiration; and to trace the uptake of water in herbaceous plant using eosin solution.

b. Essential life processes in animals

- Perform practical work to identify composition in some common foodstuffs; to demonstrate the effect of bile salt on oil; to simulate digestion and absorption in the alimentary canal using dialysis tubing; and to compare the differences in composition between inhaled and exhaled air.
- Design and perform investigations to compare the amount of vitamin C in different fruits and vegetables; and to study the action of digestive enzymes (e.g. amylase on starch-agar plate, protease on milk-agar plate or egg white).
- Examine the alimentary canal and its associated glands, and the breathing system of a dissected mammal or a human torso.
- Examine a pig's lungs; and the capillary flow in a fish's tail fin or frog's web.
- Examine the structure of air sacs, arteries and veins, and the components of blood using prepared slides or photomicrographs.
- Perform dissection of a pig's heart and examine its structures.

c. Reproduction, growth and development

- Examine photomicrographs, video clips or live cell images of binary fission of bacteria, sperms and ova.
- Use audiovisual materials to study the process of fertilisation.
- Examine the adaptive features of insect-pollinated and wind-pollinated flowers.
- Examine the male and female reproductive systems of dissected mammals or a human torso.
- Examine photos or video clips taken by ultrasound showing different stages of foetal development.
- Cultivate and examine any vegetative propagation organ of flowering plants.
- Search for information on the effectiveness and possible side effects of various birth control methods; *in vitro* fertilisation and termination of pregnancy.
- Discuss the harmful effects of drinking and smoking habits of a pregnant woman on the development of the foetus.
- Design and perform investigations to study seed germination and the growth of young seedlings.

d. Coordination and response

- Perform dissection of an ox's eye and examine its structures.
- Search for information on how modern technology helps in rectifying eye defects (e.g. short/long sight, astigmatism, cataract or glaucoma).
- Examine models of the human brain, eye, ear and arm.
- Design and perform investigations on the phototropic responses of roots and shoots.
- Perform practical work to observe the contraction of teased muscle from the leg of a pithed frog.

e. Homeostasis

- Construct a flow chart to illustrate the feedback mechanism.
- 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

- Visit nature reserves, country parks, marine parks, field study centres and other local habitats.
- Construct and interpret food chains, food webs, and pyramids of numbers and biomass.
- Use live or audiovisual materials to show the relationships of organisms in an ecosystem.
- Conduct an ecological study of a local habitat (e.g. freshwater stream and rocky shore).

COMPULSORY PART

IV. Health and Diseases

Overview

Students will acquire knowledge and develop an understanding of what constitutes health; so that they can make informed decisions on the choice of lifestyles, habits, and disease prevention measures. This is designed to help students develop a positive attitude towards health and be aware of both individual and public responsibility for the maintenance of a healthy community. The routes of pathogen transmission and the causes of some non-infectious diseases are to be learned in association with the biological principles that may lead to their prevention and control. The physiological defence mechanisms employed by the human body to combat diseases, the principle of vaccination, the use of antibiotics, and some of the related issues, are also discussed.

Scientific Inquiry

This should enable students to:

- make careful observations and accurate records (e.g. examine prepared slides or photomicrographs of pathogens and make biological drawings);
- identify questions and carry out appropriate studies to understand various infectious and non-infectious diseases in our society;
- classify, collate and display both first and second hand data (e.g. collect information related to health and diseases from the Hospital Authority, Department of Health or the Internet); and
- understand that the process of scientific investigations includes analysing evidence and providing explanations based upon scientific theories and concepts (e.g. body defence mechanisms, treatment and prevention of infectious diseases).

STSE Connections

This should enable students to:

- be aware of the application of biological knowledge in maintaining a healthy community and its social, ethical, economic and environmental implications;
- analyse ways in which societal needs have led to technological advances (e.g. treatment and prevention of diseases);
- appreciate how modern technological advances and scientific discoveries contribute to the detection, diagnosis, treatment, prevention and monitoring of diseases (e.g. cancer and tuberculosis); and
- be aware of personal responsibility in preventing disease transmission.

Nature and History of Biology

This should enable students to:

- be aware of the dynamic nature of biological knowledge related to body defence mechanism and diseases, and understand that science is a human endeavour;
- appreciate the contributions of various people in advancing the application of biology (e.g. the development of vaccines and the discovery of antibiotics);
- be aware that biological knowledge and theories related to the prevention and control of diseases are developed through observations, hypotheses, experimentations and analyses; and
- understand the nature and limitations of scientific activity (e.g. the causes and transmission of some diseases are not yet known).

Students should learn	Students should be able to
a. Personal health	
Meaning of health	• Recognise the meaning of health.
b. Diseases	
Types of diseases • Infectious diseases • Non-infectious diseases	• Understand the concept of disease. • Distinguish between infectious and non-infectious diseases.
Infectious diseases (e.g. Cholera, dengue fever, hepatitis B, influenza and tuberculosis) • Causes • Ways of transmission – Water, air, droplets, food, body fluids, vector and direct contact • Treatment – Antibiotics ▪ Action of antibiotics ▪ Indiscriminate use – Other drugs (e.g. sulpha drugs)	• Understand how infectious diseases are transmitted. • Discuss how to reduce the spread of some common infectious diseases. • Discuss the consequences of indiscriminate use of antibiotics. • Be aware of the various ways of disease treatment.
Non-infectious diseases • Cancer • Cardiovascular diseases (e.g. coronary heart disease) • Diabetes – Forms of diabetes (insulin-dependent diabetes and non-insulin-dependent diabetes) – Control of diabetes	• Discuss the causal relationships between the incidence of various non-infectious diseases and certain lifestyles. • Outline the biological principles in the control of insulin-dependent diabetes.
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.

Students should learn	Students should be able to
c. Body defence mechanisms	
Non-specific defence mechanisms • Skin, mucus and other secretions, cilia, phagocytes, blood clotting and inflammatory responses Specific defence mechanisms • Immune response • Antigen and antibody • Lymphocytes (B and T cells) • Primary and secondary responses • Active and passive immunity	• Understand the non-specific and specific defence mechanisms. • Outline the principles of immune response. • Compare primary and secondary responses. • Distinguish between active and passive immunity.

Suggested Learning and Teaching Activities

b. Diseases

- Examine photomicrographs, prepared slides or live cell images of some pathogens (e.g. viruses, bacteria, fungi and protists).
- 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; and the incidences of various types of cancer in Hong Kong.
- Conduct a study on the incidence of liver cancer and lung cancer in relation to lifestyles.
- Design a poster, leaflet or web page to advise how to reduce the chances of developing one form of cancer.
- Suggest ways to reduce the incidence of cardiovascular diseases.
- Search for information on the types, symptoms, risk factors, diagnosis, management and control of diabetes; 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.
- Read stories about how scientists (e.g. Edward Jenner, Louis Pasteur and Jonas Salk) contributed to the development of vaccination.
- 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.
- Study a personal immunisation record to find out the types of diseases that are covered by the local immunisation programme.
- Use audiovisual materials to illustrate the effects of antibiotic discs on a bacterial lawn.

c. Body 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.
- Use audiovisual materials or animations to demonstrate the production of antibodies in response to an antigen, and the antigen-antibody reactions.
- Discuss why breast feeding may confer passive immunity on a child.

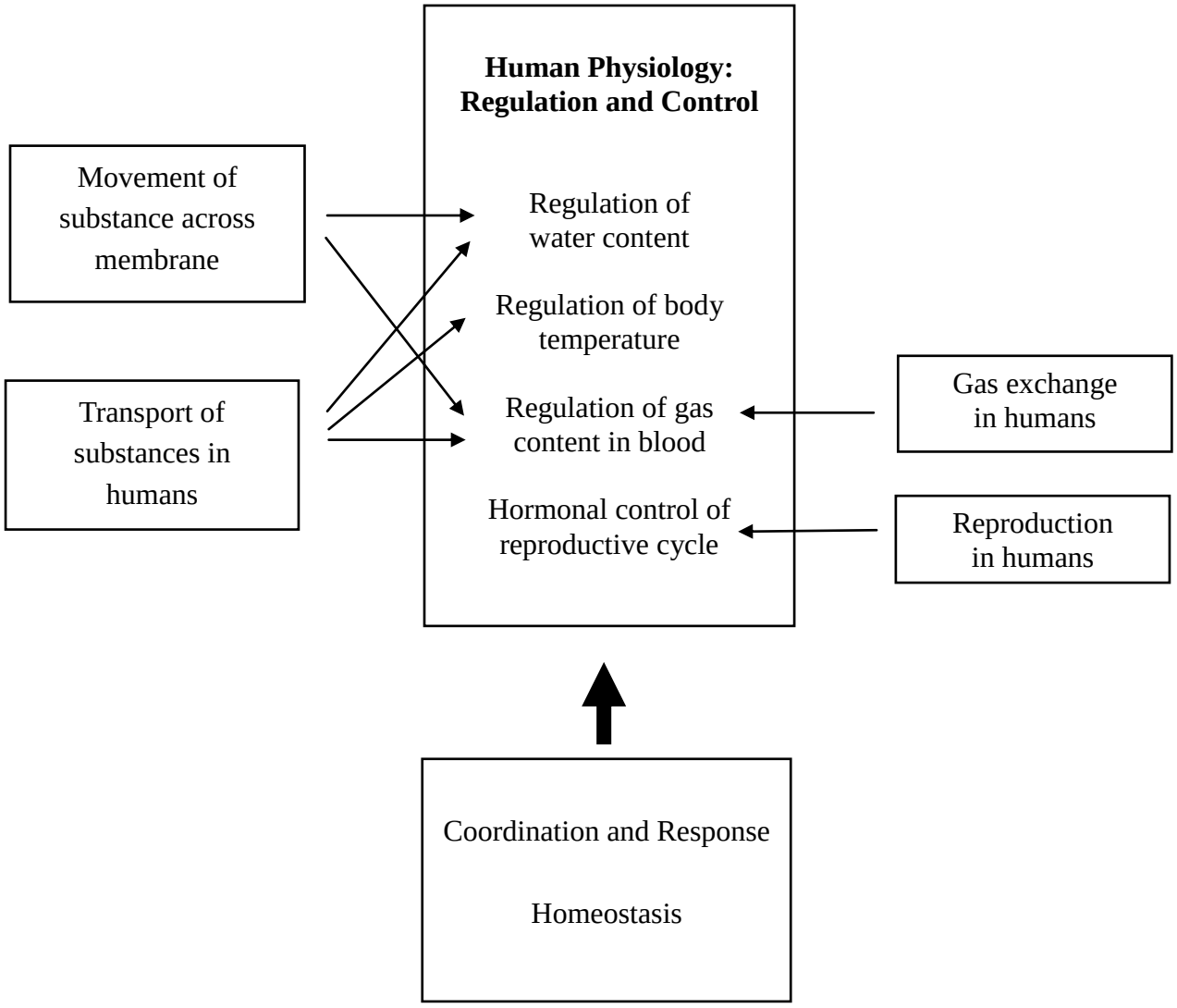
ELECTIVE PART

V. Human Physiology: Regulation and Control

Overview

In this topic, students will develop a deeper understanding of the physiological processes in humans. Regulation and control is an interesting topic concerning the intriguing mechanisms which enable our bodies to function normally regardless of the changes in environmental conditions. Students are expected to understand the roles of nervous control and hormonal control in coordinating different organs and systems to achieve a steady internal environment.

Human Physiology: Regulation and Control builds on students' prior knowledge of *Movement of substances across membrane*, *Essential life processes*, *Coordination and response* and *Homeostasis* studied in the compulsory part. The diagram below shows how the prior knowledge is related to this topic.



Scientific Inquiry

This should enable students to:

- ask relevant questions, identify problems and formulate hypotheses for investigations related to nervous and hormonal control of the human body;
- plan, conduct and write a report on a scientific investigation (e.g. study the change in heart rate and breathing rate before and after exercise);
- use appropriate instruments and proper techniques for carrying out practical work (e.g. measuring breathing rate and heart rate);
- make careful observations and accurate records; and
- classify, collate and display both first and second hand data (e.g. hormonal change in the menstrual cycle).

STSE Connections

This should enable students to:

- be aware of the significance of knowledge in human physiology to improve the quality of life and maintain a healthy community;
- be aware that societal needs have led to technological advances (e.g. dialysis machines and the use of contraceptives); and
- appreciate the role of science and technology in understanding the human body.

Nature and History of Biology

This should enable students to:

- be aware of the dynamic nature of biological knowledge in human physiology, and understand that science is a human endeavour; and
- be aware that biological knowledge and theories are developed through observations, hypotheses, experimentations and analyses.

Students should learn	Students should be able to
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 – Ultrafiltration – Reabsorption • Action of antidiuretic hormone (ADH) • Biological principles of the dialysis machine (kidney machine)	• Relate the structure of nephron to its function in regulation of water content. • Understand the action of ADH. • Recognise the excretory function of the kidney.
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.
c. Regulation of gas content in blood	
Importance of regulation of gas content in blood Control of rate and depth of breathing • Nervous control – Respiratory centre and chemoreceptors – Effects of carbon dioxide concentration in blood Control of cardiac output • Heart rate and stroke volume • Pacemaker and cardiac cycle	• Understand the control mechanism of breathing. • Outline the major events during the cardiac cycle. • Understand the nervous and hormonal control of cardiac output. • Explain how the gas content in blood is regulated during and after exercise.

Students should learn	Students should be able to
• Nervous control – Vagus nerve and sympathetic nerves • Hormonal control – Adrenaline Effects of exercise • Rate and depth of breathing • Oxygen debt • Cardiac output	
d. Hormonal control of reproductive cycle	
Interaction of hormones in the menstrual cycle	• Understand the significance of hormonal control of the menstrual cycle.
Use of hormones as contraceptives and in the treatment of infertility	• Explain how hormones can be used as contraceptives and in the treatment of infertility.

Suggested Learning and Teaching Activities

a. Regulation of water content

- Examine a dissected mammalian kidney or a kidney model.
- Examine the urinary system of a dissected mammal or a human torso.

b. Regulation of body temperature

- Examine prepared slides or photomicrographs to identify features of mammalian skin that are related to temperature regulation.
- Construct a concept map to show the mechanism of temperature regulation.
- Search for information on human physiological conditions under extreme hot and cold environments.

c. Regulation of gas content in blood

- Design and perform investigations to study the changes in heart rate and breathing before and after exercise using data loggers or other methods.

d. Hormonal control of reproductive cycle

- 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.

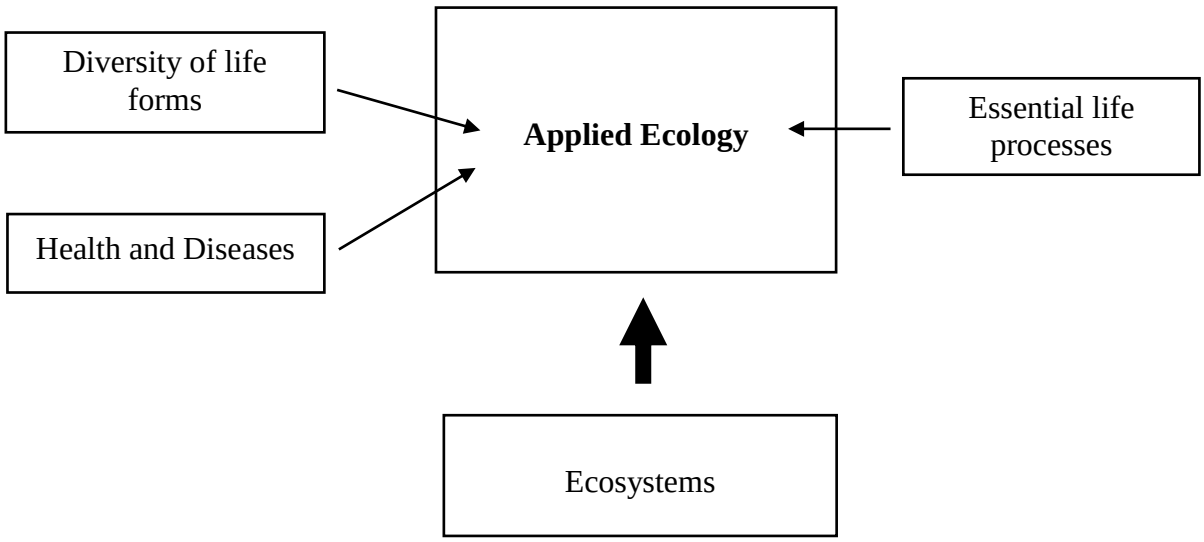
ELECTIVE PART

VI. Applied Ecology

Overview

In this topic, students will build on their prior knowledge of basic ecological principles and develop a further understanding of applied ecology. Students will explore some of the ways in which human activities can impose far-reaching effects on the environment. Local and global pollution issues, resources management, pollution control measures and conservation will be also discussed. At the end, students are expected to apply a range of field study skills to investigate the impact of pollution on the local environment.

Applied Ecology builds on students' prior knowledge of the *Diversity of life forms*, *Essential life processes*, *Ecosystems* and *Health and Diseases* studied in the compulsory part. The diagram below shows how the prior knowledge is related to this topic.



Scientific Inquiry

This should enable students to:

- make careful observations, ask relevant questions, identify problems and formulate hypotheses for investigations related to pollution;
- identify and explain the importance of control variables in scientific investigations related to pollution;
- explain why sample size, random sampling, replicates and repeat procedures are important in ecological investigations; and
- 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).

STSE Connections

This should enable students to:

- be aware of the application of ecological knowledge in society and its social, ethical, economic and environmental implications;
- analyse ways in which scientific and technological advancement have influenced our lives, society and the environment (e.g. pollution resulting from industrialisation and urbanisation);
- develop sensitivity and responsibility in striking a balance between the needs of humans and a sustainable environment; and
- explain how biological knowledge is used in technological application for management of the environment (e.g. sewage treatment).

Nature and History of Biology

This should enable students to:

- be aware of the dynamic nature of biological knowledge in ecology and understand that science is a human endeavour;
- 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); and
- understand the nature and limitations of scientific activity.

