Science Education Key Learning Area

# Biology Curriculum Guide (Secondary 4-5)

Prepared by
The Curriculum Development Council

Recommended for use in schools by
The Education Department
HKSAR
(2002)

SECONDARY SCHOOLS
CURRICULUM GUIDE

# SCIENCE EDUCATION
# KEY LEARNING AREA

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# (SECONDARY 4-5)

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# Membership of the CDC Ad Hoc Committee on the Revision of S4-5 Biology Curriculum

(Since December 1999)

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(Since October 2000)

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# PREAMBLE

This Curriculum Guide is one of the series prepared by the Hong Kong Curriculum Development Council for use in secondary schools.

The Curriculum Development Council is an advisory body giving recommendations to the Hong Kong Special Administrative Region Government on all matters relating to curriculum development for the school system from kindergarten to sixth form. Its membership includes heads of schools, practising teachers, parents, employers, academics from tertiary institutions, professionals from related fields or related bodies, representatives from the Hong Kong Examinations Authority and the Vocational Training Council, as well as officers from the Education Department.

This Curriculum Guide is recommended by the Education Department for use in secondary schools. The curriculum developed for the senior secondary levels normally leads to appropriate examinations provided by the Hong Kong Examinations Authority.

The Curriculum Development Council will review the curriculum from time to time in the light of classroom experiences. All comments and suggestions on the Curriculum Guide may be sent to:

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# I. AIMS AND OBJECTIVES

## Aims

The overarching aim of science education in Hong Kong is to provide learning experiences through which students understand and apply scientific concepts and principles, and recognise the impacts and cultural significance of scientific and technological developments. These will lay the foundation on which students communicate ideas and make informed judgements based on scientific evidences, develop further in science and technology, and become life-long learners in these fields of study.

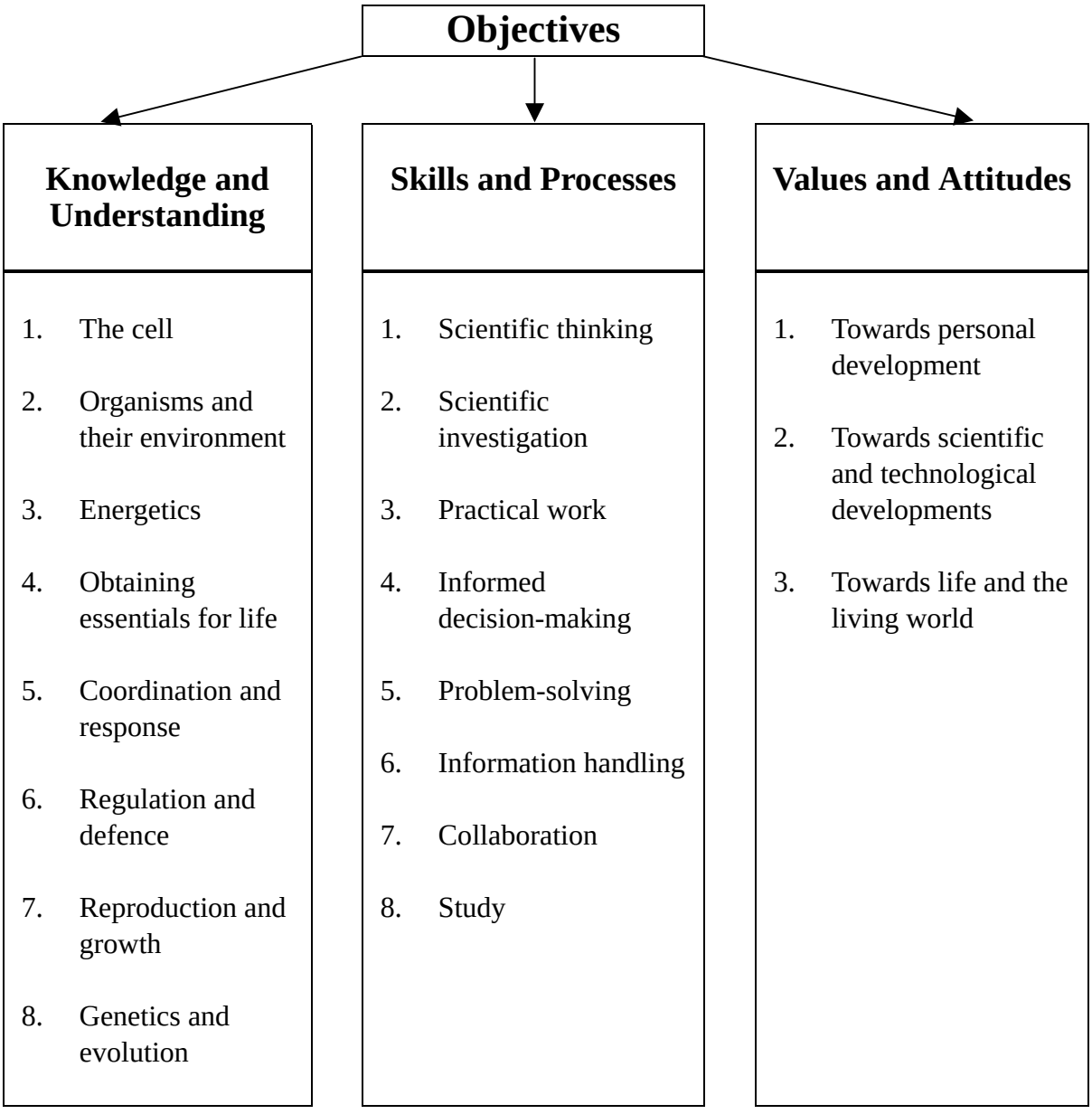
The Secondary 4-5 Biology Curriculum aims to provide learning experiences through which students will:

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

## Objectives

The general learning objectives listed below are to be achieved through a course of study of biology at S4-5 level as a whole. The learning objectives are categorised into three domains: knowledge and understanding, skills and processes, and values and attitudes. Throughout the course of studying the biology curriculum, students will acquire the necessary knowledge, skills and attitudes under various biology-related contexts. The specific learning objectives of the individual sections with regard to each of the domains will be highlighted in the sections.

The following is a schematic diagram on the objectives of the biology curriculum:



## A. Knowledge and Understanding

Students should be able to

1. recall and understand biological facts, terms, concepts and principles;
2. show understanding of practical techniques and process skills specific to the study of biology;
3. apply biological knowledge to familiar and unfamiliar situations;
4. show understanding of the applications of biological knowledge in daily life; and
5. show understanding of the technological implications of biological knowledge and ideas.

## B. Skills and Processes

### 1. Scientific thinking

Students should be able to

1.1 be critical towards scientific evidence;
1.2 realise the importance of evidence in supporting, modifying or refuting proposed scientific theories;
1.3 formulate generalisations in the light of both first-hand and second-hand evidence;
1.4 inquire into biological phenomena, and how related principles are evolved from experiments;
1.5 acquire an analytical mind to evaluate issues related to biology;
1.6 reflect on the positive and negative sides of issues related to nature, science and technology; and
1.7 group and organise biological knowledge and concepts, and apply them to new situations.

### 2. Scientific investigation

Students should be able to

2.1 make careful observations on biological phenomena;
2.2 ask relevant questions, identify problems and formulate hypotheses for investigations;

2.3 design and perform experiments for testing the hypotheses set;
2.4 recognise the presence of interacting variables, and identify the dependent and independent variables in investigations;
2.5 record observations, interpret experimental data and extrapolate from them;
2.6 draw conclusions from the findings of investigations and with reference to the hypotheses; and
2.7 evaluate the conclusions, and plan for further investigations if appropriate.