Students should learn	Students should be able to
a. Human impact on the environment	
Human population growth • Impact of rapid human population growth on the environment • Need for population control	• Evaluate the impact and control of rapid human population growth. • Recognise the impacts of malpractices in fisheries and agriculture. • Explain the ecological impacts of land clearance and reclamation. • Recognise the effects of air and water pollution on the environment and human health. • Account for the accumulation of toxic substances along a food chain. • Design and perform investigation to study air or water pollution.
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 – Air pollution (e.g. respiratory illnesses) – Water pollution (e.g. gastroenteritis)	
b. Pollution control	
Reduce, reuse, recycle and replace Sewage treatment	• Recognise strategies for pollution control. • Describe the biological principles of sewage treatment.
c. Conservation	
Importance of biodiversity Conservation of species • Endangered species in Hong Kong Measures to protect endangered species	• Understand the need for conservation. • 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.

Students should learn	Students should be able to
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	
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.

Suggested Learning and Teaching Activities

a. Human impact on the environment

- Conduct a project on the effects of human population growth on the environment and the quality of life.
- Design and perform investigations to study the lichen distribution as an indication of air pollution by sulphur dioxide; 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.
- 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.

b. Pollution control

- Search for information on the joint efforts of governments to control regional air pollution problems.
- Develop action plans to reduce environmental pollution.
- Visit a sewage treatment plant.

c. 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.
- 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.

d. Global issues

- 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.

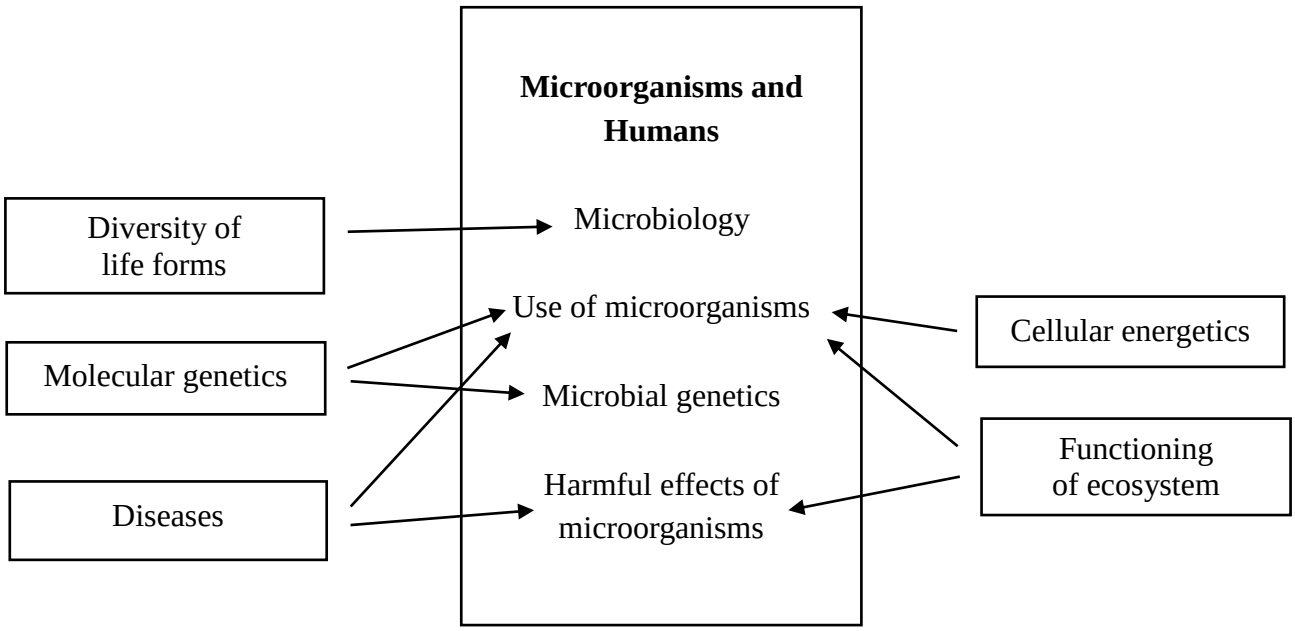
ELECTIVE PART

VII. Microorganisms and Humans

Overview

Humans are living in a world full of microorganisms, and our daily lives are directly and indirectly affected by them. In this topic, students will develop an understanding of the diversity of microorganisms, and their beneficial and harmful roles. Students will have the opportunity to study the growth of microorganisms, and develop appropriate laboratory skills and techniques for conducting practical work with microorganisms. Examples of uses of microorganisms in food, medicine, industry pollution control and genetic engineering are included, so as to illustrate the importance of microorganisms and their wide applications. Finally, human diseases caused by pathogenic microorganisms, and microbial deterioration are used to illustrate the harmful effects of microorganisms.

Microorganisms and Humans builds on students' prior knowledge of *Cellular energetics*, *Molecular genetics*, *Diversity of life forms*, *Functioning of ecosystem*, and *Diseases* studied in the compulsory part. The diagram below shows how the prior knowledge is related to this topic.



Scientific Inquiry

This should enable students to:

- make careful observations, ask relevant questions, identify problems and formulate hypotheses for investigations related to the study of microorganisms;
- plan, conduct and write a report on an investigation (e.g. study the optimal conditions for fermentation);
- use appropriate instruments and proper techniques for carrying out practical work (e.g. aseptic techniques and measuring the growth of yeast);
- identify and explain the importance of control variables in scientific investigations related to microbiology; and
- classify, collate and display both first and second hand data (e.g. collect data from the Hospital Authority, Department of Health and World Health Organisation).

STSE Connections

This should enable students to:

- be aware of the influences of various types of microorganisms on society and the environment (e.g. as pathogens, decomposers);
- be aware of the applications of knowledge of microorganisms and their social, economic and environmental implications (e.g. the use of bacteria in biotechnology);
- analyse ways in which scientific and technological advancement have enhanced our understanding in microbiology(e.g. aseptic techniques, recombinant DNA technology); and
- explain how biological knowledge is used in technological application (e.g. the use of microorganisms in sewage treatment).

Nature and History of Biology

This should enable students to:

- be aware of the dynamic nature of biological knowledge related to microorganisms and understand that the development of microbiology is a human endeavour;
- appreciate the contributions of various people in advancing the application of biology (e.g. the development of vaccines and the discoveries of antibiotics); and
- understand the nature and limitations of scientific activity.

Students should learn	Students should be able to
a. Microbiology	
Viruses • Multiplication of viruses	• Describe how a virus reproduces by infecting a living cell.
Diversity of microorganisms • Representative organisms of Bacteria, Protista and Fungi	• Distinguish different groups of microorganisms based on group features.
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.
Aseptic techniques • Principles • Precautions and risk assessment	• Outline the principle of aseptic techniques. • Use aseptic techniques and follow safety procedures in handling, culturing and disposing of microorganisms.
b. Use of microorganisms	
Food processing (e.g. beer-brewing)	• Outline the process of food production involving the use of microorganisms in fermentation.
Vaccines	
Antibiotics	• Understand the roles of microorganisms in sewage treatment.
Industrial enzymes (e.g. biological washing powder and pectinase for extracting fruit juice)	• Be aware of the wide applications of microorganisms.
Sewage treatment	
Biogas production	

Students should learn	Students should be able to
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.
d. Harmful effects of microorganisms	• Outline the principles of how microorganisms cause diseases in humans.
Diseases caused by microorganisms • Food-borne infection and food poisoning	• Recognise the causes of food-borne infection and food poisoning.
Microbial deterioration	• Recognise the problems of microbial deterioration to our daily lives.
Control of growth of microorganisms	• Discuss how to control and eliminate the harmful effects of microorganisms.

Suggested Learning and Teaching Activities

a. Microbiology

- Perform practical work to demonstrate aseptic techniques; and to grow yeast in liquid culture and on agar.
- Design and perform investigations to study the growth of microorganisms (e.g. yeast).

b. Use of microorganisms

- Visit a food production plant or a sewage treatment plant.
- Conduct a project on the applications of microorganisms.
- 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; and to study the content and effectiveness of biological and non-biological washing powder.

c. Microbial genetics

- Search for information on the wide application of genetically modified microorganisms.

d. Harmful effects of microorganisms

- Search for information on the incidence of food poisoning in Hong Kong.
- Conduct a project on the prevention of microbial deterioration.

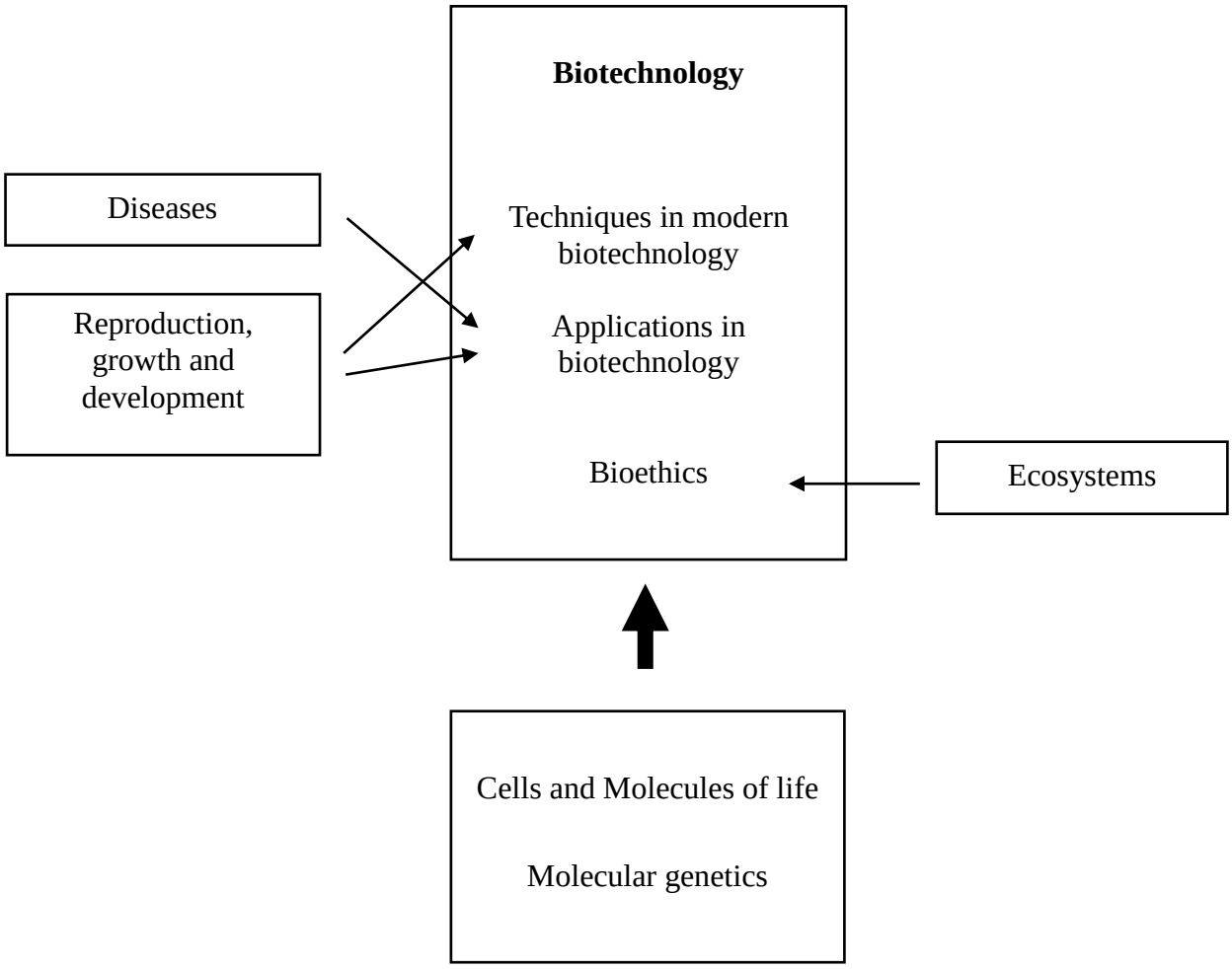
ELECTIVE PART

VIII. Biotechnology

Overview

This topic is expected to provide students with opportunities to study the general principles of biotechnology and its wide range of applications. This will enable them to recognise biotechnology as a rapidly expanding branch of Biology. Students will first develop an understanding of the principles of different techniques in modern biotechnology, e.g. recombination DNA technology, polymerase chain reaction, genetically modification of organisms, plants and animal cloning. They will also become familiar with the applications of biotechnology in the area of medicine and agriculture, and be aware of the ethical, legal, social, economic and environmental implications of biotechnology. Current issues, research and developments in biotechnology, as well as the contribution of biotechnology to the advancement of biology will also be discussed.

Biotechnology builds on students' prior knowledge of *Cells and Molecules of Life*; *Molecular genetics*; *Reproduction, growth and development; Ecosystems* and *Diseases* studied in the compulsory part. The diagram below shows how the prior knowledge is related to this topic.



Scientific Inquiry

This should enable students to:

- 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); and
- analyse and draw conclusions from data (e.g. DNA fingerprinting).

STSE Connections

This should enable students to:

- be aware of the wide application of biotechnology and its social, ethical, economic and environmental implications (e.g. issues related to stem cells therapy, gene therapy, animal cloning and genetically modified food);
- 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);
- appreciate the role of science and technology in understanding the inheritance of humans;
- be aware that societal needs have led to technological advances (e.g. the production of genetically modified crops to solve food shortage problem) ; and
- understand how science has been influenced by societies (e.g. debates on human cloning and human stem cells research).

Nature and History of Biology

This should enable students to:

- be aware of the dynamic nature of biological knowledge related to biotechnology and understand that biotechnology is a human endeavour;
- recognise the contributions of various people in biotechnology (e.g. Herbert Boyer and Stanley Cohen - development of recombinant DNA technology, Kary Mullis - invention of the PCR technique, and Alec Jeffreys - development of DNA fingerprinting); and
- 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).

Students should learn	Students should be able to
a. Techniques in modern biotechnology	
Process of recombinant DNA technology • the production of insulin Polymerase chain reaction (PCR) and its application DNA fingerprinting and its application Genetically modified organisms • Principles of producing genetically modified microorganisms, animals and plants Animal cloning • Major steps in cloning of mammals (e.g. Dolly the sheep) Plant cloning • Major steps in plant tissue culture	• Outline the principles of recombinant DNA technology, PCR, DNA fingerprinting, constructing genetically modified organisms, cloning of mammals, and plant tissue culture. • Recognise the wide application of PCR. • Discuss the benefits and hazards of genetic engineering. • Be aware of the advantages, disadvantages, applications and limitations of cloning in animals and plants.
b. Applications in biotechnology	
Production of pharmaceutical products (e.g. Insulin, human growth hormone, vaccine and monoclonal antibodies) Gene therapy • Somatic cell gene therapy Stem cells therapy • Nature of stem cells	• Understand the role of bacteria in the production of pharmaceutical products. • Recognise the possible benefits and hazards of gene therapy. • Recognise the potential application of stem cells in medicine.
Transgenic animals and plants	• Recognise the use of transgenic animals and plants in scientific research, food industry and agriculture.

Students should learn	Students should be able to
c. Bioethics Ethical, legal, social, economic and environmental issues Areas of current concern in biotechnology • Genetically modified food • Animal and plant cloning • Human Genome Project • Gene therapy • Stem cells therapy	• Be aware of the potential impact of biotechnology on society. • Discuss the issues related to one of the areas of concern in biotechnology.

Suggested Learning and Teaching Activities

a. Techniques in modern biotechnology

- Perform practical work to amplify DNA fragments using PCR; and to separate DNA fragments by gel electrophoresis.
- Use diagrams, audiovisual materials or animations to illustrate the processes of recombinant DNA technology, PCR, DNA fingerprinting and cloning.
- 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).
- Search for information on animal or plant cloning.

b. Applications in biotechnology

- Read articles about the treatment of severe combined immunodeficiency disease (SCID) by means of gene therapy.
- Search for information on the application of biotechnology in the pharmaceutical industry.
- Search for information on the uses of transgenic plants in agriculture.
- Compare traditional breeding and genetic engineering in crop production.

c. Bioethics

- Debate on the issues related to genetically modified food, animal and plant cloning, HGP, gene therapy and stem cells therapy.
- Search for information on the ways in which scientists inform the public and debate their discoveries in cloning.

(Blank page)

Chapter 3 Curriculum Planning

This chapter provides guidelines to help schools and teachers to develop a flexible and balanced curriculum that suits the needs, interests and abilities of their students, and the contexts of their schools, in accordance with the central framework provided in Chapter 2.

3.1 Guiding Principles

Curriculum planning is essential to facilitate effective learning and teaching in schools. Teachers are encouraged to develop a balanced and coherent school-based curriculum, taking into account the characteristics of their students and school contextual factors. When planning and developing their own Biology Curriculum at senior secondary level, schools and teachers are encouraged to:

- address the different needs and interests, abilities and learning styles of their students;
- facilitate progression from the junior secondary science curriculum to the senior secondary science curriculum through a comprehensive coverage of the learning targets, to promote integrative use of skills and a balanced development of learning experiences;
- plan and devise appropriate and purposeful learning and teaching materials, practical work, scientific investigations and projects to develop students' knowledge and understanding, skills and processes, values and attitudes, problem-solving skills, critical thinking skills, creativity, and strategies for learning to learn;
- set and work on clear and manageable curriculum goals to develop a progressive and appropriate curriculum that serves to bring about pleasurable, meaningful and productive learning experiences; and
- review and plan the curriculum flexibly and make appropriate adjustments when necessary, taking into account the SBA implementation arrangements as specified in Chapter 5.

3.2 Progression

The Biology Curriculum is designed to enable students to explore their interests in different senior secondary subjects at S4, and to progress smoothly in the chosen subjects through S5 and S6. In this regard, foundation topics in the compulsory part of the curriculum framework are identified. These topics include fundamental biological knowledge and skills required for further studies in different areas of biological science. Through the study of the foundation topics, students will understand the nature and significance of biology before they decide on their choice of subjects at S5. The foundation topics identified in the compulsory part are listed in Figure 3.1.

Topic	Remarks
I Cells and Molecules of Life a. Molecules of life b. Cellular organisation c. Movement of substances across membrane d. Cell cycle and division e. Cellular energetics	• I (d) *Cell cycle and division* can be introduced together with III (c) *Reproduction, growth and development*. • The subtopics *Photosynthesis* and *Respiration* in I (e) can be studied together with III (a) and (b) *Essential life processes in plants and animals* or at a later stage of S5. • III (d), (e) and (f) can be studied at the early stage of S5.
III Organisms and Environment a. Essential life processes in plants b. Essential life processes in animals c. Reproduction, growth and development	

Figure 3.1 Foundation Topics in the Compulsory Part of the Biology Curriculum

For students with a strong interest in learning science and those intending to take two science subjects in their senior secondary education, it is suggested that schools offer a broad and balanced science curriculum in S4, through including the foundation topics in the Biology, Chemistry and Physics Curricula. This will help students understand the differences in the nature and requirements of the respective disciplines, so that they may make appropriate choices of specialised study in S5 and S6. A broad and balanced foundation laid in S4 will also enable students to follow their interests in science in wider contexts.

Under the senior secondary academic structure, there will be flexibility for some students to start the study of Biology at S5. Schools may consider allocating more learning time and providing other supporting measures (e.g. bridging programmes) to these students to enable them to develop the foundation knowledge and skills as soon as possible. Figure 3.2 presents possible pathways and options that schools may offer for their students.

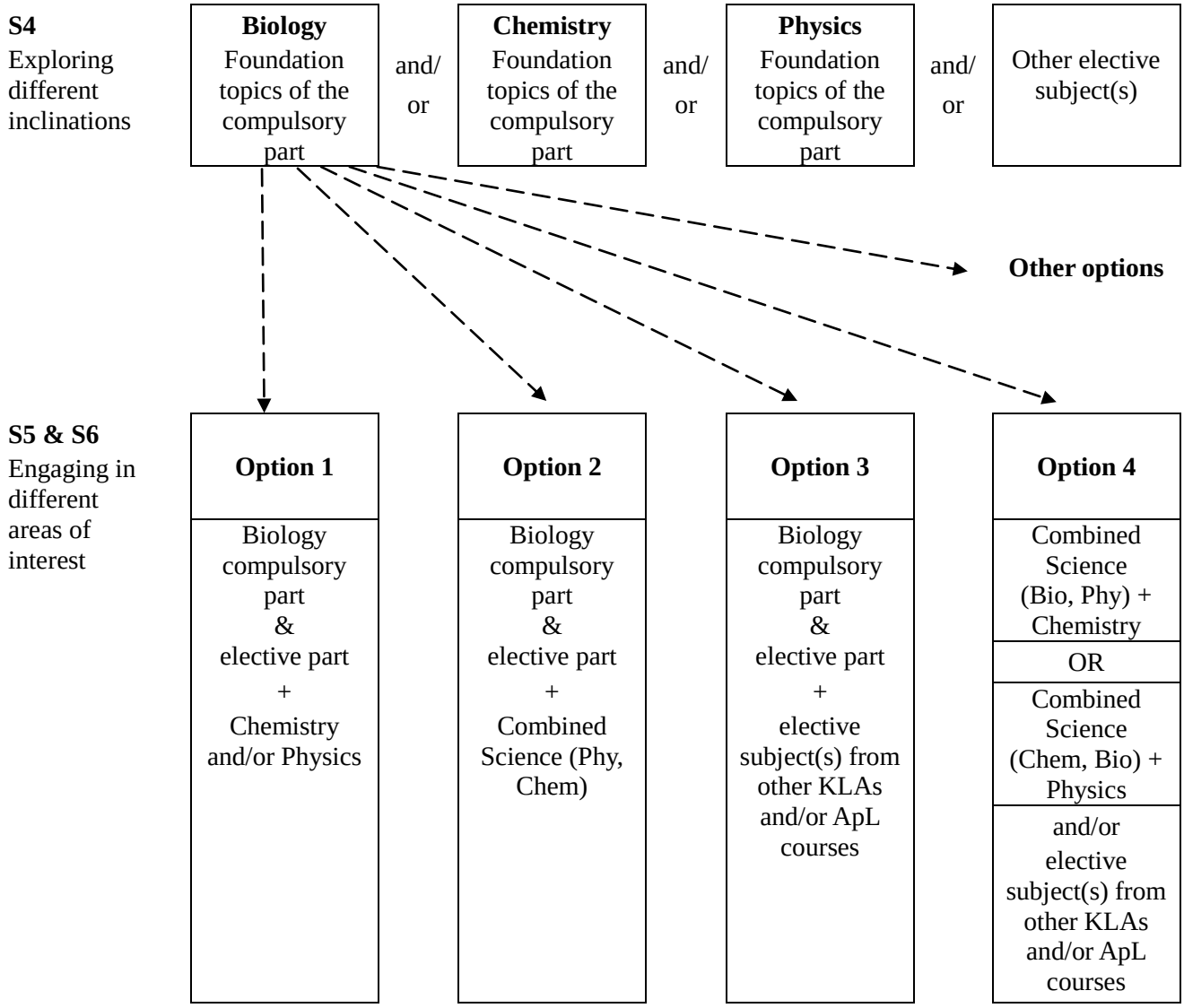


Figure 3.2 Possible Pathways and Options that Schools may offer for their Students

3.3 Curriculum Planning Strategies

The curriculum framework provides a central curriculum with curriculum aims, learning targets, essential learning elements and learning outcomes for the learning and teaching of the Biology Curriculum. However, it is not to be viewed as a prescribed syllabus to be taught uniformly in all schools. Schools are encouraged to adapt the central curriculum to different degrees to enable their students to achieve the curriculum aims and learning targets. In school-based curriculum development, schools may vary the way in which they organise learning elements, contexts and optional topics in the elective part, as well as the learning, teaching and assessment strategies through which students are to learn. The aim is to meet the school vision and mission; the needs, interests and abilities of students; and the expertise of teachers. Teachers are advised to consider the following recommendations when planning school-based curriculum development.

3.3.1 Interface with the Junior Secondary Science Curriculum

To ensure a smooth transition between junior and senior secondary science education, schools should plan for effective progression from the one to the other. Teachers should refer to the learning targets and objectives of Key Stage 3 as outlined in the *Science Education Key Learning Area Curriculum Guide (Primary 1 – Secondary 3)* (CDC, 2002c), and the *Syllabuses for Secondary Schools – Science (Secondary 1-3)* (CDC, 1998). The study of the Biology Curriculum should build on the knowledge and skills that students acquired through studying the junior secondary science curriculum. The relationship between the Science (S1–3) Syllabus and the Biology Curriculum is shown in Figure 3.3.

Science (S1–3)		Biology
Unit	Title	Topic
1.4	Conducting a simple scientific investigation	Scientific Investigation
2.1	Living things	II Genetics and Evolution
2.2	Observing an animal	
2.3	Diversity of plant and animal life	
2.4	Sorting things into groups	
2.5	Endangered species	VI Applied Ecology
3.1	The basic units of living things	I Cells and Molecules of Life
3.2	A new life is born	III Organisms and Environment
3.3	Puberty	
3.4	Pregnancy	
5.2	Further treatment of water	VI Applied Ecology
5.4	Water conservation and pollution	
7.3	How does man obtain energy?	III Organisms and Environment
7.4	How do green plants obtain energy?	
7.5	Gaseous exchanges in animals and plants	
7.6	Balance of CO_2 and O_2 in nature	
7.7	Effects of smoking and polluted air on a respiratory system	IV Health and Diseases
10.4	Acid rain	VI Applied Ecology
11.1	Sensing the environment	III Organisms and Environment
11.2	How we see	
11.3	Limitations of our eyes	
11.4	Defects of the eye	
11.5	How we hear	
11.6	Limitations of our ears	
11.7	Effects of noise pollution	
11.8	Senses of smell, taste and touch	
11.9	The brain and our senses	
11.10	Responses to stimuli	
11.11	Effects of drugs and solvent on our senses	IV Health and Diseases
12.1	Keeping our bodies healthy	
12.2	Food substances	I Cells and Molecules of Life
		III Organisms and Environment
12.3	Balanced diet	IV Health and Diseases
12.5	How food is digested and absorbed in our body	III Organisms and Environment
12.6	The fate of the digested food	
12.7	Our circulatory system	
12.8	How fatty food affects our circulatory system	IV Health and Diseases
12.9	Exercise and health	
12.10	Need for rest	

Science (S1–3)		Biology
Unit	Title	Topic
13.5	Environmental problems associated with the disposal of used metals	VI Applied Ecology
14.2	Environmental problems associated with the disposal of plastics	
15.3	Colour	III Organisms and Environment
15.4	Beyond the visible spectrum	

Figure 3.3 Relationships between the Science (S1-3) Syllabus and the Biology Curriculum

3.3.2 Learning and Teaching Sequence

The sequence of topics in the compulsory part of the curriculum framework is organised in such a way as to explore how biological systems work, from biomolecules through cells and organisms to ecosystems. It includes developing an understanding of genetics and evolution as well as the interactions within and between organisms and between organisms and their environment.

The topics in the compulsory part of the curriculum framework are not in a fixed order. The sequence of learning and teaching may be varied to accord with teachers' preferences and approaches to the subject, and with the interests, needs, abilities and prior knowledge of students. Teachers are encouraged to use their professional judgment to plan a sequence that suits their students and their context. Figure 3.4 depicts possible sequences for the learning and teaching of the compulsory part.

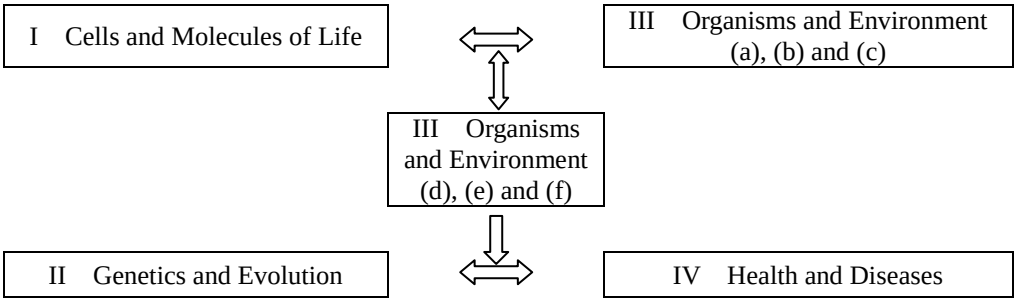


Figure 3.4 Possible Sequences for the Learning and Teaching of the Compulsory Part

It is suggested that at S4, schools focus on the foundation topics to equip students with the necessary knowledge and skills for further study of the Biology Curriculum; and at S5 and S6 introduce other topics in the compulsory and elective parts, taking into consideration students' prior knowledge. Teachers are advised to make reference to the diagrammatic presentations in the *Overview* of different topics in the elective part. These show the prior knowledge and concepts developed in the compulsory part, and how they are related to individual elective topics. For example, the study of *Applied Ecology* in the elective part should build on the knowledge and concepts developed through the study of *Organisms and Environment* in the compulsory part.

3.3.3 Linking Major Concepts within the Curriculum

It is recommended that individual topics in the compulsory part should be studied as integral parts of the whole curriculum and not as separate entities. Figure 3.5 shows the relationships between different topics in the compulsory part.

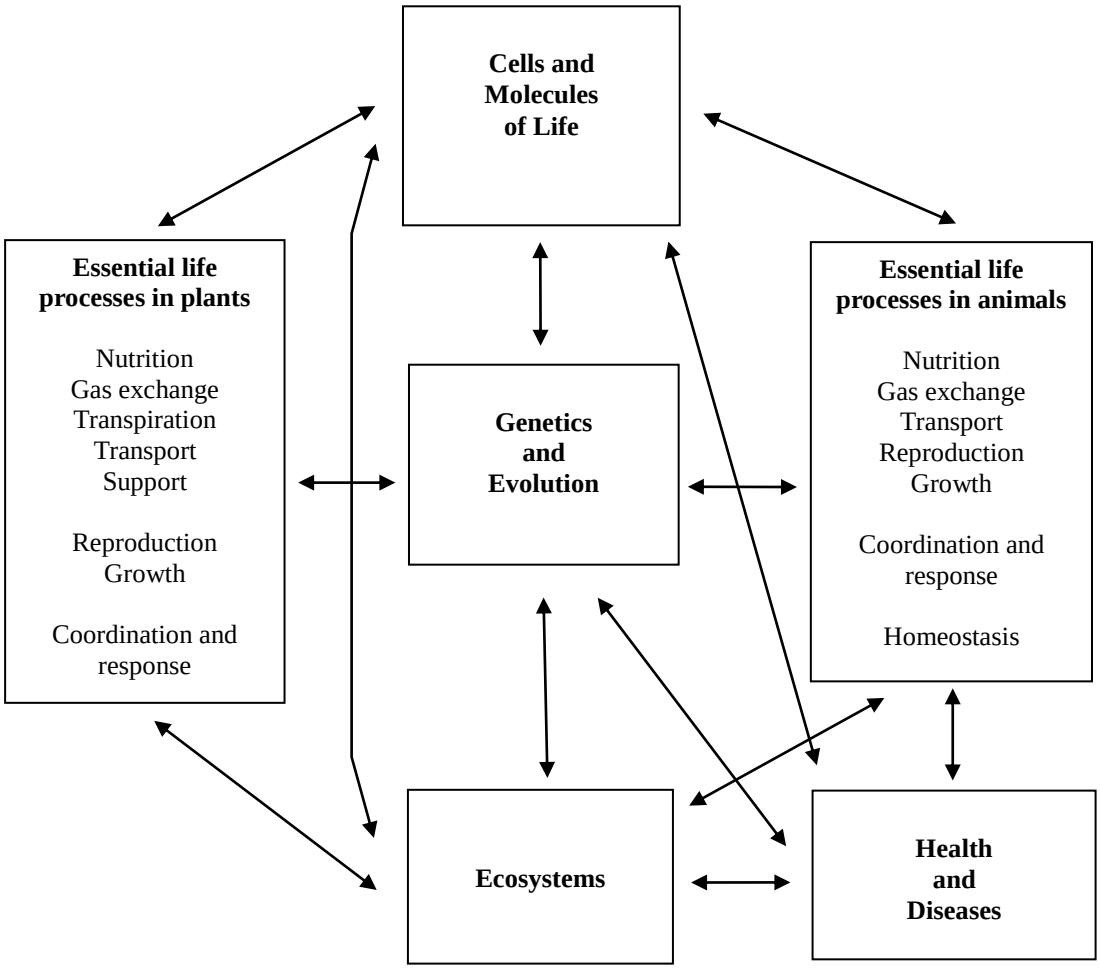


Figure 3.5 Relationships between Different Topics in the Compulsory Part

For example, in *I Cells and Molecules of life*, the concept of properties of cell membrane in cellular organisation should be connected to the concept of movement of substances across membrane; and the concept of cell division developed in *I Cells and Molecules of life* should be linked together with the concept of reproduction, growth and development in *III Organisms and Environment*. The relationship between prior knowledge to be acquired in the compulsory part and different topics in the elective part are set out in the *Overview* of each elective topic. The diagrammatic representations may be referred to when planning the school-based curriculum.

3.3.4 Applying the Curriculum Emphases across the Curriculum

The Biology Curriculum has identified three curriculum emphases that permeate the curriculum. They include Scientific Inquiry, STSE Connections and Nature and History of Biology. The scientific process skills, generic skills, and values and attitudes that emerge from each curriculum emphasis are highlighted in each topic for teachers' reference. It is advisable to cover different curriculum emphases systematically and extensively throughout the curriculum by matching major content areas with the relevant curriculum emphases.

3.3.5 Catering for Learner Diversity

There are differences among students in various dimensions such as interests, academic readiness, aspirations and learning styles. In order to help all students achieve the learning targets of the curriculum, teachers may alter the organisation of learning elements in the curriculum framework and use lesson time flexibly to cater for students with a range of abilities and inclinations. Outlined below are some suggestions that teachers can do to cater for diversity.

- Vary the sequence of learning and teaching to cater for students with different interests and abilities.
- Adjust the learning targets to make them more challenging for students with a strong interest or outstanding ability in biology and provide them with learning opportunities to develop their full potential.
- Focus learning on the compulsory part to build up sound fundamental knowledge and skills in students before studying the elective part.
- Adapt the depth of treatment to an appropriate level for demanding topics in the compulsory part, and provide extra support to help students master the knowledge and understanding of these topics.

3.3.6 Flexible Use of Learning Time

As mentioned in Chapter 2, 250 hours lesson time should be allocated to cover this curriculum. Teachers are encouraged to use this time flexibly to help students attain all the different targets of the curriculum. Since students have diverse interests, they may find some of the topics more interesting and spend more time to explore particular topics and related issues in depth. Some schools may allocate more lesson time for the study of the compulsory part to ensure that students are equipped with sound fundamental knowledge and skills, before starting the elective part. Within the 250 hours, the 20 hours allocated to scientific investigation can be used flexibly to promote self-directed learning and develop a full range of skills. Schools are also encouraged to include half-day or whole-day activity sessions (shared among different KLAs) in the school time-table, to allow continuous stretches of time for field trips, visits or scientific investigations.

3.4 Curriculum Management

3.4.1 Effective Curriculum Management

In order to manage the curriculum effectively, curriculum leaders in a school have to work collaboratively in school-based curriculum development. They should take the following aspects into consideration:

(1) Understanding the curriculum and student needs

Curriculum leaders and teachers should have a good understanding of the Biology Curriculum, the needs and interests of students, and the strengths and culture of the school. This will facilitate effective school-based curriculum development and align learning and teaching with the school vision and mission as well as with the central curriculum framework.

(2) Organisation and structure

Curriculum leaders including the Science Education KLA coordinator, biology panel chairperson and biology teachers have to work as a team and play different roles in managing school-based curriculum development. In addition to overseeing and coordinating the implementation of the curriculum, the Science Education KLA coordinator and panel chairpersons have to develop a plan for enhancing teamwork and the professional capacity of teachers.