## 3. Practical work

Students should be able to

3.1 take necessary laboratory and fieldwork safety measures;
3.2 handle living organisms with care and necessary precautions;
3.3 follow procedures to carry out practical work in a systematic and organised way;
3.4 manipulate scientific equipment and apparatus competently;
3.5 recognise the needs for accurate measurements, select appropriate instruments and realise the limitations of the instruments used; and
3.6 suggest improvements on practical work.

## 4. Informed decision-making

Students should be able to

4.1 understand the dynamically changing environment and the importance of making informed judgements in a technological society;
4.2 collect evidence, and judge the reliability and validity of the data in making decisions on issues related to biology;
4.3 discuss and evaluate critically the biological issues that have social, economic, environmental and ethical implications; and
4.4 identify the pros and cons of the applications of biological knowledge for informed decision-making.

## 5. Problem-solving

Students should be able to

5.1 identify and analyse problems related to biology;
5.2 apply biological concepts and principles to solve problems;
5.3 think critically, and suggest creative ideas and solutions to problems;
5.4 propose solution plans and evaluate the feasibility of these plans; and
5.5 tolerate the uncertainties and ambiguities faced during the course of resolving difficulties.

## 6. Information handling

Students should be able to

6.1 retrieve relevant scientific information from various sources, including libraries, the Internet, multimedia resource packages, etc;
6.2 extract and organise relevant points of interest for discussion, and present them in a clear and logical manner;
6.3 use information technology to process and present the information;
6.4 distinguish among facts, opinions, and value judgements in processing scientific information; and
6.5 communicate the processed information effectively with others.

## 7. Collaboration

Students should be able to

7.1 organise themselves and others to participate actively in group work;
7.2 listen to, negotiate and make compromise with, and motivate others in group work;
7.3 identify collective goals, define and agree on roles and responsibilities of members;
7.4 act responsibly to accomplish the agreed collective goals;
7.5 share with others actively to bring about an interaction of ideas in teamwork;
7.6 be open and responsive to ideas and constructive criticisms from team members;
7.7 build on the different strengths of members to maximise the potential of the team; and
7.8 adopt strategies to work effectively as a member of the project team.

### 8. Study

Students should be able to

8.1 develop basic study skills to improve the effectiveness and efficiency of learning biology;
8.2 engage in self-learning activities in the study of biology; and
8.3 develop life-long learning skills in our rapidly changing knowledge-based society.

## C. Values and Attitudes

### 1. Towards personal development

Students should be able to

1.1 develop a habit of self-reflection and a critical and inquiring mind;
1.2 develop and reinforce values and attitudes such as integrity, curiosity, openness to new ideas and informed scepticism through the study of biology;
1.3 observe objectively and think logically and scientifically; and
1.4 have positive values and attitudes in developing a healthy lifestyle.

### 2. Towards scientific and technological developments

Students should be able to

2.1 appreciate the hard work of frontier scientists and their contributions to developments in science and technology;
2.2 show an appreciation for the roles of science and technology in understanding Nature;
2.3 be aware of the dynamic nature of the body of biological knowledge;
2.4 appreciate how science, technology and society are interrelated through exploring biological issues;
2.5 be aware of the applications of biological knowledge in society and their social, economic, environmental and ethical implications; and
2.6 appreciate that the advancement of science requires perseverance, openness and scepticism.

## 3. Towards life and the living world

Students should be able to

3.1 show an interest and enjoyment in studying living organisms and their interrelationships;
3.2 show a respect towards life;
3.3 appreciate the wonders and complexity of Nature;
3.4 show concern towards global environmental issues; and
3.5 be responsible in caring and protecting the local environment.

# II. CURRICULUM FRAMEWORK

## A. Organisation

The S4-5 Biology Curriculum serves as a continuation of the CDC Science S1-3 Syllabus (1998). With careful consideration of students' prior knowledge and everyday experiences, it is designed to cover major aspects of biology, along with its social and technological relationships.

There are eight sections in the biology curriculum. Each section is made up of four major parts: *Overview, Skills and Processes, Values and Attitudes*, and a table of contents which is organised into four columns: ***Topics, Knowledge and Understanding***, ***Skills and Processes***, and ***STS (Science, Technology and Society) Connections***.

(a) ***Overview*** – This part introduces the main theme and foci of each section. While it may not be possible to provide an exhaustive description on the interconnections between the topics, it tries to make plain any major relationships to the Science S1-3 Syllabus, and other topics of the S4-5 Biology Curriculum so that different sections can be studied with proper integration.

(b) ***Skills and Processes*** – This part refers to the generic skills and scientific process skills associated with the practice of science, such as problem-solving, critical thinking, investigating, scientific thinking, informed decision-making, creativity, collaboration, practical, numeracy and use of information technology. Students will be expected to develop these skills by collaborating with others in project work and group practical work, searching and presenting information, designing and performing scientific investigations, processing and analysing data, and discussing and evaluating issues concerned. Some of the activities listed are for the development of skills which are cognitive in nature, e.g. learning how to control variables in an experiment and proposing hypotheses. Other activities are very practical in nature, aiming at the development of practical skills, e.g. preparing temporary microscopic slides or handling equipment and apparatus. Throughout the course students should be exposed to various learning opportunities to develop their proficiencies in these skills. However, the activities listed in this part should ***not*** be used solely to consolidate concepts depicted in the column "Knowledge and Understanding", as these suggestions also serve to foster the development of both generic skills and scientific process skills.

Generally speaking, the teaching of science should ensure that the content develops directly from related activities, the teaching of biology being no exception. In this guide, "Skills and Processes" are treated as a central component, from which the subject matter ("Knowledge and Understanding"), applications, and implications ("STS Connections") emerge. This part suggests possible learning and teaching activities, which are by no means exhaustive nor meant to be prescriptive. Teachers should do the planning flexibly and open-mindedly in order to cater for the different abilities, interest, strengths and weaknesses of their students.

(c) ***Values and Attitudes*** – This part refers to personal qualities that are to be fostered in students. This encompasses attitudes towards personal development, scientific and technological developments, and life and the living world. By focusing on biology-related issues, biology education can help students learn decision-making skills, develop values and healthy attitudes and, if appropriate, make judgements for the future, all of which will contribute to their effectiveness as responsible citizens. The STS Connections can provide a channel for the incorporation of moral/value education into biology. Undoubtedly some newly added topics in biology may involve different viewpoints, morals and even beliefs, giving rise to discussions of sensitive issues. Teachers should bear in mind that such discussions are important and should not evade them, but the discussions should be focused and should provide an open forum for the expression of different viewpoints. Teachers should guide students to examine reasons for disagreements amongst scientists and people from other sectors of the community on current controversial issues, in biology, that are of interest and relevance to students.

(d) ***Topics*** – This part indicates the major contents in each section.

(e) ***Knowledge and Understanding*** – This part gives a brief amplification of the topics and provides a broader framework upon which learning and teaching activities can be developed. Students are expected to understand facts, terms, concepts and principles, be able to apply knowledge and concepts to daily lives, think critically and creatively, and construct knowledge. It should be noted that a significant portion of the curriculum content in various sections of this curriculum guide have already been covered in the Science S1-3 Syllabus, either in the core part or the extension part. Such topics are marked with "Refer to *Science S1-3: Topic X.X*" or "*Science S1-3: Topic X.X extension*". Teachers are advised to find out what concepts the students have already mastered, and revise them without going into greater breadth or depth for students of average abilities. Teachers should not assume that all students have

studied the extension part of the Science S1-3 Syllabus, and should therefore judiciously assign time to go over topics that have not been covered previously. For topics that have been touched upon in the Science S1-3 Syllabus but without bearing such remarks, (e.g. 3.1 Photosynthesis – the significance of photosynthesis in converting light energy to chemical energy in plants), students are expected to learn these topics to a greater depth. However, more capable students can still learn beyond the confines of the curriculum on topics that are marked.