(3) Curriculum planning

Schools have to develop a holistic plan for school-based curriculum development in science education to ensure vertical and lateral coherence among different science subjects and with other subjects. It is important to plan effective progression from the junior secondary science curriculum to the senior secondary one, and to provide a balanced foundation in science education for all students. For details of helpful curriculum planning strategies, please refer to section 3.3 of this chapter.

(4) Capacity building and professional development

Team building can be enhanced through the regular exchange of ideas, experiences and reflections among teachers in collaborative lesson preparation, peer coaching and lesson observation. These practices promote a collaborative and sharing culture among teachers which fosters professional development. Schools should also provide time for teachers to participate in various professional development programmes and deploy them appropriately in accordance with their strengths.

(5) Resource development

Learning and teaching resources will be developed by the EDB to support the implementation of the curriculum. Schools are encouraged to adapt these resources or to develop their own learning and teaching materials to meet the needs of their students. These materials may be shared among teachers through the development of a school-based learning and teaching resources bank or a sharing platform in the school Intranet. Teachers may refer to Chapter 6 for details about the effective use of learning and teaching resources.

(6) Managing change

In view of the changing nature of biological knowledge and of society, school-based curriculum development needs to be flexible. While schools can define the scope and direction of curriculum development with a degree of certainty, the implementation of the curriculum needs to remain flexible enough to respond to changes. Strategies for managing change include fostering participation and communication, periodic reviewing to monitor progress, and collecting evidence to make informed changes in the implementation of the curriculum.

3.4.2 Role of Different Stakeholders in Schools

Curriculum leaders take on different roles in managing curriculum change and these roles may vary depending on the school context.

(1) Biology teachers

Biology teachers contribute to school-based curriculum development by working in line with the school policy and assisting the panel chairperson as individuals and in collaboration with other biology teachers. They can also play the role of curriculum leaders by initiating innovative changes in the curriculum.

To help implement the school-based curriculum, teachers should:

- explain clearly to students the overall plan and objectives of the school-based curriculum;
- foster a motivating learning environment among students and enable them to become self-directed learners;
- take initiatives to try out innovative learning and teaching strategies;
- initiate sharing of ideas, knowledge and experiences to foster peer support and improvement in learning and teaching;
- collaborate with laboratory technicians to design appropriate activities and provide a safe environment conducive to learning;
- keep abreast of the latest curriculum developments through reading and sharing with other teachers;
- participate actively in professional development courses, workshops, and seminars to enhance their professionalism; and
- review or evaluate the school-based curriculum from time to time to bring about improvements.

(2) Science Education KLA coordinator/Biology panel chairperson

Science Education KLA coordinators/Biology panel chairpersons play a significant role in developing, managing and implementing the curriculum. They act as a "bridge" between the school administrative personnel and other science panel members to bring about effective communication and collaboration. They should:

- take the lead in developing a holistic plan for providing a balanced science education to students by referring to the guidelines set out in the *Science Education KLA Curriculum Guide (P1-S3)* (CDC, 2002c) and relevant C&A Guides;

- promote effective communication and collaboration among school administrative personnel and science panel members for the overall implementation of science education in schools;
- ensure effective progression from one Key Stage to the next by enhancing communication between different science panels;
- plan for a school-based curriculum to promote effective learning of subject knowledge as well as the development of generic skills, scientific process skills, and values and attitudes, in accordance with the guidelines set out in the Biology Curriculum framework;
- decide on the topics to be offered in the elective part, by taking into account students' needs, interests and abilities as well as panel members' strengths and the school context;
- hold regular meetings to discuss matters such as curriculum planning, assessment policies, the use of learning and teaching materials, the adoption of learning and teaching strategies; and to review the effectiveness of learning and teaching;
- promote regular exchange of learning and teaching ideas, experiences and reflections by various means such as peer coaching, peer lesson observation and collaborative lesson preparation;
- encourage panel members to participate in professional development courses, workshops, seminars and projects;
- ensure effective provision and use of facilities and resources to support the implementation of the curriculum (e.g. laboratory facilities and equipment, laboratory technicians, and IT equipment); and
- coordinate among teachers and laboratory technicians to ensure that safety and precautionary measures are taken for the conduct of practical work and scientific investigations.

(3) School head

School heads should play a leading role in directing, planning and supporting school-based curriculum development. They need to understand the central curriculum framework and be fully aware of contextual factors such as the needs of the students, the strengths of the Biology Panel and other panels in the Science Education KLA. School heads are encouraged to appoint a Science Education KLA coordinator to oversee and coordinate the implementation of school-based curricula across all the subjects in the Science Education KLA. School heads have to work closely with Deputy Heads or the Academic Master/Mistress to carry out the roles as curriculum leaders. They should:

- understand the full picture and define the scope of science curriculum development in alignment with the vision and mission of the school, and the direction of whole school curriculum development;
- clarify the implementation roles and responsibilities of middle level curriculum leaders of the Science Education KLA;

- provide students with different options in taking elective subjects from the Science Education KLA to cater for their needs and aspirations, and equip them with a balanced foundation in science (e.g. adopting flexible time-tabling to facilitate the implementation of the Combined Science Curriculum);
- deploy school resources (e.g. laboratory technicians and equipments) appropriately to facilitate effective learning and teaching;
- promote a collaborative and sharing culture among teachers by encouraging collaborative lesson preparation and peer lesson observation;
- provide time for teachers to participate in professional development programmes;
- appreciate and commend progress made, and sustain appropriate curriculum initiatives;
- help parents and students to understand the school's beliefs, rationale and practices in the implementation of the curriculum, and their roles in facilitating learning; and
- network with other schools to promote professional exchange of information and sharing of good practices.

For details of the role of teachers as the key change agents, please refer to Chapter 9 of the *334 Report* and Booklet 9 of the *Senior Secondary Curriculum Guide* (CDC, 2007).

Chapter 4 Learning and Teaching

This chapter provides guidelines and suggestions for effective learning and teaching of the Biology Curriculum. It is to be read in conjunction with Booklet 3 in the *Senior Secondary Curriculum Guide* (CDC, 2007), which provides the basis for the suggestions set out below.

4.1 Knowledge and Learning

Biology is a discipline with a well-established body of scientific knowledge that contributes to students' understanding of life on Earth and of the contemporary world. This body of knowledge includes biological facts, principles and laws, theories, procedures for inquiry and applications. Biological knowledge is continuously advancing and dynamically changing. To facilitate learning and teaching of this growing body of knowledge, different approaches may be used, ranging from direct instruction, inquiry to co-construction of knowledge. In addition to direct instruction and individual study, students should also learn through scientific inquiry processes and collaboration with others.

The primary emphasis of the curriculum is on understanding of biological concepts and principles rather than on memorising unrelated facts. It is essential for students to gain personal experience of scientific inquiry, to see science as a process, and to develop an understanding of its nature and methods. In the learning process, teachers may take up a variety of roles ranging from a transmitter of knowledge to a resource person, facilitator, consultant, counsellor, assessor, and learning partner – and, very often, involve a mixture of some of these. All these roles share the common goal of helping students to become independent and self-directed learners.

4.2 Guiding Principles

The key guidelines for effective learning and teaching of the subject are listed below, which take into account the recommendations on learning and teaching in Booklet 3 of the *Senior Secondary Curriculum Guide* (CDC, 2007) and the emphases of Science Education KLA.

(1) Building on strengths

The strengths of both teachers and students in Hong Kong should be acknowledged and treasured. In learning science, most Hong Kong students are strong in memorising content knowledge, analysing numerical data and understanding scientific concepts.

(2) Prior knowledge and experience

Learning and teaching activities should be planned with due consideration given to students' prior knowledge and experience.

(3) Understanding learning targets

Learning and teaching activities should be designed and deployed in such a way that the learning targets are clear to both the teacher and the students.

(4) Teaching for understanding

Learning and teaching activities should aim at understanding, and at enabling students to think and act intelligently with what they know.

(5) A wide range of learning and teaching approaches and strategies

A variety of learning and teaching approaches and strategies should be used so that different learning targets can be attained effectively.

(6) Promoting independent and self-directed learning

Learning and teaching activities that aim at nurturing generic skills and thinking skills should be employed in appropriate learning contexts to enhance students' capacity for independent learning. Students should be provided with opportunities to take responsibility for their own learning.

(7) Motivation

Students learn most effectively when they are motivated to learn. Various motivation strategies should be used to arouse and sustain the interest of students.

(8) Engagement

Learning and teaching activities should aim to engage students' minds actively in the learning process, so that they remain "on task" and focused.

(9) Feedback and assessment

Providing prompt and useful feedback to students should be an integral part of learning and teaching. In addition to summative assessment, appropriate formative assessment should be adopted as part of the learning process.

(10) Resources

A variety of resources, including laboratory equipment and IT resources can be employed flexibly as tools for learning. Suggestions on resources which can be used to enhance the quality of learning are given in Chapter 6.

(11) Catering for learner diversity

Students have different characteristics and strengths. A range of learning and teaching strategies should be employed so that all students realise their full potential.

4.3 Approaches and Strategies

4.3.1 Approaches to Learning and Teaching

Broadly speaking, there are three common and intertwined pedagogical approaches to learning and teaching of biology.

(1) "Teaching as direct instruction" is a pedagogical approach in which teachers transmit knowledge or model behaviours to be learnt by students. This teaching approach typically includes three key methods: presenting content systematically, providing close guidance to students, and assessing students' understanding through questioning, assignments or tests. Direct instruction may be an effective way to deliver certain content knowledge in biology, such as the molecules of life, the structures of organisms, classification systems, and safety in practical work.

(2) "Teaching as inquiry" means that learners have to be actively involved in finding out information for themselves. This approach to learning and teaching has important implications for classroom practice. It engages learners actively in observing, classifying, predicting, formulating hypotheses, designing investigating methods, collecting and analysing data, and drawing conclusions. This approach is emphasised throughout the Biology Curriculum. Teachers are encouraged to incorporate scientific inquiry activities into the learning and teaching of the subject where appropriate. Examples of scientific inquiry suggested for individual topics are provided in Chapter 2.

(3) "Teaching as co-construction" is based on the view that the class is a community of learners which works together to share and develop knowledge. This approach stresses the value of dialogue among students, and between students and teachers. Co-construction of knowledge can take place in a variety of ways, such as by asking open-ended questions, by posing contradictions and inviting responses, by engaging students in discussion and debate, and by setting collaborative group work. In the Biology Curriculum, emphases such as STSE connections and the nature and history of biology may be pursued effectively through co-construction involving the sharing of experiences and perspectives brought together by students and the teacher.

The most important factor in choosing the learning and teaching approach is that it should be "fit for purpose". Teachers should adopt a variety of approaches and strategies to meet the different learning targets and outcomes of individual lessons, as well as the varied needs and learning styles of their students. Teachers should also note that students can achieve more than one learning target in a single learning activity. A range of learning and teaching activities commonly used in biology classrooms is listed in Figure 4.1.

Direct instruction	Interactive teaching	Individualisation	Inquiry	Co-construction
• Explanation • Demonstration • Video shows	• Teacher questioning • Whole-class or group discussion • Visits • Use of IT and multimedia packages	• Constructing concept maps • Reading to learn • Information searching • Writing learning journals/note-taking	• Problem-solving • Scientific investigation • Practical work • Simulation and modelling	• Discussion forums • Role-play • Debates • Project work

Figure 4.1 Range of Learning and Teaching Activities in Biology

4.3.2 Variety and Flexibility in Learning and Teaching Activities

Teachers should adopt appropriate learning and teaching approaches and engage students in a variety of learning activities to help them attain the learning targets and enhance active learning. Learning and teaching activities such as questioning, reading, discussions, model-making, demonstrations, practical work, field studies, investigations, oral reporting, assignments, debates, information search and role-play should be chosen carefully to bring about meaningful learning for students.

4.3.3 From Curriculum to Pedagogy: How to Start

The pedagogical strategies adopted to help learners achieve specific learning targets should, as far as possible, be made relevant to students' daily lives, so that they experience biology as interesting, relevant and important to them. When evaluating the appropriateness of a pedagogical strategy, teachers are advised to refer to the guiding principles outlined in section 4.2. In addition, they should ensure safety in all practical work and scientific investigations in collaboration with laboratory technicians.

Listed below are some useful strategies and activities for the learning and teaching of biology.

(1) Historical approach

Incorporating the historical development of biological knowledge in various parts of the curriculum can provide students with an understanding of the nature of science. The work of some famous biologists can be revisited, so that students can discover how they went about exploring biological phenomena and solving problems through systematic inquiry. It is important that the focus of these studies should be on analysis and deduction, using evidence drawn from experimental work. Students should not be expected to study all the examples suggested, or link all the names with particular pieces of work or be familiar with all the details of the techniques that these biologists employed. Teachers can use historical stories to elaborate on the various aspects of scientific inquiry and on different historical and cultural perspectives in biology. This may cultivate a positive attitude towards the learning of biology in students. In addition, students should be aware of the interrelationships between biology and other science disciplines such as physics and chemistry.

Examples

- the development of the microscope and the discovery of cells.
- the genetic experiments of Gregor Mendel
- the work on DNA structures by Watson and Crick
- the theory of evolution by Darwin and Wallace
- the development of vaccines and the discovery of antibiotics

(2) Contextual approach

When the study of biology is related to students' everyday lives, they will find their learning more meaningful. Therefore, where possible, teachers should adopt a contextual approach, which helps students to integrate their daily life experiences into their learning of biology. The list of *Suggested Learning and Teaching Activities* for each topic in Chapter 2 included activities that link biology to technological applications, societal issues and students' daily experiences. These activities provide contexts where students will experience biology as interesting and dynamic. Relating biology topics to the context of students' lives will enhance their motivation to inquire, apply and reflect on what they have learned. Through a systematic inquiry guided by teachers, students should be able to acquire the relevant concepts, skills and attitudes in a step-wise manner. To maximise effectiveness, both the learning contexts and inquiry activities should build upon the existing knowledge, ideas and experiences of the students.

Example
In *III (f) Ecosystems*, the activities suggested are visiting nature reserves, country parks, marine parks and other local field sites. These activities allow students to come across animals and plants in the field, thus enhancing their understanding of the interactions of organisms and their environment in their habitats.

(3) Practical work and scientific investigation

As biology is a practical subject, it is essential for students to gain personal experience of science through "hands-on" practical activities, and to develop the skills and thinking processes associated with the practice of science. Such activities require students to link scientific thinking with the processes of problem-solving, decision-making and evaluation of evidence. Practical activities should be integrated into the learning of scientific principles as far as possible, so that students can associate the findings of the experiments with the theories they have learned. Teachers are encouraged to design a wide range of practical activities (e.g. dissection of animal specimens, and observation of plant and animal cells) and open-ended investigations (e.g. the effect of changing environmental conditions on the rate of photosynthesis).

Scientific investigations involve observing phenomena, defining problems, formulating hypotheses, designing and conducting investigations, and interpreting results. These kinds of activity are not just for verification purposes; they also allow students to understand the process of science, including how to clarify questions, how to design an experiment, how to record and interpret data, and how to communicate the knowledge generated. It should be noted that developing science process skills is as important as finding correct answers. Students are expected to master much more than facts and manipulative skills. They must learn to be critical thinkers.

A balanced set of learning experiences should include an adequate amount of practical and investigative work for students to enable them to develop both their practical skills and higher-order thinking skills. Designing and undertaking practical work and investigations that are relevant to students' real-life contexts will enhance learning effectiveness.

Practical work and investigations should be performed by students under proper teacher supervision to ensure that safety measures are observed. Teachers are advised to try out new or unfamiliar practical work beforehand to identify potential risks in order to avoid them.

(4) Issue-based learning

Discussion of an issue inevitably gives rise to different points of view representing different values and interests. Relevant issues can provide meaningful learning contexts in the learning of biology. For instance, the incorporation of STSE issues into the study of biology helps students to bring together the scientific knowledge they have acquired and the societal implications of using technology. The moral and value components embedded in these issues provide opportunities for students to consider the implications of various viewpoints in the light of fundamental societal values such as respect for life, respect for others, respect for the environment, freedom and justice. Some issues, such as *the origins of life*, may be controversial, as they involve religious perspectives and beliefs. Teachers should ensure that such issues are treated sensitively and rationally, and avoid imposing their own values on students. Students should be exposed to different perspectives and viewpoints, and be given ample opportunity to share their beliefs and values and to develop arguments based on evidence before making their own decisions.

Example

In *VI (c) Conservation,* the issue of *the conflicting interests of economic development and environmental conservation* can be raised for discussion.

This issue involves the impact of humans on the environment, pollution and control measures, the importance of biodiversity, the concept of sustainable development and economic implications.

(5) Problem-based learning

Problem-based learning is an instructional method that challenges students to solve real problems by applying thinking skills and working cooperatively in a group. Students are required to find and use appropriate learning resources, and to think critically and analytically. During the process of solving a problem, students construct new knowledge and develop their problem-solving, collaborative and communication skills. Problem-based learning may start with a poorly defined or open-ended problem, or a real-life scenario. Students work collaboratively to define the problem, pose questions or formulate hypotheses, search for information, generate alternatives, and develop solutions to the problem. Teachers become facilitators of learning and observers of students' participation and achievements during the whole process. Problem-based learning engages students actively in the learning process and allows them to take responsibility for their own learning.

Example

In *VIII (e) Bioethics*, teachers can use the following questions as the starting point for discussion:

The progress of the Human Genome Project has reached the stage that, perhaps in the not-so-distant future, geneticists will be able to locate particular genes and decode their genetic information. People will have the option of knowing their current status for any genetic defects before they decide to have a child.

Would you prefer to know the genome of yourself/family members/next-of-kin? Should we have the right to genetically engineer ourselves to prevent illness?

Should we have the right to genetically engineer our children?

What are the ethical and legal issues, and societal concerns, regarding the Human Genome Project?

(6) Project learning

Projects provide inviting and productive learning experiences, and bridge the gap between learning in school and learning in the real world. Project learning enables students to construct knowledge, skills, values and attitudes through a variety of learning experiences. Projects take place within an extended time-frame, ranging from a week to a term, depending on their nature. They usually consist of several stages, including planning (goal-setting, identifying the focuses of projects), gathering (researching, finding resources, collecting data), processing (analysing, sorting and synthesising information), and applying (prioritising tasks, reviewing, revising, evaluating). The final stage is normally a presentation which may be done in the form of a written report, a multimedia presentation, a poster design or the construction of a model. Group projects can facilitate the development of collaboration and study skills in students. Project ideas are listed in the *Suggested Learning and Teaching Activities* for each topic in Chapter 2. Teachers may select some of these ideas to enhance biology learning in suitable contexts, and provide opportunities for students to learn by conducting individual or group projects on particular biology and cross-curricular topics or issues.

Examples

- Conduct a project on the contribution of the development of the microscope to the understanding of cells.
- Conduct a project on how a greenhouse works in enhancing plant growth.
- 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 prevention; and the incidence of the various types of cancer in Hong Kong.

(7) Life-wide learning

As learning can take place everywhere, not just in the classroom or school, it is essential to provide opportunities for students to learn in real contexts. Life-wide learning can widen the exposure of students to the real scientific world and enable them to achieve certain learning targets that are difficult to attain through classroom learning alone. Examples of appropriate learning programmes include popular science lectures, debates and forums, field studies, museum visits, invention activities, science competitions, science projects and science exhibitions. These programmes also offer challenging learning opportunities for capable students to achieve their full potential. When organising life-wide learning programmes, teachers may refer to the examples described in the *STSE Connections* for each topic in Chapter 2.

Examples

- Visit nature reserves, country parks, marine parks, field study centres and other local habitats.
- Visit a herbarium, country park or special area (e.g. Lions Nature Education Centre, and Tai Po Kau Nature Reserve).
- Visit a sewage treatment plant.

(8) Reading to learn

Reading to learn can be used to promote students' independent learning. In particular, it can help students to understand aspects of the past, present and likely future developments in biology. Students should be given opportunities to read science articles of appropriate breadth and depth. This strategy aims at developing students' ability to comprehend, interpret, analyse and communicate scientific concepts and ideas. Meaningful discussions on good science articles among students, and between students and teachers, may also strengthen students' communication skills. The development of their capacity for self-directed learning in this way is invaluable in preparing students to become active lifelong learners.

Articles which emphasise the interconnections between science, technology, society and environment can broaden and enrich the curriculum by bringing in current developments and relevant issues, and so arouse students' interest in learning. Teachers should select articles suited to the interests and abilities of their students. Students should be encouraged to search for articles themselves from newspapers, science magazines, the Internet and library books.

It is important to encourage reading for meaning. Rote memorisation of the content of articles is undesirable and should be discouraged. After-reading tasks should be arranged to enable students to construct personal knowledge from what they have read. This involves them having to work on the new knowledge they have had access to, through tasks such as writing a summary or a short report about an article, preparing a poster or writing a story to stimulate imaginative thinking. Students should also be encouraged to share what they have read with their classmates in order to cultivate the habit of reading biology articles.

Examples

- Read articles about the work of Carl Linnaeus and his system for naming organisms.
- Read articles about the different explanations for the origins of life; and the work of some biologists (e.g. Jean Baptiste Lamarck, Charles Darwin and Sir Alfred Russel Wallace) on evolution.

(9) Constructing concept maps

Concept maps provide a visual means through which to depict ideas and the links between them. They can be used as a tool to generate ideas, communicate complex ideas, integrate newly learned and prior knowledge, and assess understanding or diagnose misconceptions. Students should be encouraged to construct concept maps of their understanding of a topic, and subsequently refine them in the light of teachers' comments, peer review and self-evaluation in the course of learning. To familiarise students with this way of representing their understanding of scientific concepts, teachers can ask them to add the links between concepts or label the links on a partially-made concept map at the beginning; and later they should be encouraged to construct concept maps on their own. Apart from drawing them by hand, a wide range of computer programmes for concept mapping are available which enable users to create and edit concept maps easily.

(10) Searching for and organising information

In the information era, the skill of searching for information is important. Students can gather information from various sources such as books, magazines, scientific publications, newspapers, CD-ROMs and the Internet. They need, however, to select what to pay attention to, categorise it and evaluate it as the learning task warrants.

Examples

- Search for information to compare the photosynthetic rates and productivities in different climatic areas; and to understand scientists' work related to photosynthesis and cellular respiration.
- Search for information on the use of DNA fingerprinting in forensic science.
- Search for information on the effectiveness and possible side-effects of various birth control methods, *in vitro* fertilisation and the termination of pregnancy.

(11) Group discussion/role-play/debate

Group discussion, role-play and debate are effective ways to motivate and engage students actively in learning, and to develop their generic skills such as collaboration, communication, critical thinking, and problem-solving. These learning activities involve students in the processes of researching and analysing information, organising and presenting ideas in a clear and logical manner, and making judgments from arguments. Group discussion and debate are particularly suitable for dealing with controversial issues such as *the definitions of life* and *genetically modified food*. In such activities, students may first be given some background

information on a specific case and allowed time to do some individual thinking. They are then divided into groups to discuss their opinions and exchange views. Students should be encouraged to interact with their peers, while the teacher acts as a facilitator to guide students' work in the right direction, and provide feedback on their performance. Some biological, environmental and ethical issues provide meaningful contexts for students to explore conflicting viewpoints through role-play. In this way, students can explore the experience and views of different characters in a given situation, and widen their perspectives on the topic being considered.

Examples

- Discuss why breast feeding may provide passive immunity in a child.
- 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.

(12) Information technology (IT) for interactive learning

Information technology is a valuable tool for interactive learning which complements strategies for learning both inside and outside the classroom. In biology, IT can be used to support scientific investigations, as in the use of data loggers for data acquisition and analysis. IT can also help students to create data tables, plot the results, and find out mathematical relationships of data by using user-friendly computer packages. Through computer animations or simulations, IT can enhance students' learning. Animations can help students to visualise abstract concepts and processes such as cellular processes; and simulations can be used to present animal dissections, laboratory experiments or environmental scenarios – for example, the process of natural selection can be simulated by using appropriate software. IT also allows students to work at their own pace, and gives them more time to pursue creative activities in biology, as well as to experience enjoyment through biology-related games or programmes. In addition, the use of IT may extend students' learning through the Internet, which is an extremely valuable source of scientific information and resources. The Internet may also provide opportunities for students to learn, sometimes collaboratively, with students in another part of the world.

Examples

- Use computer simulations and other materials (e.g. genetic corn) to study patterns of inheritance.
- Use computer simulations or other simulations to model natural selection.

4.4 Interaction

Interaction is an essential integral part of most learning and teaching strategies. It involves communication among students, as well as between teachers and students as a means towards better understanding.

4.4.1 Scaffolding Learning

To achieve the learning targets of the curriculum, teachers have to scaffold students' learning to help them overcome any hurdles they face. Scaffolding learning involves purposeful interaction between teacher and students, in which the teacher facilitates learning by breaking difficult learning challenges into manageable tasks, by showing possible directions and means, or by providing appropriate tools. Scaffolding may take many forms, such as:

- a collection of resource materials – for example, an article on the recombinant DNA technology with a detailed uncluttered description and schematic drawings of the major steps, to help students to understand the basic principles and applications of this technology;
- procedural guidelines and templates – for instance, a worksheet with well-structured questions to guide students in planning for their own experiments;
- guidance, in a variety of formats, on the development of cognitive abilities, and investigative and social skills – for example, showing a video clip or presenting a demonstration on how to conduct an agarose gel electrophoresis, to enhance the acquisition of the practical skills required for the separation of DNA fragments;
- teacher debriefings – for instance, the presentation of a clear conceptual framework at the end of a learning and teaching activity when students have difficulties in "distilling" the essence of the activity, or when they encounter obstacles that significantly hinder their learning.

Scaffolding is an effective teaching strategy that enables students to keep up their momentum in learning. However, in order to develop students' capacity for independent learning, it is important that scaffolds should be removed gradually in accordance with their progress in learning.

4.4.2 Effective Questioning

Questioning is a useful instructional mode for maintaining the quality of classroom interaction. To be effective, a range of types of question has to be used for different purposes and in different contexts. For example, closed questions which have predetermined correct answers, are concerned with recalling factual knowledge or reporting simple information. They are useful for checking students' background knowledge and focusing their learning. On the other hand, open questions allow for more thinking and may give rise to a range of responses. They can be used for eliciting students' understanding, leading them to articulate their ideas, and triggering divergent thinking. The effectiveness of questioning is further enhanced when teachers give suitable "wait-time" for students to process the questions and formulate their answers.

Examples of open questions

- What is the principle of feedback mechanism as illustrated by the regulation of blood glucose level? (This question requires the understanding and integration of the concept of homeostasis and the mechanism of regulation of blood glucose level.)
- Would you accept genetically modified food, and what is the rationale for your decision? (This question requires students to think critically about information and opinions, and make informed decisions.)

4.4.3 Feedback

Teachers can provide useful feedback to students as a result of formative assessment through oral questioning, observation of students' performance, practical work, scientific investigation, project work or assignments. Students also receive feedback from their peers and others (e.g. laboratory technicians). Feedback from students can also assist teachers to adjust their pedagogy to enhance learning effectiveness.

Effective feedback goes beyond the simple provision of marks, and involves, for example, teachers' oral or written comments on students' strengths and weaknesses in learning, or suggestions on areas for improvement to enable students to learn effectively and efficiently. Teachers can also use feedback to diagnose and clarify misunderstandings, reinforce achievements, and promote self-regulation.

Figure 4.2 outlines the fact that good feedback enables both teachers and students to reflect on what they are doing and take appropriate action.

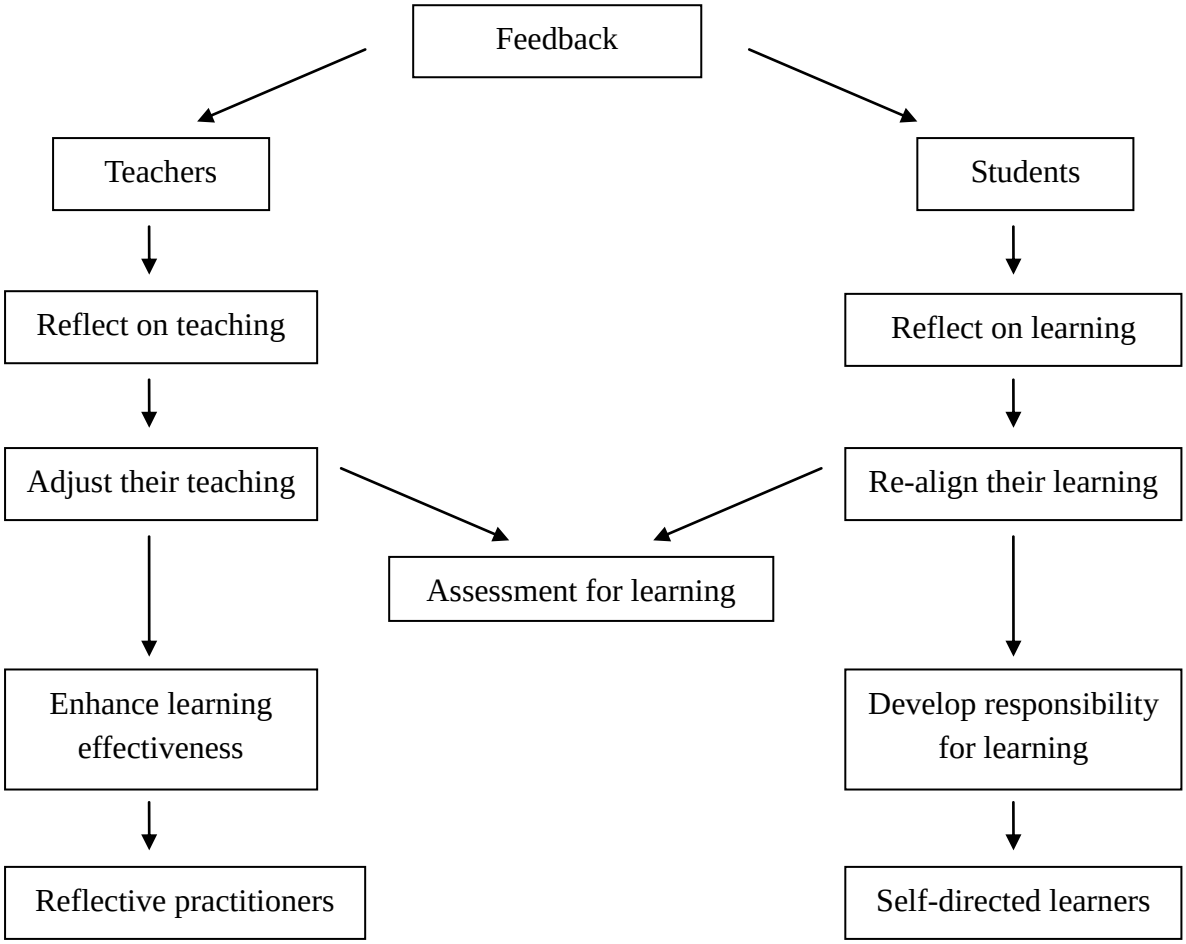


Figure 4.2 The Use of Feedback

4.5 Catering for Learner Diversity

Learner diversity exists in every classroom and should be taken into account in learning and teaching. It is unrealistic to expect every student to have the same level of achievement. In this regard, teachers are encouraged to find out more about their students' interests, abilities, strengths and needs through investigating their general background, personal contacts with other students, and progress in learning. This will enable teachers to make informed decisions on the most appropriate strategies for handling students' individual differences.

4.5.1 Strategies to Cater for Learner Diversity

Suggestions on how to cater for learner diversity in curriculum planning are outlined in section 3.3.5 of Chapter 3. Teachers may consider the following suggestions in designing their learning and teaching strategies.

(1) Employing a variety of learning and teaching activities to address students' different learning styles

Teachers have to be flexible in their choice of learning, teaching and assessment strategies to maximise the learning of students with different learning styles. Some students are visual learners; some are auditory learners; and some are kinaesthetic learners. Teachers have to adopt a range of presentation modes and vary their pedagogical strategies to address such differences. A variety of resources including textual, visual and audio materials may be used; and individual and group work should also be arranged to allow students to study and learn in their preferred styles.

Example

In *III (f) Ecosystem*, there are two different ways of learning the components and functioning of an ecosystem (i.e. abiotic factors, biotic community, energy flow and materials cycling). For example, this topic can be introduced and explained to students simply through lecturing with illustrative examples, with students then being assessed through round-up questions and assignments. This is an effective way of learning for students who have good concentration and self-motivation. Alternatively, students can be asked to observe a video of different ecosystems, and then work in small groups to identify the components of each ecosystem and discuss the relationships of organisms living in various habitats. In this case, students have to watch the video and then build relevant knowledge through discussion and reflection. Teachers may provide appropriate scaffolding for students in different groups in line with their varied learning needs. This way of learning is more suitable for learners who prefer a visual and kinaesthetic approach to learning.

(2) Arranging learning tasks for students with different abilities

Teachers should vary the scale, nature and demand of learning tasks for students with different abilities. For capable students, teachers can design tasks which are challenging enough to maintain their motivation. With students who are less able, small and less demanding tasks can help them to build up their capacity and confidence gradually. For example, for less able students, the teacher may break down a complicated investigation into a series of simple ones. However, for capable students, such a scientific investigation can be made more demanding by including more variables and requiring the collection of more data or the adoption of more sophisticated instrumentation and skills (see also section 4.6.3 on gifted students).

Example
In *I (e) Cellular energetics*, teachers may ask capable students to design and conduct investigations to study the factors affecting the rate of enzymatic reactions. For less able students, teachers may break the study down into a series of simple investigations to probe separately the effects of individual factors (e.g. temperature, pH) on the activity of enzymes; and they can also provide guidance on the design of the procedure and use an enzyme with a comparatively narrower range of active temperature or pH.

(3) Varying the level of support and challenge

Students with diverse capabilities need varied degrees of support, guidance and challenge to achieve the learning targets of the curriculum. It is very important for teachers to provide students with manageable "building blocks" systematically, in accordance with their ability. In studying a biological issue, capable students may understand, sort out and interpret important facts and information on their own – and these students can proceed towards self-directed learning at the early stage. On the other hand, less able students may need more information and guidance (e.g. a structured worksheet with guiding questions) before they can reach the threshold to start on their own exploration. As the performance of such slow starters improves, teachers should gradually reduce the extent to which they intervene in the learning process, to allow them to learn more independently.

(4) Adopting flexible grouping of students

Group activities in which students work collaboratively to complete learning tasks can facilitate the co-construction of knowledge among students and allow them to learn from their peers. In such activities, teachers usually cater for diversity by grouping students of similar ability together so that the tasks present an appropriate level of demand for different groups. However, teachers can also group students with different strengths to work together to enhance peer learning. This might be done as a jigsaw activity where the whole solution to a problem only becomes clear when each group has presented its part of the solution.

4.5.2 Information Technology as a Learning Tool to Cater for Learner Diversity

Used properly, information technology can be very effective in catering for different learning styles and expanding students' learning beyond the classroom. Students who are quiet in class may participate actively and contribute useful ideas in an online discussion forum. Online assessment tools, with mechanisms to support learning, can be used to motivate students and promote "assessment for learning". The multimedia and interactive elements are particularly useful for students who prefer visual or auditory approaches to learning. Also, the boundless nature of web-based learning resources provides flexibility for students to learn at their own pace and follow up their own interests. Students are encouraged to build up a learning community with their teachers and classmates by using e-mail, web-based instant messages, and bulletin boards.

4.5.3 Catering for Gifted Students

Students with a strong interest or talent in biology should be allowed to fulfil their full potential. One way of achieving this is through enrichment – that is, by involving such gifted students in additional, more sophisticated, and more thought-provoking work, while keeping them with their peers in the class. For example, in conducting scientific investigations, teachers may not only design complex tasks for them, but also allow them to choose challenging topics of interest to work on. Gifted students can also set the objectives for their own investigations, thus allowing them to think and act independently in defining problems, using information sources and evaluating procedures. Another approach is acceleration, by allowing gifted students to move more quickly through what has to be learnt.