(f) ***STS Connections*** – This part aims at developing students' awareness and appreciations of the interrelationships between science, technology and society. This component should add interest and excitement to the subject matter. Traditionally science education addresses only scientific knowledge, but its application as technology, and the resulting societal implications are equally important when issues are being examined. This column provides a source of daily life issues and important discoveries in biology for teachers to consider when organising project works and investigative activities. However, the activities listed in the guide are by no means exhaustive. Teachers could select ***some*** of the suggested activities and project work to enhance biology learning in suitable contexts, and to meet the interest and abilities of their students. Alternatives can be made where other examples of applications or implications are more appropriate than those listed in the guide. Rote learning is discouraged, and students are ***not required*** to recall those facts and information they gathered during these learning activities. Where possible, the activities should be framed in the context of students' own experiences to enable them to make connections with scientific knowledge, society around them, developments in science and technology, and the nature of science itself. Students would then be empowered with abilities to apply scientific concepts, theories, processes, and values in investigating and solving everyday problems, considering the ethical implications of various points of view in the light of fundamental societal values, and making responsible and wise decisions.

The sequence of presentation of topics in this guide ***should not be regarded as a fixed teaching order***. 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 where appropriate and not in isolation.

## Core and Extension

The two components, *Core* and *Extension*, of the curriculum cater for students of different abilities and needs. The *Core* is the basic component of S4-5 Biology Curriculum gearing towards all students whereas the *Extension* component **(underlined in the table of contents)** is generally more demanding and more suitable for students aiming to pursue further study in the subject. For some students, it will be more desirable to just concentrate on the *Core* so that more time is available to confidently master the basic concepts and principles. For others, the challenges provided by the *Extension* component may generate a greater sense of achievement. In schools, it is hoped that learning experiences in the *Core* part should be provided to all students, while allowing individual differences in aptitude. In the long run, schools should work towards developing their own school-based curriculum to best suit their students' needs.

## B. Time Allocation

The S4-5 Biology Curriculum is divided into eight sections. With a time allocation of four 40-minute periods each week, a total of 192 periods in Secondary 4 and 5 should be enough to cover the whole curriculum. Sixteen out of the 192 periods are allocated for investigative work, which helps develop students' skills and attitudes for scientific investigations. An estimate of the number of periods required for each section is shown below to provide some guidance on the weighting to be placed on individual sections:

| | | *No. of periods* |
|---|---|---|
| **Investigations** | | 16 |
| Some relatively large-scale investigative work may include proposing hypotheses, designing and performing experiments, making evaluation and preparing reports. Some laboratory periods should be specially allocated to accommodate such investigations. However, simple investigative work requiring shorter periods of time should be subsumed in other practical work in the teaching periods suggested for each section. | | |
| **Section 1** | **The cell** | 13 |
| 1.1 | Chemicals of life | |
| 1.2 | Discovery of cells | |
| 1.3 | The basic structure of a cell | |
| 1.4 | Cell activities | |
| 1.5 | The cell as a basic unit of life | |
| **Section 2** | **Organisms and their environment** | 19 |
| 2.1 | Diversity of organisms | |
| 2.2 | Classification | |
| 2.3 | The ecosystem | |
| 2.4 | Energy flow within an ecosystem | |
| 2.5 | Cycling of materials | |
| 2.6 | Ecological interdependence of organisms | |
| 2.7 | Human impacts on the environment | |
| 2.8 | Environmental protection | |
| **Section 3** | **Energetics** | 15 |
| 3.1 | Photosynthesis | |
| 3.2 | Respiration | |

| | | *No. of periods* |
|---|---|---|
| **Section 4** | **Obtaining essentials for life** | 46 |
| | 4.1 Nutrition, gas exchange, water relation and transport in plants | |
| | 4.2 Nutrition, gas exchange and transport in humans | |
| **Section 5** | **Coordination and response** | 21 |
| | 5.1 Detecting environmental conditions | |
| | 5.2 Nervous coordination in humans | |
| | 5.3 Hormonal coordination in humans | |
| | 5.4 Locomotion in humans | |
| | 5.5 Growth responses of plants | |
| **Section 6** | **Regulation and defence** | 14 |
| | 6.1 Concept of homeostasis | |
| | 6.2 Osmoregulation and excretion | |
| | 6.3 Regulation of body temperature | |
| | 6.4 Regulation of glucose level in blood | |
| | 6.5 Defence against diseases | |
| **Section 7** | **Reproduction and growth** | 28 |
| | 7.1 Types of cell division | |
| | 7.2 Asexual reproduction | |
| | 7.3 Sexual reproduction in flowering plants | |
| | 7.4 Sexual reproduction in humans | |
| | 7.5 Growth and development | |
| **Section 8** | **Genetics and evolution** | 20 |
| | 8.1 Genes and inheritance | |
| | 8.2 The pattern of inheritance | |
| | 8.3 Variations | |
| | 8.4 Genetic engineering | |
| | 8.5 Evolution | |
| | **Total:** | **192** |
| | (Equivalent to 128 hours) | |

# C. Content

# Section 1 The cell

## Overview

In this section, the chemical basis of life and the functions of various chemicals to organisms are discussed in *1.1 Chemicals of life*. Looking at developments of the microscope and cell theory in *1.2 Discovery of cells*, the interdependence of biological science with other science disciplines is highlighted. The concept of metabolism, the properties and action of enzymes, and the movement of substances in and out of a cell are included in *1.4 Cell activities*. The concept that a cell is the basic unit of organisms and is capable of performing a number of life processes, is illustrated in *1.3 The basic structure of a cell* and *1.5 The cell as a basic unit of life*. The hierarchy of the body organisation of an organism is also highlighted here.

This section builds on *Science S1-3 Topics: 3.1 The basic units of living things* and *12.2 Food substances.* It provides students with a foundation for the study of *Sections 4, 7* and *8.*

## Skills and Processes



In this section, students will develop the generic skills and scientific process skills as exemplified by:

- conducting project work on the discovery of cells or developments of the microscope;
- performing practical work on some common foodstuffs, enzymes and osmosis;
- preparing temporary mounts of animal and plant tissues, and examining them under light microscope; and
- designing and performing investigations to study the bioactive ingredients of commercial washing powder.

## Values and Attitudes

Students are encouraged to:

- appreciate the complexity of cells and organisms, and the wonders of life;
- appreciate that advancement in scientific knowledge requires curiosity, creative thinking and perseverance;
- develop an awareness of the importance of evidence in supporting, modifying or refuting proposed scientific theories;
- value the hard work of frontier scientists in the pursuit of knowledge; and
- show an appreciation for the roles of science and technology in understanding Nature.