In addition, arrangements can be made for gifted students to participate in a variety of learning programmes (e.g. Young Scholar Programme for Biology) or learning activities in the form of science competitions (e.g. Hong Kong Student Science Project Competition) and research projects which may further develop their talents. In this way, they can explore their own personal interests in the learning of biology.

(Blank page)

Chapter 5 Assessment

This chapter discusses the roles of assessment in Biology learning and teaching, the principles that should guide assessment of the subject and the need for both formative and summative assessment. It also provides guidance on internal assessment and details of the public assessment of Biology. Finally, information is given on how standards are established and maintained, and how results are reported with reference to these standards. General guidance on assessment can be found in the *Senior Secondary Curriculum Guide* (CDC, 2007).

5.1 The Roles of Assessment

Assessment is the practice of collecting evidence of student learning. It is a vital and integral part of classroom instruction, and serves several purposes and audiences.

First and foremost, it gives feedback to students, teachers, schools and parents on the effectiveness of teaching and on students' strengths and weaknesses in learning.

Second, it provides information to schools, school systems, government, tertiary institutions and employers to enable them to monitor standards and to facilitate selection decisions.

The most important role of assessment is in promoting learning and monitoring students' progress. However, in the senior secondary years, the more public roles of assessment for certification and selection come to the fore. Inevitably, these imply high-stakes uses of assessment since the results are typically employed to make critical decisions about individuals.

The Hong Kong Diploma of Secondary Education (HKDSE) provides a common end-of-school credential that gives access to university study, work, and further education and training. It summarises student performance in the four core subjects and in various elective subjects, including both discipline-oriented subjects such as Biology and the new Applied Learning courses. It needs to be interpreted in conjunction with other information about students given in the Student Learning Profile.

5.2 Formative and Summative Assessment

It is useful to distinguish between the two main purposes of assessment, namely "assessment *for* learning" and "assessment *of* learning".

"Assessment *for* learning" is concerned with obtaining feedback on learning and teaching,

and utilising this to make learning more effective and to introduce any necessary changes to teaching strategies. We refer to this kind of assessment as "formative assessment" because it is all about forming or shaping learning and teaching. Formative assessment is something that should take place on a daily basis and typically involves close attention to small "chunks" of learning.

"Assessment *of* learning" is concerned with determining progress in learning, and is referred to as "summative" assessment because it is all about summarising how much learning has taken place. Summative assessment is normally undertaken at the conclusion of a significant period of instruction (e.g. at the end of the year, or of a key stage of schooling) and reviews much larger "chunks" of learning.

In practice, a sharp distinction cannot always be made between formative and summative assessment, because the same assessment can in some circumstances serve both formative and summative purposes. Teachers can refer to the *Senior Secondary Curriculum Guide* (CDC, 2007) for further discussion of formative and summative assessment.

Formative assessment should be distinguished from continuous assessment. The former refers to the provision of feedback to improve learning and teaching based on formal or informal assessment of student performance, while the latter refers to the assessment of students' on-going work and may involve no provision of feedback that helps to promote better learning and teaching. For example, accumulating results in class tests carried out on a weekly basis, without giving students constructive feedback, may neither be effective formative assessment nor meaningful summative assessment.

There are good educational reasons why formative assessment should be given more attention and accorded a higher status than summative assessment, on which schools tended to place a greater emphasis in the past. There is research evidence on the beneficial effects of formative assessment when used for refining instructional decision-making in teaching and generating feedback to improve learning. For this reason, the CDC report *Learning to Learn – The Way Forward in Curriculum Development* (CDC, 2001) recommended that there should be a change in assessment practices, with schools placing due emphasis on formative assessment to make assessment *for* learning an integral part of classroom teaching.

It is recognised, however, that the primary purpose of public assessment, which includes both public examinations and moderated school-based assessments (SBA), is to provide summative assessments of the learning of each student. While it is desirable that students are exposed to SBA tasks in a low-stakes context and that they benefit from practice and experience with such tasks (i.e. for formative assessment purposes) without penalty, similar tasks will need to be administered subsequently as part of the public assessment to generate marks to summarise the learning of students (i.e. for summative assessment purposes).

Another distinction to be made is between internal assessment and public assessment. Internal assessment refers to the assessment practices that teachers and schools employ as part of the ongoing learning and teaching process during the three years of senior secondary studies. In contrast, public assessment refers to the assessment conducted as part of the assessment process in place for all schools. Within the context of the HKDSE, this means both the public examinations and the moderated SBA conducted or supervised by the HKEAA. On balance, internal assessment should be more formative, whereas public assessment tends to be more summative. Nevertheless, this need not be seen as a simple dichotomy. The inclusion of SBA in public assessment is an attempt to enhance formative assessment or assessment *for* learning within the context of the HKDSE.

5.3 Assessment Objectives

The assessment objectives are closely aligned with the curriculum framework and the broad learning outcomes presented in earlier chapters. The assessments in Biology aim to evaluate students' abilities to:

- recall and show understanding of facts, concepts and principles of biology, and the relationships between different topic areas in the curriculum framework;
- apply biological knowledge, concepts and principles to explain phenomena and observations, and to solve problems;
- formulate working hypotheses, and plan and perform tests for them;
- demonstrate practical skills related to the study of biology;
- present data in various forms, such as tables, graphs, charts, drawings, diagrams, and transpose them from one form into another;
- analyse and interpret both numerical and non-numerical data in forms such as continuous prose, diagrams, photographs, charts and graphs – and make logical deductions and inferences and draw appropriate conclusions;
- evaluate evidence and detect errors;
- generate ideas; select, synthesise and communicate ideas and information clearly, precisely and logically;
- demonstrate understanding of the applications of biology to daily life and its contributions to the modern world;
- show awareness of the ethical, moral, social, economic and technological implications of biology, and critically evaluate biology-related issues; and
- make suggestions, choices and judgments about issues affecting the individual, society and the environment.

5.4 Internal Assessment

This section presents the guiding principles that can be used as the basis for designing internal assessment and some common assessment practices for Biology for use in schools. Some of these principles are common to both internal and public assessment.

5.4.1 Guiding Principles

Internal assessment practices should be aligned with curriculum planning, teaching progression, student abilities and local school contexts. The information collected will help to motivate, promote and monitor student learning, and will also help teachers to find ways of promoting more effective learning and teaching.

(1) Alignment with the learning objectives

A range of assessment practices should be used to assess the achievement of different learning objectives for whole-person development, which include: knowledge and understanding of biological principles and concepts; scientific skills and processes; and positive values and attitudes. The weighting given to different areas in assessment should be discussed and agreed among teachers. The assessment purposes and assessment criteria should also be made known to students so that they can have a full understanding of what is expected of them.

(2) Catering for the range of student ability

Assessment practices at different levels of difficulty and in diverse modes should be used to cater for students with different aptitudes and abilities. This helps to ensure that capable students are challenged to develop their full potential and the less able ones are encouraged to sustain their interest and succeed in learning.

(3) Tracking progress over time

As internal assessment should not be a one-off exercise, schools are encouraged to use practices that can track learning progress over time (e.g. portfolios). Assessment practices of this kind allow students to set their own incremental targets and manage their own pace of learning, which will have a positive impact on their commitment to learning.

(4) Timely and encouraging feedback

Teachers should provide timely and encouraging feedback through a variety of means, such as constructive verbal comments during classroom activities and written remarks on assignments. Such feedback helps students to sustain their momentum in learning, and to identify their strengths and weaknesses.

(5) Making reference to the school's context

As learning is more meaningful when the content or process is linked to a setting which is

familiar to students, schools are encouraged to design assessment tasks that make reference to the school's own context (e.g. its location, relationship with the community, and mission).

(6) Making reference to the current progress in student learning

Internal assessment tasks should be designed with reference to students' current progress, as this helps to overcome obstacles that may have a cumulative negative impact on learning. Teachers should be mindful in particular of concepts and skills which form the basis for further development in learning.

(7) Feedback from peers and from the students themselves

In addition to giving feedback, teachers should also provide opportunities for peer assessment and self-assessment in student learning. The former enables students to learn among themselves, and the latter promotes reflective thinking which is vital for students' lifelong learning.

(8) Appropriate use of assessment information to provide feedback

Internal assessment provides a rich source of data for providing evidence-based feedback on learning in a formative manner.

5.4.2 Internal Assessment Practices

A range of assessment practices suited to Biology, such as assignments, practical work and scientific investigations, oral questioning and projects, should be used to promote the attainment of the various learning outcomes. However, teachers should note that these practices should be an integral part of learning and teaching, not "add-on" activities.

(1) Assignments

Assignments are a valuable and widely used assessment tool that reflects students' efforts, achievements, strengths and weaknesses over time. A variety of assignment tasks – such as exercises, essays, designing posters or leaflets, and model construction – can be used to allow students to demonstrate their understanding and creative ideas. The assignment tasks should be aligned with the learning objectives, teaching strategies and learning activities. Teachers can ask students to select a topic of interest, search for information, summarise their findings and devise their own ways of presenting their work (e.g. role-play, essays, poster designs or PowerPoint slides). Teachers should pay close attention to students' organisation of the materials, the language they use, the breadth and depth of their treatment, and the clarity with which they explain concepts. The scores or grades for assignments can be used as part of the record of students' progress; and the comments on their work, with suggestions for improvement, provide valuable feedback to them. Assignments can also help in evaluating the effectiveness of teaching by providing feedback upon which teachers can set further operational targets for students and make reasonable adjustments in their teaching strategies.

(2) Practical work and scientific investigation

Practical work and scientific investigation are common activities in the learning and teaching of science subjects. They offer students "hands-on" experience of exploring, and opportunities to show their interest, ingenuity and perseverance. In scientific investigations, teachers can first pose a problem and ask students to devise a plan and suggest appropriate experimental procedures for solving it – and the design of the investigations can then be discussed and, if necessary, modified. During such sessions, teachers can observe students' practical skills and provide feedback on how the experiment/investigation might be improved. Reading students' laboratory reports can provide teachers with a good picture of students' understanding of the biological concepts and principles involved, as well as their ability to handle and interpret data obtained in investigations.

(3) Oral questioning

Oral questioning can provide teachers with specific information on how students think in certain situations, as their responses often provide clues to their level of understanding, attitudes and abilities. Teachers can use a wide range of questions, from those which involve fact-finding, problem-posing, and reason-seeking to more demanding ones which promote higher levels of thinking and allow for a variety of acceptable responses. This can be a valuable supplement to conventional assessment methods.

(4) Projects

A project can be any piece of extended work on any topic. Asking students to carry out project work provides an opportunity for them to study a topic of interest in depth. Teachers can make use of the project work listed in the *Suggested Learning and Teaching activities* for each section, and develop appropriate criteria to assess the ideas being formed and skills being developed by students during the process.

5.5 Public Assessment

5.5.1 Guiding Principles

Some principles guiding public assessment are outlined below for teachers' reference.

(1) Alignment with the curriculum

The outcomes that are assessed and examined through the HKDSE should be aligned with the aims, learning targets and intended learning outcomes of the senior secondary curriculum. To enhance the validity of the public assessment, the assessment procedures should address the range of valued learning outcomes, and not just those that are assessable through external written examinations.

The public assessment for Biology will place emphasis on testing candidates' ability to apply and integrate knowledge in authentic and novel situations. In addition, the SBA component extends the public assessment to include valuable scientific investigative skills and generic skills such as creativity, critical thinking, communication and problem-solving.

(2) Fairness, objectivity and reliability

Students should be assessed in ways that are fair and are not biased against particular groups of students. A characteristic of fair assessment is that it is objective and under the control of an independent examining authority that is impartial and open to public scrutiny. Fairness also implies that assessments provide a reliable measure of each student's performance in a given subject so that, if they were to be repeated, very similar results would be obtained.

(3) Inclusiveness

The assessments and examinations in the HKDSE need to accommodate the full spectrum of student aptitude and ability.

The public examination for Biology will contain questions testing candidates' knowledge of the foundations and selected areas in biology, and test higher-order thinking skills. At the same time, the SBA component offers room for a wide range of activities to cater for the different preferences and readiness of students and/or schools.

(4) Standards-referencing reporting

The reporting system is "standards-referenced", i.e. students is matched against standards, which indicate what students have to know and be able to do to merit a certain level of performance. Level descriptors will be developed for Biology in due course to provide information about the typical performance of candidates at the different levels.

(5) Informativeness

The HKDSE qualification and the associated assessment and examinations system provide useful information to all parties. Firstly, it provides feedback to students on their performance and to teachers and schools on the quality of the teaching provided. Secondly, it communicates to parents, tertiary institutions, employers and the public at large what it is that students know and are able to do, in terms of how their performance matches the standards. Thirdly, it facilitates selection decisions that are fair and defensible.

5.5.2 Assessment Design

The table below shows the assessment design of the Biology for the 2014 to 2016 HKDSE Examinations. The assessment design is subject to continual refinement in the light of feedback from live examinations. Full details are provided in the Regulations and Assessment Frameworks for the year of the examination and other supplementary documents, which are available on the HKEAA website (www.hkeaa.edu.hk/en/hkdse/assessment/assessment_framework/).

Component		**Weighting**	**Duration**
Public examination	Paper 1 Compulsory Part	60%	2½ hours
	Paper 2 Elective Part (a choice of two out of four elective topics)	20%	1 hour
School-based assessment (SBA)		20%	

5.5.3 Public Examinations

The overall aim of the public examination is to assess candidates' ability to demonstrate their knowledge and understanding in different areas of biology, and to apply this to familiar and unfamiliar situations.

Various kinds of items, including multiple-choice questions, short questions, structured questions and essays, are used to assess students' performance in a broad range of skills and abilities. Multiple-choice questions permit a more comprehensive coverage of the curriculum, while basic knowledge and concepts can be tested through short questions. In structured questions, candidates may be required to analyse given information and to apply their knowledge to different situations. Finally, essay questions allow candidates to discuss biological issues in depth and demonstrate their ability to organise and communicate ideas logically and coherently. Schools may refer to the sample and live examination papers regarding the format of the examination and the standards at which the questions are pitched.

5.5.4 School-based Assessment (SBA)

In the context of public assessment, SBA refers to assessments administered in schools and marked by the students' own teachers. The primary rationale for SBA in Biology is to enhance the validity of the assessment by including the assessment of students' practical skills and generic skills.

There are, however, some additional reasons for SBA. For example, it reduces dependence on the results of public examinations, which may not always provide the most reliable indication of the actual abilities of candidates. Obtaining assessments based on student performance over an extended period of time and developed by those who know the students best – their subject teachers – provides a more *reliable* assessment of each student.

Another reason for including SBA is to promote a positive "backwash effect" on students, teachers and school staff. Within Biology, SBA can serve to motivate students by requiring them to engage in meaningful activities; and for teachers, it can reinforce curriculum aims and good teaching practice, and provide structure and significance to an activity they are in any case involved in on a daily basis, namely assessing their own students.

The SBA of Biology covers the assessment of students' performance in practical tasks throughout the S5 and S6 school years. Students are required to perform a stipulated number of pieces of practical work/investigations. The practical work/investigations should be integrated closely with the curriculum content and form a part of the normal learning and teaching process. In investigative work, students are required to: design and perform investigations; present, interpret and discuss their findings; and draw appropriate conclusions. They are expected to make use of their knowledge and understanding of biology in performing these tasks, through which their practical, process and generic skills will be developed and assessed.

It should be noted that SBA is not an "add-on" element in the curriculum. The modes of SBA above are normal in-class and out-of-class activities suggested in the curriculum. The requirement to implement the SBA has taken into consideration the wide range of student ability and effort have been made to avoid unduly increasing the workload of both teachers and students. Detailed information on the requirements and implementation of the SBA and samples of assessment tasks are provided to teachers by the HKEAA.

5.5.5 Standards and the Reporting of Results

Standards-referenced reporting is adopted for the HKDSE. What this means is that candidates' levels of performance are reported with reference to a set of standards as defined by cut scores on the mark scale for a given subject. Standards referencing relates to the way in which results are reported and does not involve any changes in how teachers or examiners mark student work. The set of standards for a given subject can be represented diagrammatically as shown in Figure 5.1.

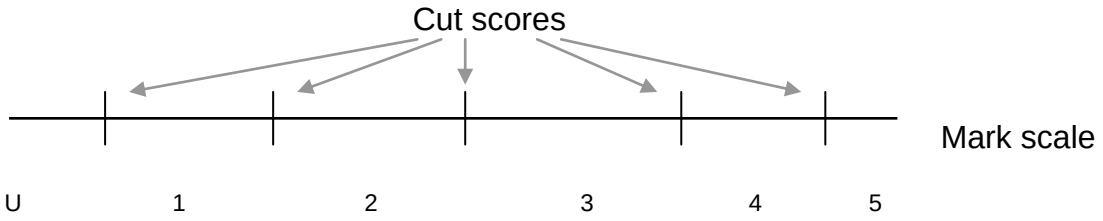


Figure 5.1 Defining Levels of Performance via Cut Scores on the Mark Scale for a given subject

Within the context of the HKDSE there are five cut scores, which are used to distinguish five levels of performance (1–5), with 5 being the highest. A performance below the cut score for Level 1 is labelled as "Unclassified" (U).

For each of the five levels, a set of written descriptors has been developed to describe what the typical candidate performing at this level is able to do. The principle behind these descriptors is that they describe what typical candidates *can* do, not what they *cannot* do. In other words, they will describe performance in positive rather than negative terms. These descriptors represent "on-average" statements and may not apply precisely to individuals, whose performance within a subject may be variable and span two or more levels. Samples of students' work at various levels of attainment are provided to illustrate the standards expected of them. These samples, when used together with the level descriptors, will be able to clarify the standards expected at the various levels of attainment.

In setting standards for the HKDSE, Levels 4 and 5 are set with reference to the standards achieved by students awarded grades A–D in the HKALE. It needs to be stressed, however, that the intention is that the standards will remain constant over time – not the percentages awarded at different levels, as these are free to vary in line with variations in overall student performance. Referencing Levels 4 and 5 to the standards associated with the old grades A–D is important for ensuring a degree of continuity with past practice, for facilitating tertiary selection and for maintaining international recognition.