Section 1 The cell

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 1.1 Chemicals of life | • The inorganic and organic chemical constituents in organisms.<br>• The functions of carbohydrates, fats, proteins and DNA in organisms.<br>• The importance of water to life: its roles in many vital life processes.<br>• The presence of minerals in all living cells. | • Performing common food tests to identify chemicals in some foodstuffs (Refer to Topic 4.2). | |
| 1.2 Discovery of cells | • The contribution of technological developments of the microscope to the discovery of cells and cell theory. | | • Conducting a project work on the discovery of cells or developments of the microscope; discussing the importance of technological advances on the development of science. |
| 1.3 The basic structure of a cell | • The functions of the following cell structures: cell membrane, nucleus, chromosome, cytoplasm and mitochondrion; chloroplast, cell wall and large vacuole in plant cells.<br>• The similarities and differences between animal and plant cells. | • Preparing temporary mounts of animal and plant tissues.<br>• Examining animal and plant cells, and identifying nucleus, cytoplasm, cell wall, chloroplast and vacuole.<br>• Comparing animal and plant cells under the microscope. | |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 1.4 Cell activities | • Metabolism as the catabolic and anabolic processes taking place within a cell. | | |
| | • The properties of enzymes. | • Performing practical work to demonstrate the breaking down or building up action of enzymes. | |
| | • The roles of enzymes in metabolism. | | • Relating the application of enzymes in industrial processes and commercial products. |
| | • The effects of temperature and pH on enzyme activities. | • Performing practical work to study the effects of temperature and pH on the activities of enzymes.<br>• Designing and performing investigations to compare the activities of enzymes, e.g. bioactive ingredients in commercial washing powder. | |
| | • The processes by which substances move across a cell membrane: diffusion, active transport and osmosis. | | • Relating how diffusion and osmosis are applied in industrial and medical fields. |
| | • Water movement across selectively permeable cell membrane in terms of water potential. | • Performing practical work on osmosis using non-living materials.<br>• Performing practical work using living materials to study osmosis at cellular, tissue or organ level. | |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 1.5 The cell as a basic unit of life | • The cell as the basic structural and functional unit of life.<br>• The presence of different types of cells inside a multicellular organism for performing specialised functions.<br>• The different levels of organisation in a multicellular organism: tissue, organ and system. | • Examining cell and tissue samples.<br>• Examining an angiosperm, a dissected mammal or a human torso. | |

# Section 2 Organisms and their environment

## Overview

In this section, prior knowledge about plants and animals developed in Science S1-3 is extended. A wider range of organisms on Earth is studied in *2.1 Diversity of organisms*. The needs and principles of classification are then discussed in *2.2 Classification*. Building on the concept of *Ecosystem (in 2.3)* as a dynamic system, the *Energy flow (in 2.4)* and the C*ycling of materials (in 2.5)* within an ecosystem are examined; hence the idea of *Interdependence of organisms (in 2.6)* and their environment is established. In *2.7 Human impacts on the environment* and *2.8 Environmental protection*, the undesirable effects of human activities are studied and reflected, so as to bring out the importance of environmental protection and sustainable development.

This section builds on *Science S1-3 Topics: 2.1 Living things, 2.2 Observing an animal, 2.3 Diversity of plant and animal life, 2.4 Sorting things into group* and *5.4 Water conservation and pollution.*

## Skills and Processes

In this section, students will develop the generic skills and scientific process skills as exemplified by:

- identifying organisms with simple keys;
- conducting project work on the variety of living organisms in a local habitat, the effects of pollutants on air quality or water quality, or environmental issues, etc.;
- evaluating critically the controversy of economic, social and environmental needs in Hong Kong; and
- constructing pyramids of numbers and biomass using given data.

## Values and Attitudes

Students are encouraged to:

- value the roles of organisms in an ecosystem;
- appreciate the diversity of organisms and the wonders of Nature;
- develop a respect towards life and a sense of caring to the natural environment of Hong Kong; and
- be aware of their own responsibility in protecting the environment.

Section 2 Organisms and their environment

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 2.1 Diversity of organisms | • The existence of many different kinds of organisms on Earth (Refer to *Science S1-3: Topics 2.1-2.3*). | | • Conducting a project work on the variety of living organisms found locally in Hong Kong. (Students can select one habitat or one type of organism, e.g. butterflies.) |
| 2.2 Classification | • The need of a classification system for biological studies (Refer to *Science S1-3: Topic 2.4*).<br>• The classification of organisms into five kingdoms: Prokaryotes, Protoctists, Fungi, Plants and Animals.<br>• The classification of plants into flowering plants and non-flowering plants (mosses, ferns and gymnosperms).<br>• The classification of animals into invertebrates and vertebrates (fishes, amphibians, reptiles, birds and mammals).<br>• The existence of virus as a non-cellular entity. | • Identifying organisms with simple keys.<br>• Classifying organisms found in a local habitat, e.g. old wall, tree trunk, school campus or field. | |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 2.3 The ecosystem | • Ecosystem as a dynamic system resulting from the interactions of organisms and their environment.<br>• The biotic and abiotic factors in an ecosystem. | | • Visiting Nature Reserves, marine parks and other local field sites. |
| 2.4 Energy flow within an ecosystem | • The Sun as the ultimate source of energy in most ecosystems.<br>• Energy flows within an ecosystem via producers and consumers.<br>• The uses of food chains, food webs, pyramids of numbers and biomass to represent the feeding relationship of organisms, and the energy flow between different trophic levels in an ecosystem. | • Constructing and interpreting food chains, food webs, and pyramids of numbers and biomass. | |
| | • <u>The accumulation of toxic substances along a food chain.</u> | | • <u>Conducting a project work on ciguatoxin or pesticide poisoning.</u> |
| 2.5 Cycling of materials | • The cycling of carbon in an ecosystem by natural and human activities.<br>• <u>The cycling of nitrogen in an ecosystem by natural and human activities.</u><br>• The important role of decomposers in the cycling of materials. | | |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 2.6 Ecological interdependence of organisms | • The relationship of organisms in an ecosystem: predation, competition, commensalism, mutualism and parasitism. | • Using living/audiovisual materials to show examples on the relationship of organisms in an ecosystem. | • Conducting a project work on biological pest control. |
| 2.7 Human impacts on the environment | • The increasing effects of human activities on the environment. | | |
| | • The effects of pollutants on the environment and human health. | | • Conducting a project work on the effects of pollutants on air quality or water quality. |
| | • The existence of renewable and non-renewable resources. | | |
| | • The undesirable effects of over-exploitation of resources: deforestation and over-consumption of fossil fuels. | | • Evaluating the impacts of urban development on the environment. |
| 2.8 Environmental protection | • The need of environmental protection. | | • Evaluating the controversy of economic, social and environmental needs in Hong Kong in relation to major local urban development projects, and discussing the responsibility of an individual in protecting the environment. |
| | • The concept of sustainable development. | | |
| | • Some measures of environmental protection, e.g. preserving biodiversity, protecting endangered species, recycling of used materials and pollution control including sewage treatment. | | • Discussing the consequences of not preserving biodiversity. |

# Section 3 Energetics

## Overview

In this section, prior knowledge developed in Science S1-3 of how plants obtain energy is further elaborated. The dependence of animals on plants in terms of energy supply is highlighted. In *3.1 Photosynthesis*, the process by which plants absorb light energy and convert it into chemical energy, which is stored in their synthesised organic substances, is discussed. These materials are the basic food sources, from which all organisms in the ecosystem derive energy. In *3.2 Respiration*, the process where all organisms break down their food to release energy for various body functions is introduced.

This section builds on *Science S1-3 Topics: 7.3 How does man obtain energy* and *7.4 How do green plants obtain energy*. It links to *Biology S4-5 Topic: 2.4 Energy flow within an ecosystem* and provides a basis for the study of other life processes in *Section 4*.

## Skills and Processes

In this section, students will develop the generic skills and scientific process skills as exemplified by:

- designing and performing investigations to study photosynthesis and respiration;
- performing practical work to detect photosynthetic products;
- conducting project work on how a greenhouse works in enhancing plant growth; and
- discussing the applications of fermentation in the food industry .

## Values and Attitudes

Students are encouraged to:

- appreciate the significance of plants in ecosystems;
- appreciate the complexity of the ecosystem with attention being paid to the interrelationships between organisms in terms of energy and food supply; and
- develop an awareness of the uses of some microbes in producing useful products for humans.