The overall level awarded to each candidate is made up of results in both the public examination and the SBA. SBA results for Biology are statistically moderated to adjust for differences among schools in marking standards, while preserving the rank ordering of students as determined by the school.

To provide finer discrimination for selection purposes, the Level 5 candidates with the best performance have their results annotated with the symbols ** and the next top group with the symbol *. The HKDSE certificate itself records the Level awarded to each candidate.

(Blank Page)

Chapter 6 Learning and Teaching Resources

This chapter discusses the importance of selecting and making effective use of learning and teaching resources, including textbooks, to enhance student learning. Schools need to select, adapt and, where appropriate, develop the relevant resources to support student learning.

6.1 Purpose and Function of Learning and Teaching Resources

The purpose of learning and teaching resources is to provide a basis for students' learning experiences. Besides textbooks and workbooks, there is a wide range of available learning and teaching resources. These include audio-visual aids, web-based learning materials and interactive computer programs on the Internet, the media, libraries, and various organisations including the EDB – and even the natural environment. All of these should be drawn upon to keep students abreast of the latest scientific and technological developments, broaden their learning experience, enhance self-directed learning and meet their varied learning needs. The effective use of learning and teaching resources will help students to consolidate what they have learned, grasp abstract ideas and concepts, develop generic skills and values, and construct knowledge independently as well as collaboratively – and to gradually become lifelong learners.

6.2 Guiding Principles

Textbooks and other resource materials should be chosen and used to:

- address the learning targets and cover the core elements of the Biology Curriculum;
- arouse students' interest and motivate them to engage actively in learning tasks;
- provide students with access to an adequate knowledge base;
- provide scaffolds to help students construct their scientific concepts;
- cater for learner diversity by including different levels of difficulty;
- complement and extend what students have learned in class to promote independent learning; and
- promote discussion and provide possibilities for further inquiry.

6.3 Types of Resources

6.3.1 Textbooks

Well-written textbooks developed in accordance with the curriculum framework can facilitate learning and teaching. Textbooks should contain the core elements of learning in the subject recommended by the CDC and be used to develop critical thinking, creativity and other generic skills. By reading textbooks of a good standard, students can achieve the learning targets and outcomes, consolidate what they have learned, and extend their personal knowledge.

(1) Selection of textbooks

A set of guiding principles has been formulated for the writing, reviewing and selection of textbooks; and a list of recommended textbooks will be compiled and updated. Schools and teachers should refer to the list and guidelines at http://www.edb.gov.hk/en/curriculum-development/index.html, when choosing the textbooks for their students. The following factors should be taken into account when selecting biology textbooks:

- the approach and content should facilitate the development of the knowledge, skills, values and attitudes promoted in the curriculum;
- the learning content should be suitable;
- the language should be accurate and appropriate;
- the learning activities should be appropriate;
- the examples and illustrations should promote effective learning; and
- the safety aspects of the practical work should have been taken into consideration.

(2) Flexible use of textbooks

Teachers are encouraged to use textbooks flexibly according to the needs, abilities and interests of their students. While textbooks can be used as the basic resource for learning and teaching activities, they should not be the only resource. Other learning and teaching resources (e.g. audio-visual materials, natural resources from the environment, the Internet and community resources) should be used to complement textbook materials. Teachers should feel free to select and/or adapt relevant parts of textbooks, and to modify the sequence of presentation to suit their learning and teaching approaches and purposes. Teachers may also choose to provide students with school-based learning and teaching resources which are better suited for implementing the curriculum. Overall, teachers are advised to use their professional judgment to select tasks and exercises from textbooks, make use of a variety of educational resources, and develop school-based learning and teaching resources based on the needs of their students.

6.3.2 References

A variety of references can be used to enrich the curriculum, arouse students' interest in learning, and promote "Reading to Learn".

(1) Textual material

Students should be encouraged to read extensively to extend the scope of their knowledge and understanding. There are a lot of useful and interesting texts (e.g. books, journals, magazines) of appropriate breadth and depth. These include, for examples, stories about modern science, and articles on current developments or issues in the field of life science. It is important to set up a text-rich environment with ample curriculum-related materials appropriate to students' ability, linguistic competence and interests to encourage them to get into the habit of reading about science, and so kindle a lifelong interest in the area.

(2) Mass media

Materials from the mass media, including audio-visual materials, news articles, TV programmes and advertisements are authentic learning resources for encouraging discussion and helping students to make informed decisions and judgments. Some videotaped programmes can keep students abreast of the latest scientific and technological developments; and a large number of television programmes have a high educational value. Also, documentaries produced by professional bodies and broadcasting organisations are often pitched at an appropriate level for students. Teachers are encouraged to bring such TV programmes to students' attention as they may make learning more relevant and interesting.

Local newspapers can also be a valuable source from which to develop learning activities and assessment tasks. To extend their learning, students can collect cuttings on topics of interest to them in relation to the Biology Curriculum, such as the ozone depletion in the Earth's atmosphere, or the Human Genome Project. Learning and teaching resources from the media can provide students with a variety of perspectives on biology-related issues and stimulate their thinking. Students' motivation and interest in learning biology may be increased by discussing relevant media reports. Teachers should make flexible use of such resources for consolidating biological concepts, raising conceptual conflicts, visualising connections, and evaluating and applying biological knowledge.

Teachers should, however, be aware of the risks associated with the use of such a variety of resources as they may sometimes present inaccurate, biased or out-of-date information and present scientific knowledge in "black and white" terms, as if there were no doubts about the information. Resources need to be examined carefully to ensure that they are appropriate for the learning and teaching intentions.

6.3.3 The Internet and Technology

The Internet and technology play an important role in the provision of learning and teaching resources for biology. Strategic use of technology can enhance student engagement and give convenient access to vast amounts of information. Teachers can act as facilitators of learning by helping students to search for information and to work on it in ways that enable them to turn it into personal knowledge.

The Internet and technology can help students to learn by:

- providing audio-visual aids for difficult concepts and abstract ideas;
- providing access to information from a wide variety of sources and processing large quantities of information;
- allowing students to work at their own pace, including the use of specially designed software;
- promoting interaction and collaboration among learners, and between the teacher and learners; and
- facilitating the acquisition of information, the development of critical thinking, and the co-construction of knowledge.

Teachers are encouraged to make use of the Internet to promote active learning in students, as it offers opportunities for them to collaborate with their peers in other schools, obtain and deal with real life data, discuss with scientists, publish their work and access learning materials and journals. Many internet sites offer rich sources of information and materials on issues related to biology, such as genetically modified food, stem cell therapy, environmental conservation, and the outbreak of disease. It is useful for teachers to give students hints, key words or focused areas for Internet searches, to preview and bookmark useful websites and to make connections to useful websites in their school network.

There are also computer software programs suitable for the learning and teaching of biology. Such programs include tutorial software, databases of information and simulations or modelling of life processes and experiments. For instance, teachers may use a computer simulation of rat dissection to help students to investigate its body structure. Also, modelling software, which allows students to test their proposed models through virtual experiments, is useful in helping students to develop conceptual understanding and reasoning from their own ideas. Some CD-ROMs provide students with interactive learning experiences by presenting information in a variety of forms and requiring them to make notes, search for key words, answer questions, give explanations or solve problems. Finally, the use of devices such as data loggers and computer-based laboratories can help students to collect, interpret and analyse data when conducting scientific investigations.

6.3.4 Community Resources

The learning of biology is more effective, when students are able to relate their study to daily-life contexts. Life-wide learning opportunities should be provided to widen their exposure to the scientific world. A variety of organisations and persons in the community can contribute useful learning and teaching resources for biology or provide students with appropriate learning experiences and up-to-date information. Some examples of community resources are noted below for teachers' reference, but the list is by no means exhaustive. Teachers are encouraged to explore further opportunities available in the community and use them effectively to make the learning of biology interesting, authentic and meaningful.

- Resource materials are available from professional organisations (e.g. the Hong Kong Association for Mathematics and Science Education, the Hong Kong Medical Association), non-government organisations (e.g. the Family Planning Association of Hong Kong, the World Wide Fund For Nature (WWF) Hong Kong, the Conservancy Association), pharmaceutical companies, forensic laboratories and hospitals.
- Government departments such as the Environmental Protection Department, the Agriculture, Fisheries and Conservation Department, the Hospital Authority, the Department of Health and the Food and Environmental Hygiene Department support the learning and teaching of biology in many ways. For examples, they are sources for people who can provide valuable assistance or advice for the development of school-based programmes. The visitor centres, education centres, laboratories, herbaria and libraries of some of these departments may also provide life-wide learning contexts and abundant learning resources to complement self-learning.
- Venues such as natural ecosystems, field study centres, country parks, marine parks, botanical gardens, Ocean Park, museums, universities, research institutions and school grounds are good places for fieldwork. Fieldwork allows students to integrate the study of key concepts and gain first-hand experience of biological phenomena. Some organisations also offer guided educational tours for schools.
- Local competitions such as the Hong Kong Student Science Project Competition can provide valuable opportunities for students to develop their biological knowledge and skills for scientific investigation. The publications provided by organisers of these competitions are also very useful references for ideas on scientific investigations and inventions.

In addition, parents and alumni can be a very valuable resource for supporting student learning. Parents and alumni from different professions can be invited to deliver speeches or lectures to enable students to gain authentic knowledge about various disciplines and careers. They can also discuss social, moral and ethical issues related to biology with students, and share their views on the value of learning to learn to encourage active learning in students.

The EDB will continue to develop and update useful resources to support the implementation of the Biology Curriculum. A list of resource materials published by the EDB can be found in Appendix 2. Also, to assist schools in managing curriculum change, the EDB has provided a one-stop curriculum resources directory service at http://www.edb.gov.hk/en/curriculum-development/resource-support/overview/index.html which provides a central pool of ready-to-use learning and teaching resources and useful references developed by the EDB and other parties.

6.4 Flexible Use of Learning and Teaching Resources

Learning and teaching resources should be used flexibly to enhance the effectiveness of learning and teaching. To assist schools in the implementation of the senior secondary curriculum, the EDB will continue to provide funding and allow flexibility in the use of resources to cater for their diverse needs. Schools are advised to refer to the relevant and latest circulars issued by the EDB from time to time.

Teachers' selection of learning and teaching resources from the various sources outlined above should be based on the needs of their students; and, for this purpose, they may adapt and modify the materials from different sources or develop school-based learning and teaching resources to complement the textbook when necessary.

6.5 Resource Management

Teachers and students should share the responsibility for finding useful learning and teaching resources. Teachers may provide students with lists of recommended websites and references which are specific to the learning of particular topics in biology; and students can then follow them up by searching for useful resources from the Internet, libraries, government departments and other community organisations on their own, and can also make suggestions for enriching the teachers' lists.

A culture of sharing is necessary for effective resource and knowledge management. Schools should make arrangements for:

- teachers and students to share learning and teaching resources through the Intranet or other means within the school; and
- teachers to form professional groups for the exchange of experiences.

A resource bank for the Biology Curriculum is essential for storing and retrieving resources. This requires a joint effort by teachers, school librarians and students to collect, identify, locate and update resources. An up-to-date inventory of resources should be kept on the school Intranet so that students and teachers can easily locate and access the resources they need.

Appendix 1

Time-tabling arrangements and deployment of teachers to cater for the diverse needs of students

There are four subjects – Biology, Chemistry, Physics and Science (including Mode I and Mode II) – offered in the Science Education KLA, leading to a number of possible subject combinations for students. The provision of these different subject combinations is valuable for serving the needs of students who intend to pursue further study in different areas. Possible ways of managing school time-tabling and resources to allow students more choices are discussed below.

Implementation of Mode I - Integrated Science Curriculum

If this subject is to be taken by a class of students as a single elective subject, the normal time-tabling for elective subjects can be adopted. It is common practice in schools for teachers to be involved in teaching a course for three years. However, due to the multi-disciplinary nature of this subject, schools may consider assigning teachers with different expertise to teach this subject at different levels (S4, 5 & 6), or two teachers of different subject expertise to teach one class, so that teachers can focus more on modules with which they are familiar. This also help share out the effort required in preparing for new curriculum.

We encourage schools to promote partnership in the preparation of lessons, team teaching and lesson observations, so that teachers can learn from each other. It is recommended that schools reserve time for collaborative lesson preparation in the time-table so that teachers can work together.

In cases where a school is offering this subject to two or more classes, it is advisable to assign teachers with different subject expertise to the different classes. With special time-tabling, it will be possible to swap classes so that teachers can concentrate on the modules that they know best. After a few years, the teachers will be able to cover the teaching of the whole curriculum and be better placed to monitor student progress.

The following illustrates the different arrangements that schools may adopt according to the resources they have and the readiness of their teachers:

Option A: One teacher teaching one class at all three levels. If the teacher is required to teach beyond his/her own expertise, more time should be allowed for his/her professional development in knowledge updating and lesson preparation.

Option B: Teachers with different expertise share the teaching of one class. This allows them to concentrate on preparing the modules in areas in which they are most knowledgeable.

Option C: Two teachers with different expertise teach two classes, with each teaching one class. These teachers should share their knowledge and experience regularly and help each other in preparing resources.

Option D: Two teachers with different expertise teach two classes, with a special time-table arrangement which allows them to swap their responsibilities at various times in the year.

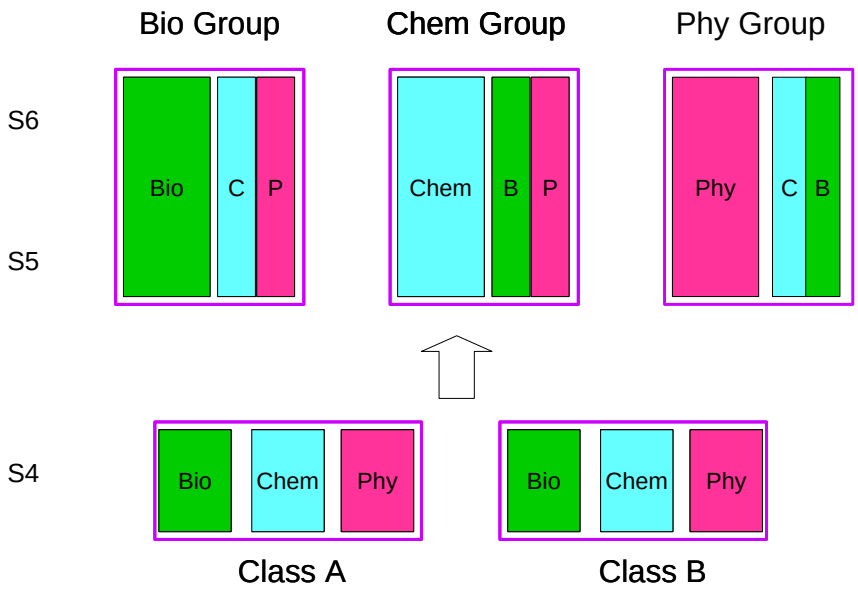
Implementation of Mode II - Combined Science Curriculum with Biology, Chemistry and Physics

The Combined Science Curriculum is designed for students taking two elective subjects in the Science Education KLA. Students will take one specialised science and Combined Science in the two parts that are complementary to the discipline in which they specialise. Special time-tabling and staff deployment are needed for implementation of this option in schools.

To help students build up a broad knowledge base, it is recommended that they should be offered more elective subjects in S4, and be guided to select two or three electives to focus on in S5 and S6. Students wishing to take two elective subjects in the Science Education KLA should start with all three science disciplines using the lesson time for two elective subjects in S4. That is, if four periods per cycle are allocated for one elective subject, schools may arrange three periods for each science discipline in S4. Teachers should refer to the C&A Guides for a selection of topics suitable for inclusion in the S4 curriculum to help students build up a broad-based foundation. Schools may consider the following two arrangements in S5 and S6:

(A) Flexible grouping and a split-class arrangement

Students from two or three different classes are arranged into three groups – namely, a Biology group, a Chemistry group and a Physics group, depending on the specialised subject they opt for. As illustrated in the diagram below, the students will have four periods per cycle for their specialised subject and two periods per cycle for the other two complementary subjects.



An example of two classes taking two elective subjects from the Science Education KLA

To implement the split-class arrangement, three common blocks in the time-table have to be arranged for the Biology, Chemistry and Physics teachers. That is, in the four periods allocated for the 1st Block, subject teachers will be teaching the groups that chose to specialise in their subject areas. In the 2nd and 3rd Blocks, they will give two periods each to the groups taking the other two specialised subjects.

	Biology Teacher	**Chemistry Teacher**	**Physics Teacher**
1st Block (4 periods)	Biology (Bio Group)	Chemistry (Chem Group)	Physics (Phy Group)
2nd Block (2 periods)	Bio part of Combined Science (Chem Group)	Chem part of Combined Science (Phy Group)	Phy part of Combined Science (Bio Group)
3rd Block (2 periods)	Bio part of Combined Science (Phy Group)	Chem part of Combined Science (Bio Group)	Phy part of Combined Science (Chem Group)

(B) Block time-table arrangement

Schools may arrange three common blocks in the time-table for three classes. The three subjects in each block will share the same time slots in the time-table. In each block, students may take any one subject from the three subjects offered in the block.

	Class A	**Class B**	**Class C**	**Other Classes**
Core subjects	Chin Lang	Chin Lang	Chin Lang	Chin Lang
	Eng Lang	Eng Lang	Eng Lang	Eng Lang
	Math	Math	Math	Math
	LS	LS	LS	LS
1st Block	Bio / Combined Sci (Chem, Bio) / X from other KLAs			Integrated Science
2nd Block	Chem / Combined Sci (Phy, Chem) / X from other KLAs			X from other KLAs
3rd Block	Phy / Combined Sci (Bio, Phy) / X from other KLAs			X from other KLAs

In the above arrangement, X is an elective subject from the other KLAs or an ApL course. Students in Classes A, B and C are offered the following possible choices:

- Biology + 2X
- Chemistry + 2X
- Physics + 2X
- Biology + Combined Science (Phy, Chem) + X
- Chemistry + Combined Science (Bio, Phy) + X
- Physics + Combined Science (Chem, Bio) + X
- Biology + Chemistry + X
- Chemistry + Physics + X
- Biology + Physics + X
- Biology + Chemistry + Physics
- 3X (from other KLAs / ApL)

From the time-table, it is clear that two teachers of each science disciplines are needed. For example, in the first common block, one Biology teacher is needed to teach four periods of Biology and another Biology teacher is needed to teach the two periods for the Biology part of Combined Science.

Appendix 2

Resources published by the Education Bureau

	Title	Category	Year of Production
1.	Cells and Cellular Processes"	CD-ROM	2008
2.	Curriculum Resources for Infusing Ideas about Nature and History of Biology and Scientific Inquiry into the Learning and Teaching of the Senior Secondary Biology Curriculum	Folder & CD-ROM	2009
3.	Curriculum Resources for Infusing Science – Technology – Society – Environment Connections into the Learning and Teaching of the Senior Secondary Biology Curriculum	Folder & CD-ROM	2009
4.	Learning and Teaching Resources for Senior Secondary Biology Curriculum: Problem-based Learning	Folder & CD-ROM	2009
5.	An English-Chinese Glossary of Terms Commonly Used in the Teaching of Biological Sciences in Secondary Schools http://cd1.edb.hkedcity.net/cd/science/glossarysci.html	Online	2007

(Blank page)

Glossary

Term	Description
Applied Learning (ApL, formerly known as Career-oriented Studies)	Applied Learning (ApL, formerly known as Career-oriented Studies) is an essential component of the senior secondary curriculum. ApL uses broad professional and vocational fields as the learning platform, developing students' foundation skills, thinking skills, people skills, positive values & attitudes and career-related competencies, to prepare them for further study /work as well as for lifelong learning. ApL courses complement 24 subjects, diversifying the senior secondary curriculum.
Assessment objectives	The outcomes of the curriculum to be assessed in the public assessments.
Biliterate and trilingual	Capable of reading and writing effectively in Standard Written Chinese, English and to use Cantonese, Putonghua and spoken English. The language education policy of Hong Kong is to enable the Hong Kong students to become biliterate (in written Chinese and English) and trilingual (in Cantonese, Putonghua and spoken English).
Co-construction	Different from the direct instruction and construction approaches to learning and teaching, the co-construction approach emphasises the class as a community of learners who contribute collectively to the creation of knowledge and the building of criteria for judging such knowledge.
Core subjects	Subjects recommended for all students to take at senior secondary level: Chinese Language, English Language, Mathematics and Liberal Studies.
Curriculum and Assessment (C&A) Guide	A guide prepared by the CDC-HKEAA Committee. It comprises curriculum aims, curriculum framework, curriculum planning, learning and teaching, and assessment.

Term	Description
Curriculum interface	Curriculum interface refers to the interface between the different key stages/educational stages of the school curriculum (including individual subjects), e.g. the interface between Kindergarten and Primary; Primary and Secondary; and Junior Secondary and Senior Secondary. The Hong Kong school curriculum, made up of eight key learning areas (under which specific subjects are categorised), provides a coherent learning framework to enhance students' capabilities for whole-person development through engaging them in the five essential learning experiences and helping them develop the nine generic skills as well as positive values and attitudes. Thus when students move on to senior secondary education, they will already have developed the basic knowledge and skills that the study of various subjects requires. When designing the learning and teaching content and strategies, teachers should build on the knowledge and learning experiences students have gained in the previous key stages.
Elective subjects	A total of 20 subjects in the proposed new system from which students may choose according to their interests, abilities and aptitudes.
Generic skills	Generic skills are skills, abilities and attributes which are fundamental in helping students to acquire, construct and apply knowledge. They are developed through the learning and teaching that take place in different subjects or key learning areas, and are transferable to different learning situations. Nine types of generic skills are identified in the Hong Kong school curriculum, i.e. collaboration skills, communication skills, creativity, critical thinking skills, information technology skills, numeracy skills, problem-solving skills, self-management skills and study skills.
Hong Kong Diploma of Secondary Education (HKDSE)	The qualification to be awarded to students after completing the three-year senior secondary curriculum and taking the public assessment.
Internal assessment	This refers to the assessment activities that are conducted regularly in school to assess students' performance in learning. Internal assessment is an inseparable part of the learning and teaching process, and it aims to make learning more effective. With the information that internal assessment provides, teachers will be able to understand students' progress in learning, provide them with appropriate feedback and make any adjustments to the learning objectives and teaching strategies they deem necessary.

Term	Description
Key Learning Area (KLA)	Organisation of the school curriculum structured around fundamental concepts of major knowledge domains. It aims at providing a broad, balanced and coherent curriculum for all students in the essential learning experiences. The Hong Kong curriculum has eight KLAs, namely, Chinese Language Education, English Language Education, Mathematics Education, Personal, Social and Humanities Education, Science Education, Technology Education, Arts Education and Physical Education.
Knowledge construction	This refers to the process of learning in which learners are involved not only in acquiring new knowledge, but also in actively relating it to their prior knowledge and experience so as to create and form their own knowledge.
Learning community	A learning community refers to a group of people who have shared values and goals, and who work closely together to generate knowledge and create new ways of learning through active participation, collaboration and reflection. Such a learning community may involve not only students and teachers, but also parents and other parties in the community.
Learning differences	This refers to the gaps in learning that exist in the learning process. Catering for learning differences does not mean rigidly reducing the distance between the learners in terms of progress and development but making full use of their different talents as invaluable resources to facilitate learning and teaching. To cater for learners' varied needs and abilities, it is important that flexibility be built into the learning and teaching process to help them recognise their unique talents and to provide ample opportunities to encourage them to fulfil their potential and strive for achievement.
Learning outcomes	Learning outcomes refer to what learners should be able to do by the end of a particular stage of learning. Learning outcomes are developed based on the learning targets and objectives of the curriculum for the purpose of evaluating learning effectiveness. Learning outcomes also describe the levels of performance that learners should attain after completing a particular key stage of learning and serve as a tool for promoting learning and teaching.

Term	Description
Learning targets and learning objectives	• Learning targets set out broadly the knowledge/concepts, skills, values and attitudes that students need to learn and develop. • Learning objectives define specifically what students should know, value and be able to do in each strand of the subject in accordance with the broad subject targets at each key stage of schooling. They are to be used by teachers as a source list for curriculum, lesson and activity planning.
Level descriptors	A set of written descriptions that describe what the typical candidates performing a certain level is able to do in public assessments.
Other learning experiences	For whole person development of students, 'Other Learning Experiences' (OLE) is one of the three components that complement the examination subjects and Applied Learning (formerly named as Career-oriented Studies) under the Senior Secondary Curriculum. It includes Moral and Civic Education, Aesthetics Development, Physical Development, Community Service and Career-related Experiences.
Public assessment	The associated assessment and examination system for the Hong Kong Diploma of Secondary Education.
SBA Moderation Mechanism	The mechanism adopted by HKEAA to adjust SBA marks submitted by schools to iron out possible differences across schools in marking standards and without affecting the rank order determined by the school.
School-based assessment (SBA)	Assessments administered in schools as part of the teaching and learning process, with students being assessed by their subject teachers. Marks awarded will count towards students' public assessment results.
School-based curriculum	Schools and teachers are encouraged to adapt the central curriculum to develop their school-based curriculum to help their students achieve the subject targets and overall aims of education. Measures may include readjusting the learning targets, varying the organisation of contents, adding optional studies and adapting learning, teaching and assessment strategies. A school-based curriculum is therefore the outcome of a balance between official recommendations and the autonomy of the schools and teachers.
Standards-referenced Reporting	Candidates' performance in public assessment is reported in terms of levels of performance matched against a set of standards.

Term	Description
Student diversity	Students are individuals with varied family, social, economic and cultural backgrounds and learning experience. They have different talents, personalities, intelligence and interests. Their learning abilities, interests and styles are, therefore, diverse.
Student learning profile	It is to provide supplementary information on the secondary school leavers' participation and specialties during senior secondary years, in addition to their academic performance as reported in the Hong Kong Diploma of Secondary Education, including the assessment results for Applied Learning courses, thus giving a fuller picture of the student's whole person development.
Values & attitudes	Values constitute the foundation of the attitudes and beliefs that influence one's behaviour and way of life. They help form principles underlying human conduct and critical judgment, and are qualities that learners should develop. Some examples of values are rights and responsibilities, commitment, honesty and national identity. Closely associated with values are attitudes. The latter supports motivation and cognitive functioning, and affects one's way of reacting to events or situations. Since both values and attitudes significantly affect the way a student learns, they form an important part of the school curriculum.

(Blank page)

References

Alberta Learning. (1998). *Biology 20-30 (Senior high)*. Alberta: Alberta Learning. Retrieved January 18, 2007, from http://www.learning.gov.ab.ca/k_12/curriculum/bySubject/science/bio2030.pdf

Allen, D. (1998). *Assessing student learning: From grading to understanding.* New York: Teacher College Press.

Assessment and Qualifications Alliance. (2002). *GCE Biology 2005 specification B.* Preston: Pindar plc. Retrieved January 18, 2007, from http://www.aqa.org.uk/qual/pdf/AQA-5416-6416-W-SP-05.PDF

Assessment and Qualifications Alliance. (2004). *GCSE Biology 2005 specification B.* Manchester: AQA. Retrieved January 18, 2007, from http://www.aqa.org.uk/qual/pdf/AQA-3411-W-SP-05.pdf

Baile, M., & Hirst, K. (2001). *Biology AS.* London: Collins.

Biologist. London: Institute of Biology.

Black, P., & Wiliam, D. (1998a). Assessment and classroom learning. *Assessment in Education, 5*(1), 7-74.

Black, P., & Wiliam, D. (1998b). Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan*, October, 139-148.

Board of Studies New South Wales. (2002). *Biology stage 6 syllabus*. Sydney: Board of Studies NSW. Retrieved January 18, 2007, from http://www.boardofstudies.nsw.edu.au/syllabus_hsc/pdf_doc/biology_stg6_syl_03.pdf

Bransford, J. D., Brown, A. L. & Cocking, R. R. (1999). *How people learn: Brain, mind, experience and school*. Washington, DC: National Academy Press

Connelly, M., & Clandinin, J. (1988). *Teachers as curriculum planners: Narrative of experience*. New York: Teachers College Press.

Council for the Curriculum Examinations and Assessment. (2004). *GCSE in Biology specification*. Belfast: North Ireland Council for the Curriculum, Examinations and Assessment. Retrieved January 18, 2007, from http://www.rewardinglearning.com/development/qualifications/gcse/docs/g06specs/g06bios.pdf

Curriculum Council. (2003). *Syllabus manual year 11 & year 12 subjects 2006-2008 volume VII: Biology*. Osborne Park: Curriculum Council. Retrieved January 18, 2007, from http://www.curriculum.wa.edu.au/pages/syllabus_manuals/volumes/VII_science/biology.htm

Curriculum Development Council. (1998). *Syllabuses for Secondary Schools – Science (Secondary 1-3).* Hong Kong: Printing Department.

Curriculum Development Council. (2001). *Learning to learn – The way forward in curriculum development.* Hong Kong: Printing Department.

Curriculum Development Council. (2002a). *Basic education curriculum guide*. Hong Kong: Printing Department.

Curriculum Development Council. (2002b). *Biology curriculum guide (Secondary 4-5)*. Hong Kong: Printing Department.

Curriculum Development Council. (2002c). *Science education key learning area curriculum guide (Primary 1 – Secondary 3)*. Hong Kong: Printing Department.

Curriculum Development Council. (2007). *Senior secondary curriculum guide.* Hong Kong: Government Logistics Department.

Curriculum Development Council and Hong Kong Examinations and Assessment Authority. (2007). *Combined Science curriculum and assessment guide (Secondary 4-6).* Hong Kong: Government Logistics Department.

Curriculum Development Council and Hong Kong Examinations Authority. (2002). *Biology curriculum and assessment guide (Advanced level)*. Hong Kong: Printing Department.

Edexcel. (2000). *Edexcel GCSE in Biology A specification*. Notts: Edexcel Foundation. Retrieved January 18, 2007, from http://www.edexcel.org.uk/VirtualContent/18020.pdf

Education and Manpower Bureau. (2005). *The new academic structure for senior secondary education and higher education – Action plan for investing in the future of Hong Kong.* Hong Kong: Government Logistics Department.

Education Commission. (2000). *Learning for life, learning through life – Reform proposals for the education system in Hong Kong*. Hong Kong: Printing Department.

Hodson, D. (1998). *Teaching and learning science: Towards a personalised approach*. Buckingham: Open University Press.

Hudson, T., & Mannion, K. (2001). *Microbes and diseases*. London: Cambridge University Press.

International Baccalaureate Organization. (2001). *IB diploma programme guide: Biology*. Geneva: IBO.

Jones, A., Reed, R., & Weyers, J. (1998). *Practical skills in biology* (2nd ed.). Essex: Longman.

Jones, M., & Gregor, J. (2001). *Biology 1 & 2.* London: Cambridge University Press.

Kanuffman, S. A. (2000). *Investigations.* New York: Oxford University Press.

Lowrie, P., & Wells, S. (2000). *Microbiology and biotechnology.* Cambridge: Cambridge University Press.

Ministry of Education. (1993). *Biology in the New Zealand curriculum*. Wellington: Learning Media Ltd.

Ministry of Education. (2000). *The Ontario curriculum, grades 11 and 12: Science 2000*. Ontario: MOE.

Monk, M., & Osborne, O. (2000). *Good practice in science teaching: What research has to say?* Buckingham: Open University Press.

Oxford, Cambridge & RSA Examinations. (2004). *OCR AS GCE and advanced GCE in Biology – Approved specifications* (Rev. ed.). Retrieved January 18, 2007, from http://www.ocr.org.uk/Data/publications/specifications_syllabuses_and_tutors_handbooks/cquartetOCRTempFilezgd90MmcAz.pdf

Queensland Studies Authority. (2004). *Biology senior syllabus 2004*. Spring Hill: QSA. Retrieved January 18, 2007, from http://www.qsa.qld.edu.au/yrs11_12/subjects/biology/syllabus.pdf

Scottish Qualifications Authority. (2002). *Advanced higher Biology* (4th ed.). Glasgow: SQA.

Scientific American. New York: Scientific American Inc.

Senior Secondary Assessment Board of South Australia. (2002). *Biology curriculum statements 2004*. Adelaide: SSABSA.

Stiggins, R. (2004). New assessment beliefs for a new school mission. *Phi Delta Kappan, 86* (1), 22-27.

Stinger, E. (1999). *Action research*. Thousand Oaks: Sage Publications.

Taylor, D. (2001). *Growth, development and reproduction.* Cambridge: Cambridge University Press.

The American Biology Teacher. Washington, DC: National Association of Biology Teachers.

The College Entrance Examination Board. (2003). *2004, 2005 Course description for AP Biology*. Retrieved January 18, 2007, from http://apcentral.collegeboard.com/apc/public/repository/05837apcoursdescbio06_4312.pdf

Victorian Curriculum and Assessment Authority. (2005). *Biology Victorian Certificate of Education study design*. East Melbourne: VCAA. Retrieved January 18, 2007, from http://www.vcaa.vic.edu.au/vce/studies/biology/biologystd.pdf

Watkins, C. (2005). *Classrooms as learning communities: What's in it for schools?* New York: Routledge

Welsh Joint Education Committee. (2003). *GCE AS/A Biology specification 2005-6*. Retrieved January 18, 2007, from http://www.wjec.co.uk/albiology05.pdf

中華人民共和國教育部（2001） 《全日制義務教育生物課程標準（實驗稿）》，北京：北京師範大學出版社。

中華人民共和國教育部（2003）《全日制普通高中生物課程標準（實驗）》，北京：人民教育出版社。

《中學生物教學》，中國：中華人民共和國教育部。

江晃榮（2001） 《不可思議的生物科技》，台北：世茂出版社。

沈萍主編（2000） 《微生物學》，北京：高等教育出版社。

翟中和、丁明孝和王喜忠（1999） 《細胞生物學》，北京：高等教育出版社、施普林格出版社。

Membership of the CDC-HKEAA Committee on Biology (Senior Secondary)

(From December 2003 to September 2013)

Chairperson:	Prof TAM Fung-yee, Nora	
Members:	Ms CHENG Lai-yun	
	Prof FUNG Ming-chiu	
	Ms HO Ngar-yin, Assunta	
	Mr LAW Kim-hung, Thomas	(from February 2012)
	Dr LEE Yeung-chung	
	Mr MA Hing-tak	
	Dr MAK, William	(from September 2008)
	Dr MAN Wai-hin	(until February 2012)
	Mr NG Yau-keung, Benjamin	
	Mr PAK Chi-on	
	Prof TSAO Sai-wah, George	(until September 2008)
	Prof TSIM Wah-keung, Karl	(from February 2012)
	Dr WONG Kong-chu, Chris	(until February 2012)
	Mr WONG Leung-kwan	(until January 2010)
	Ms WONG Po-ling	(from February 2010)
Ex-officio Members:	Ms CHUNG Oi-lin, Irene (EDB)	
	Ms CHOY Siu-kwan (HKEAA)	(until September 2008)
	Mr TSUI Chi-shing, Ben (HKEAA)	(from September 2008)
Secretary:	Mr SO Chi-shing, Jason (EDB)	

Membership of the CDC-HKEAA Committee on Biology

(From September 2013 to August 2015)

Chairperson:	Prof TSIM Wah-keung, Karl
Members:	Mr CHEN Yau-hip, Louis
	Prof CHENG May-hung, May
	Dr CHEUNG Siu-gin
	Ms HO Hoi-ying
	Ms HO Ngar-yin, Assunta
	Dr LAI Chun-hong
	Mr LAM Pui-chow
	Mr LAW Kim-hung, Thomas
	Mr NG Yau-keung, Benjamin
	Mr TANG Chi-yin
Ex-officio Members:	Ms CHUNG Oi-lin, Irene (EDB)
	Mr TSUI Chi-shing, Ben (HKEAA)
Secretary:	Mr SO Chi-shing (EDB)