Section 3 Energetics

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 3.1 Photosynthesis | • The significance of photosynthesis in converting light energy to chemical energy in plants. | | |
| | • The requirements for photosynthesis: light, carbon dioxide, water and chlorophyll. | • Designing and performing investigations to study the requirements for photosynthesis. | |
| | • The photosynthetic process: the splitting of water by light, the formation of carbohydrate, and the release of oxygen. | • Performing practical work to detect the photosynthetic products. | |
| | • <u>The effects of environmental factors (light intensity and carbon dioxide concentration) on the rate of photosynthesis.</u> | • <u>Designing and performing investigations to study the effects of some environmental factors on the rate of photosynthesis.</u> | • <u>Conducting a project work on how a greenhouse works in enhancing plant growth.</u> |
| | • <u>The different ways of utilisation of photosynthetic products in plants.</u> | • <u>Performing practical work to test for the different types of food stored in plants.</u> | • <u>Discussing the significance of photosynthesis in terms of the world's food supply and the balance of the atmospheric carbon dioxide and oxygen.</u> |
| | • The structural adaptation of the leaf as a photosynthetic organ. | • Examining the morphology and the internal structures of leaves. | |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 3.2 Respiration | • The significance of respiration in releasing energy through the controlled oxidative breakdown of food.<br>• The processes of aerobic and anaerobic respiration as represented by simple word equations.<br>• Alcoholic fermentation in yeast and lactic acid production in muscle.<br>• The differences between aerobic and anaerobic respiration.<br>• <u>The importance of anaerobic respiration.</u> | • Designing and performing investigations to study aerobic and anaerobic respiration in organisms. | • Discussing the applications of fermentation in the food industry.<br>• <u>Searching for information on the degree of dependence on anaerobic respiration by athletes performing different sports.</u> |

# Section 4 Obtaining essentials for life

## Overview

This section focuses on how organisms acquire their basic needs of oxygen, water and food. The life processes, e.g. nutrition, gas exchange, and transport involved, are studied in an integrated manner. Contents are organised around the main theme of obtaining essentials for life so as to facilitate better understanding of the structures and functioning of an organism as a whole.

As autotrophs, plants can make organic substances from inorganic compounds. The organic substances thus produced are used to provide energy for driving metabolic reactions and for growth. Through the process of gas exchange, plants obtain from the air carbon dioxide for photosynthesis and oxygen for respiration. Transpiration removes water from plants in the form of water vapour, thus cooling the plants. It may facilitate the absorption of mineral ions for proper growth. Photosynthesis takes place in leaves, producing carbohydrate from carbon dioxide and water. The carbohydrate produced in the leaves is then carried by the phloem to other parts of the plant for cellular metabolism.



As heterotrophs, humans take in organic substances which provide the energy for body activities and for growth. The process of digestion breaks down food into smaller molecules along the alimentary canal. Digested food is absorbed by the small intestine and is passed to the blood and lymph for distribution to body cells via the circulatory system. Ventilation brings atmospheric oxygen to the air sacs in the lung. Exchange of respiratory gases takes place across the wall of the air sacs. Oxygen is carried by the circulatory system to the body cells. Oxygen and food materials are then utilised by the body cells for cellular respiration and for other metabolic activities.

This section builds on *Science S1-3 Topics: 12.2 Food substances, 12.3 Balanced diet, 12.5 How food is digested and absorbed in our body, 12.6 The fate of the digested food, 12.7 Our circulatory system*, and *Biology S4-5 Topics: 1.4 Cell activities, 3.1 Photosynthesis* and *3.2 Respiration.* It provides a harmonious progression from the basic understanding of the human body developed in S1-3 to a more comprehensive understanding of body functioning. It also links to *Biology S4-5 Topic: 6.2 Osmoregulation and excretion.*

## Skills and Processes

In this section, students will develop the generic skills and scientific process skills as exemplified by:

- designing and performing investigations on gas exchange in plants;
- conducting project work on the diets of people in different countries;
- examining the internal structures of the leaf, stem and root of a young dicotyledonous plant, and the digestive system, breathing system and circulatory system of a dissected mammal or a human torso; and
- discussing and evaluating the health issues related to diet.

## Values and Attitudes

Students are encouraged to:

- develop proper eating habits that enhance good health;
- develop a healthy lifestyle;
- appreciate the amazing body functioning of organisms; and
- appreciate the advancement in technology to enhance the scientific understanding of the internal systems of humans.

Section 4 Obtaining essentials for life

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 4.1 Nutrition, gas exchange, water relation and transport in plants | • Plants as autotrophs obtaining their nutrition by photosynthesis (Refer to Topic 3.1). | | |
| | • The importance of minerals (nitrogen and magnesium) for proper growth in plants. | • Studying the effects of different minerals on plant growth using potted plants. | • Relating the knowledge of mineral requirement of plant to the application of chemical fertilisers in agriculture and its environmental consequences. |
| | • The application of chemical fertilisers in agriculture. | | |
| | • The simple histology of a young dicotyledonous plant. | • Examining the cross sections of the leaf, stem and root of a young dicotyledonous plant. | |
| | • The structural features of leaves in relation to gas exchange and prevention of water loss. | | |
| | • Gas exchange in leaves and its relationship with light intensity. | • Investigating the effect of light intensity on gas exchange in land or water plants using hydrogencarbonate indicator solution or data logger. | |
| | • The process of transpiration and its possible roles in absorption of minerals and cooling. | • Performing practical work to demonstrate the occurrence of transpiration.<br>• Designing and performing an investigation to compare the distribution of stomata on both sides of a leaf. | |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| | • The effects of environmental factors on the rate of transpiration.<br>• The absorption of water and minerals in roots.<br>• The adaptive features of roots in relation to water absorption.<br>• The transport of water and minerals in flowering plants.<br>• The path of transport of organic nutrients in flowering plants.<br>• The significance of support in plants for obtaining light.<br>• The importance of cell turgidity in supporting young dicotyledonous plants.<br>• The importance of the physical nature of xylem in the support of woody stems. | • Designing and performing investigations to study the effects of environmental factors on the rate of transpiration using potometer.<br>• Examining the roots of young seedlings.<br>• Performing practical work to trace the uptake of eosin solution in herbaceous plant. | |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 4.2 Nutrition, gas exchange and transport in humans | • Humans as heterotrophs obtaining their nutrition by taking in organic substances.<br><br>• The food requirements of humans (Refer to *Science S1-3: Topic 12.2*) and the effects of deficiency in vitamins (A, C and D), minerals (calcium and iron) and dietary fibre.<br><br>• The functions of carbohydrates, fats, proteins, vitamins, minerals and dietary fibre.<br><br>• The food sources of carbohydrates, fats, proteins, vitamins (A, C and D), minerals (calcium and iron) and dietary fibre.<br><br>• The methods for detecting glucose, reducing sugar, starch, fat, protein and vitamin C in common foodstuffs. | • Performing common food tests (test for glucose using Clinistix paper, Benedict's test for reducing sugar, iodine test for starch, grease spot test for fat, test for protein using Albustix paper, test for vitamin C using DCPIP (dichlorophenol indophenol) solution) on some common foodstuffs to compare their food components.<br><br>• Designing and performing investigations to compare the amount of vitamin C in different fruits and vegetables. | |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| | • The importance of water to humans (Refer to *Science S1-3: Topic 12.2 extension*).<br>• The need for a balanced diet (Refer to *Science S1-3: Topic 12.3*).<br>• The variation in dietary requirements in relation to age, activity and pregnancy.<br>• The health problems resulting from an improper diet.<br>• The human dentition.<br>• The types and functions of teeth (Refer to *Science S1-3: Topic 12.5*), and their structures.<br>• Oral health.<br>• Causes and prevention of tooth decay (Refer to *Science S1-3: Topic 12.5 extension*).<br>• Periodontal disease and its prevention (Refer to *Science S1-3: Topic 12.5 extension*). | • Investigating the change in pH in the mouth before and after eating candies. | • Conducting a project work on the diets of people in different countries, as related to their social, cultural and economic backgrounds.<br>• Discussing ways in which eating disorders, e.g. anorexia nervosa, can affect health.<br>• Finding out the relation of diet, eating habit and oral hygiene to tooth decay.<br>• Evaluating the usefulness of adding calcium and fluoride in toothpaste as compared to adding fluoride to drinking water. |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| | • The need for digestion.<br>• The general plan of the digestive system.<br>• The functions of different parts of the alimentary canal and its associated glands.<br>• The mechanical and chemical digestion of food.<br>• The absorption of food.<br>• The structural adaptation of the small intestine for food absorption.<br>• The transport of absorbed food and their fates in cells and tissues.<br>• The role of liver in relation to food assimilation.<br>• The process of egestion. | • Examining the alimentary canal and its associated glands of a dissected mammal or a human torso.<br>• Designing and performing investigations on the action of digestive enzymes, e.g. amylase on starch-agar plate, protease on milk-agar plate or egg white.<br>• Investigating the effect of bile salt on oil.<br>• Performing practical work to simulate digestion and absorption in the alimentary canal using dialysis tubing. | • Discussing the occurrence of gastro-intestinal disorders, such as peptic ulcer, duodenal ulcer, constipation, haemorrhoid (pile), and colon cancer. |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| | • The general plan of the human breathing system.<br>• The process of gas exchange in the air sacs.<br>• The adaptive features of the air sacs in gas exchange.<br>• The mechanism of ventilation.<br>• The transport of respiratory gases.<br>• <u>The relation of exercises to energy requirement, rate of cellular respiration and ventilation.</u><br>• The general plan of the human circulatory system (Refer to *Science S1-3: Topic 12.7 extension*).<br>• The structure of various components of the human circulatory system in relation to their functions. | • Examining the breathing system of a dissected mammal or a human torso.<br>• Examining the lung of a pig.<br>• Examining the air sacs of a mammal.<br>• Investigating the differences in composition between inhaled and exhaled air.<br>• <u>Studying the change in breathing rate during exercise using breath volume kit or data logger.</u><br>• Dissecting and examining the heart of a pig.<br>• Examining the capillary flow in a fish's tail fin or frog's web.<br>• Examining the sections of an artery and a vein. | • Relating smoking to the incidence of lung cancer and emphysema.<br>• Relating diet and lifestyle to the incidence of high blood pressure, coronary heart disease and stroke. |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| | • The structure, composition and functions of blood.<br>• <u>The formation of tissue fluid.</u><br>• The exchange of materials between blood and body cells.<br>• <u>An outline of the lymphatic system and its functions.</u> | • Examining a blood smear.<br>• Performing practical work to detect the presence of glucose in plasma.<br>• Performing practical work to study the effects of oxygen and carbon dioxide on citrated blood of a chicken. | |

# Section 5 Coordination and response

## Overview

This section focuses on how organisms detect and respond to environmental changes. In humans, *detecting environmental conditions (in 5.1)* is achieved by receptors in the sense organs. External stimuli are detected by these receptors and nerve impulses are set up. A detailed study of the human eye is included to illustrate the functioning of a sense organ. Sense organs and effectors are linked by nerves to the central nervous system. Neurones carry nerve impulses from the receptors to the central nervous system. With or without integration in the brain, nerve impulses are then passed to the effectors. Muscles and glands are the common effectors in the body. On the arrival of nerve impulses, muscles contract to effect movement. The endocrine system provides an alternative mean of coordination, linking various parts of the body with chemical messengers – hormones. Plants respond to external stimuli in different ways. One way is by regulating their growth.

This section builds on *Science S1-3 Topics: 11.1 Sensing the environment, 11.2 How we see, 11.3 Limitations of our eyes, 11.4 Defects of the eye, 11.8 Senses of smell, taste & touch, 11.9 The brain and our senses,* and *11.10 Responses to stimuli.* It provides a deeper understanding of the nervous and hormonal coordination in humans, which is related to *Biology S4-5 Topic 6.1*.



## Skills and Processes

In this section, students will develop the generic and scientific process skills as exemplified by:

- searching for information on how modern technology helps in rectifying eye defects and the provision of related community services;
- conducting project work on the effects of drug abuse on body organs, or health issues related to the skeleton and muscles; and
- designing and performing investigations on phototropic, geotropic and hydrotropic growth responses in plants.

## Values and Attitudes

Students are encouraged to:

- develop proper habits towards better eye care;
- value the contribution of science and technology to helping people who suffer from eye defects or bone injuries;
- develop an awareness of the adverse effects of drug abuse on the brain; and
- be aware of the importance of occupational safety in relation to injuries of the skeleton and muscles.

Section 5 Coordination and response

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 5.1 Detecting environmental conditions | • The five senses: sight, hearing, taste, touch and smell (Refer to *Science S1-3 Topic 11.1 & 11.8*).<br>• The role of sense organs and receptors in the nervous system.<br>• The structure of the human eye, and functions of its major parts (Refer to *Science S1-3 Topic 11.2*).<br>• The functions of rods and cones in the retina.<br>• The presence of three types of cones for colour vision.<br>• The control of the amount of light entering the eye.<br>• The accommodation of the eye.<br>• <u>The causes of long sight, short sight and colour blindness (Refer to *Science S1-3 Topic 11.4 extension*).</u><br>• <u>The correction of long sight and short sight.</u> | • Dissecting and examining an ox's eye. | • <u>Searching for information on how modern technology helps in rectifying eye defects, e.g. blindness, short sight, astigmatism, cataract, glaucoma or retinopathy, and the provision of related community services.</u><br>• <u>Finding out various means of eye care, e.g. eye exercise.</u> |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 5.2 Nervous coordination in humans | • The general plan of the nervous system.<br>• The role of the skull and vertebrae in protecting the central nervous system.<br>• The role of the central nervous system in linking the receptors and the effectors.<br>• The basic structure of a neurone.<br>• The types of neurones: sensory neurone, interneurone and motor neurone.<br>• The basic structure of the spinal cord and a simple account of a spinal reflex arc.<br>• The functions of the main parts of the brain: cerebrum, cerebellum and medulla (Refer to *Science S1-3 Topics 11.9 extension & 11.10*).<br>• The differences between reflex and voluntary actions. | • Examining a human brain model. | • Conducting a project work on the effects of drug abuse on body organs, particularly the brain. |
| 5.3 Hormonal coordination in humans | • The nature of hormonal coordination. | | • Finding out the physiological consequences of imbalance of hormone, e.g. insulin, and the remedies, especially through modern advances in science and technology. |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 5.4 Locomotion in humans | • Ovaries, testes and pancreas as examples of endocrine glands.<br>• The feedback mechanism of hormonal control as illustrated by insulin secretion by the pancreas.<br>• the general effects of insulin and glucagon.<br>• The similarities and differences between hormonal and nervous coordination.<br>• The roles of skeleton, muscle, joints, tendons and ligaments in locomotion.<br>• Muscles as the body's principal effectors.<br>• The action of opposing muscle pairs in movement.<br>• The differences in the degree of movement between hinge joints (e.g. elbow joint/knee joint) and ball-and-socket joints (e.g. shoulder joint/hip joint). | • Examining an arm model. | • Conducting a project work on health issues related to the skeleton and muscles, such as osteoporosis, arthritis, sports injuries (e.g. sprains, torn ligaments, pulled muscles, cramps, displaced cartilage, fractures, dislocation).<br>• Searching for information on occupational safety, e.g. in moving heavy objects, office work. |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 5.5 Growth responses of plants | • The growth responses of root and shoot to light, gravity and water.<br>• The role of auxins in phototropic and geotropic responses. | • Designing and performing an investigation on the phototropic response of shoots.<br>• Using clinostats to study the geotropic response of roots.<br>• Designing and performing an investigation on the relative effects of gravity and water on the growth response of plants. | |

# Section 6 Regulation and defence

## Overview

This section focuses on how humans regulate their internal body environment within a fairly stable range, and how they defend against diseases. The role of feedback mechanism in homeostatic control is highlighted in *6.1 Concept of homeostasis*. In *6.2 Osmoregulation and excretion*, the concept of homeostasis is illustrated by the functioning of the kidney. Metabolic wastes such as urea, carbon dioxide and excess water, which are harmful to our bodies, must be removed. Urea is removed together with water in the urine by the urinary system. The removal of carbon dioxide through exhalation is discussed in *4.2 Nutrition, gas exchange and transport in humans*. Other homeostatic controls are further illustrated in *6.3 Regulation of body temperature* and *6.4 Regulation of glucose level in blood*. In *6.5 Defence against diseases*, the protective mechanisms against infectious diseases are briefly discussed. Our skin is the first line of defence against the entry of pathogens into our bodies. White blood cells serve as the second line of defence. Phagocytes engulf the pathogens and lymphocytes secrete antibodies to help destroying them. With an understanding of immunity and immune responses, humans develop vaccination against certain infectious diseases, thus providing better protection to our body.

This section links to *Biology S4-5 Topics: 1.4 Cell activities, 3.2 Respiration, 4.2 Nutrition, gas exchange and transport in humans* and *5.3 Hormonal coordination in humans*, which provide students with the background knowledge of the sources of the metabolic wastes and the importance of keeping a stable internal environment.



## Skills and Processes

In this section, students will develop the generic skills and scientific process skills as exemplified by:

- conducting project work on kidney failures and the provision of related community supports to the patients;
- searching for information on the development of vaccines or immunisation programmes; and
- discussing and evaluating issues related to the enhancement of immunity by the intake of ‘health food’.

## Values and Attitudes

Students are encouraged to:

- develop an awareness of the safety precautions against heatstroke, heat exhaustion or hypothermia;
- appreciate the contributions of scientists in the development of vaccines;
- develop an analytical mind for evaluating the effectiveness of ‘health food’ ; and
- increase their awareness of the importance of personal hygiene and vaccination to individual health and community health.

Section 6 Regulation and defence

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 6.1 Concept of homeostasis | • The importance of maintaining a constant internal environment.<br>• The role of feedback mechanism in homeostasis. | | |
| 6.2 Osmoregulation and excretion | • The general plan of the urinary system and the functions of various parts. | • Examining the urinary system of a dissected mammal or a human torso. | |
| | • The structure of the kidney and its osmoregulatory and excretory functions. | • Examining a kidney model or the longitudinal section of a dissected mammalian kidney. | • Discussing the issues associated with kidney transplants, e.g. sources of donated organs and related ethical issues. |
| | • The structure of a nephron.<br>• The process of ultrafiltration and reabsorption in the formation of urine. | | • Conducting a project work on kidney failures and the provision of related community supports to the patients. |
| 6.3 Regulation of body temperature | • The principle of body temperature regulation. | | • Searching for information on conditions that may lead to heatstroke, heat exhaustion or hypothermia, and the precautions against these risks.<br>• Preparing a leaflet for elderly people giving them advice on how to avoid hypothermia. It should contain symptoms of hypothermia so that the elderly can recognise when they are at risk. |
| | • The structure of skin, and its role in temperature regulation. | • Examining a skin model or a section of the mammalian skin. | |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 6.4 Regulation of glucose level in blood | • The role of liver, pancreas, insulin and glucagon in regulating blood glucose level. | | • Discussing how diabetes can be controlled. |
| 6.5 Defence against diseases | • The physical and chemical barriers for preventing the entry of pathogens.<br>• The roles of phagocytes and lymphocytes in defending against pathogens.<br>• The principle of vaccination: an induced production of antibodies and phagocytes. | | • Discussing and evaluating issues related to the enhancement of immunity by the intake of 'health food'.<br>• Reading the stories of these scientists in the development of vaccination:<br>  • Jenner (vaccine to prevent smallpox)<br>  • Pasteur (vaccine to prevent rabies)<br>  • Salk (vaccine to prevent poliomyelitis)<br>• Studying a personal immunisation record to find out the types of disease that are covered by the local immunisation programme from birth to adolescence.<br>• Searching for information on the relation of immunisation programmes to the control of infectious diseases, e.g. whooping cough and tuberculosis. |

# Section 7 Reproduction and growth

## Overview

This section focuses on how organisms reproduce for the perpetuation of their species and how new individuals grow and develop. The understanding of these life processes is linked up with the concepts of cell division. Some organisms carry out *asexual reproduction (in 7.2)* producing offspring, which are genetically identical among themselves and with their parents. This simple form of reproduction links with the role of mitotic cell division. Most organisms reproduce sexually. Sexual reproduction involves the production of male and female gametes, which are formed by meiotic cell division. Fusion of the gametes leads to the formation of a zygote which develops, into an embryo. The offspring thus produced are genetically different. In *7.3 Sexual reproduction in flowering plants* and *7.4 Sexual reproduction in humans*, the growth and development of a zygote into an embryo in humans is discussed, students will also have a basic understanding of the development of flowering plants and humans from sexual maturity to the production of new individuals. In *7.5 Growth and development*, the process of germination of seed into seedling is used to further illustrate the concept of growth and development. Students will also realise the importance of mitotic cell division in bringing about an increase in body size and that of differentiation of cells in leading to an increase in body complexity.



This section builds on *Science S1-3 Topics: 3.2 A new life is born, 3.3 Puberty & 3.4 Pregnancy.* It also reinforces students' understanding of the regulatory functions of hormones in *Biology S4-5 Topic 5.3* when discussing the secondary sexual characteristics in humans. The knowledge underlying sexual reproduction provides a basis for students to understand the concepts of *Genes and inheritance*, *The pattern of inheritance*, *Variation* and *Evolution* under *Biology S4-5 Section 8*, whereas the concept of growth and development links up with the idea of differentiation in multicellular organisms mentioned in *Topic 1.5*.

## Skills and Processes

In this section, students will develop the generic skills and scientific process skills as exemplified by:

- searching for information on prenatal and postnatal care, or the effectiveness and possible side effects of various birth control methods;
- designing and performing investigations to study seed germination and the growth of young seedlings; and
- examining the various vegetative propagating organs of flowering plants and structure of flowers.

## Values and Attitudes

Students are encouraged to:

- appreciate the complexity and wonders of life;
- be aware of their physiological and emotional changes during puberty;
- be aware of the importance of birth control in family planning; and
- have due considerations on sex.

Section 7 Reproduction and growth

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 7.1 Types of cell division | • The replication of genetic material taking place before cell division. | | |
| | • An outline of mitotic and meiotic cell division. | • Examining the processes of mitotic and meiotic cell division. | |
| | • The significance of mitotic and meiotic cell division in growth and reproduction. | | |
| 7.2 Asexual reproduction | • The occurrence of asexual reproduction in bacteria. | • Examining binary fission in bacteria. | |
| | • Asexual reproduction in flowering plants by means of vegetative propagation. | • Cultivating any vegetative propagating organ of flowering plants. | • Visiting botanical gardens/farms/plant nurseries to study the application of artificial vegetative propagation in horticulture. |
| | • An outline of the process of vegetative propagation. | • Examining one vegetative propagating organ of flowering plants and identifying the parts in vegetative propagation. | |
| 7.3 Sexual reproduction in flowering plants | • The structure and functions of various floral parts. | • Examining flowers to relate the structure and functions of various floral parts. | • Searching for information on crossing different strains of plants to produce new strains. |
| | • Insect pollination and wind pollination. | | |
| | • The adaptive features of insect-pollinated flowers and wind-pollinated flowers. | • Examining the adaptive features of insect-pollinated flowers and wind-pollinated flowers. | |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 7.4 Sexual reproduction in humans | • The process of fertilisation.<br>• The formation of fruits and seeds after fertilisation.<br>• The advantages and disadvantages of sexual reproduction as compared with asexual reproduction.<br>• The general plans of male and female reproductive systems and the functions of various parts.<br>• The structure of sperm and ovum.<br>• The development of secondary sexual characteristics as induced by sex hormones.<br>• The menstrual cycle: the periodic changes in uterine lining in relation to the time of ovulation.<br>• The transfer of semen during sexual intercourse and the process of fertilisation.<br>• The formation of identical twins and fraternal twins. | • Examining the male and female reproductive systems of dissected mammals or a human torso.<br>• Examining photomicrographs/video clips of sperms and ova. | • Discussing the social and ethical issues related to casual sex. |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| | • The development of the fertilised ovum into an embryo.<br>• The nutrition, gas exchange and excretion of the foetus in relation to the placenta.<br>• The protection of the foetus by the uterus, amniotic fluid and the placenta.<br>• The birth process.<br>• Parental care and its significance.<br>• <u>The advantages of breast-feeding.</u><br>• The biological basis of various methods of birth control. | • Examining photos/video clips taken by ultrasound showing different stages of foetal development. | • Discussing the definitions of life.<br>• Understanding the harmful effects of drinking and smoking habits of a pregnant woman on the development of foetus.<br>• Searching for information on prenatal and postnatal care.<br>• <u>Discussing the pros and cons of breast-feeding.</u><br>• Searching for information on the effectiveness and possible side effects of various birth control methods.<br>• Discussing the social and ethical issues related to artificial insemination, *in vitro* fertilisation, and termination of pregnancy.<br>• Conducting a project work on the causes of infertility and its treatment. |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 7.5 Growth and development | • The concept of growth and development as illustrated by seed germination into a new plant.<br>• The various methods used in the measurement of growth. | • Designing and performing investigations to study seed germination.<br>• Designing and performing investigations to study the growth of young seedlings. | • Searching for information on the physical and physiological problems that may be faced by pregnant women and the possible risks associated with pregnancy. |

# Section 8 Genetics and evolution

## Overview

This section provides students with the basic knowledge of genetics, genetic engineering and evolution. *8.1 Genes and inheritance* emphasises the structural relationship of DNA, genes and chromosome, and the expression of genes through the type of proteins produced. *8.2 The pattern of inheritance* provides students with some common terminology and concepts required for a better understanding of simple Mendelian genetics. The applications of gene manipulation, and their related social and ethical issues are briefly discussed in *8.4 Genetic engineering*. *8.3 Variations* introduces to students the idea of variations within a species, which lays down the foundation for an understanding of *the concepts of evolution (in 8.5)*. This section encourages students to explore the historical development of biological concepts and ideas, e.g. the development of the evolution theory by Darwin and Wallace, the discovery of the patterns of inheritance by Mendel, and the determination of the structure of DNA by Watson and Crick. These would provide students with a better understanding of the nature of science and scientific method.

This section relates to *Biology S4-5 Topics: 1.1 Chemicals of life, 2.2 Classification, 7.1 Types of cell division, 7.3 Sexual reproduction in flowering plants* and *7.4 Sexual reproduction in humans.* The functional roles of DNA in organisms discussed in *Topic 1.1* link with *8.1 Genes and inheritance*. The segregation of homologous chromosomes in meiotic cell division covered in *Section 7* provides students with a better understanding of monohybrid inheritance.



## Skills and Processes

In this section, students will develop the generic skills and scientific process skills as exemplified by:

- solving simple Mendelian genetic problems and analysing pedigree;
- examining fossil records and photomicrographs of human chromosomes;
- conducting project work on the Human Genome Project; and
- searching for information on the work of Watson and Crick, Mendel, Darwin and Wallace.

## Values and Attitudes

Students are encouraged to:

- value the hard work of frontier scientists and their collaborations in the pursuit of knowledge;
- be critical towards scientific evidence and theories;
- value the contributions of science and technology to society;
- be aware of the ethical and social dilemma that may arise from gene manipulation of organisms to meet human needs;
- appreciate that advancement in scientific knowledge requires openness and scepticism; and
- be aware of the contributions of the development of other science disciplines and information technology to the development of biology.

## Section 8 Genetics and evolution

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 8.1 Genes and inheritance | • The structural relationship between DNA, genes and chromosome.<br>• The expression of gene, which controls the types of protein produced.<br>• Down syndrome, colour blindness, G6PD (glucose-6-phosphate dehydrogenase) deficiency as examples of inherited disorders in humans.<br>• An awareness of the Human Genome Project. | • Examining photomicrographs of human chromosomes. | • Searching for information on the work of Watson and Crick.<br>• Conducting a project work on the Human Genome Project, discussing the potential benefits and drawbacks. |
| 8.2 The pattern of inheritance | • Monohybrid inheritance.<br>• Phenotypes, genotypes and alleles.<br>• Dominance and recessiveness.<br>• Homozygotes and heterozygotes.<br>• Sex determination in humans.<br>• Pedigree. | • Solving simple Mendelian genetic problems and analysing pedigree. | • Searching for information on the work of Mendel. |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 8.3 Variations | • The occurrence of variations within a species.<br>• Continuous and discontinuous variations.<br>• The causes of variations.<br>• The effects of ionising radiations and chemicals on the chance of the occurrence of mutation. | • Observing and analysing variations in humans; e.g. height variation, tongue rolling. | • Searching for information on the increased chance of mutation as a result of exposure to mutagens, e.g. ultraviolet light, ionising radiation and certain chemicals.<br>• Searching for information on the cases on mutations caused by the uses of chemical and nuclear weapons, and the potential hazards of nuclear plants. |
| 8.4 Genetic engineering | • The variations caused by human manipulation of genes.<br>• The use of genetically modified plants and animals in food production, and its implications.<br>• The use of genetically modified bacteria in the production of insulin, and its implications. | | • Discussing or debating on the issues related to genetically modified food and genetic engineering.<br>• Searching for information on the application of genetic engineering in the pharmaceutical industry. |

| Topics | Knowledge and Understanding | Skills and Processes | STS Connections |
|---|---|---|---|
| 8.5 Evolution | • Fossil records as one of the clues revealing different life forms once appeared on Earth.<br><br>• The concept of evolution:<br>  • organisms evolving from simple to complex life forms,<br><br>  • the significance of variations within a species, and<br><br>  • the role of natural selection. | • Examining fossil records. | • Searching for information on extinct organisms, e.g. dinosaurs.<br><br>• Searching for information on how misuse of antibiotics can speed up the evolution of resistant bacteria (e.g. vancomycin resistant strains).<br><br>• Searching for information on the work of Darwin and Wallace, and identifying the differences between Darwin's theory and other conflicting theories. |

# III. LEARNING AND TEACHING

**Learning** is a process of an individual's acquisition and construction of knowledge, as well as co-participation in cultural practices by which knowledge is created. Active participation in various kinds of learning activities fosters construction of meanings by the learners. The effectiveness of learning does not solely depend on teaching methods. Teaching activities are equally important. Learning and teaching are interactive processes; they involve complex and dynamic relationships between the individual learner, the teacher, and the learning context. By adopting appropriate teaching approaches and strategies in suitable learning contexts, with clear goals and expectations of learning, learners will be motivated to take an active role in the learning processes.

**Students** should be placed at the centre of learning. As active learners, students should initiate, organise, make decisions on and take responsibility for their own learning. To foster the ownership of learning, students need to be guided to, and engaged in setting goals, developing their criteria of assessment and evaluating their progress in learning. The feeling of ownership generates enthusiasm. When students start to believe in themselves, confidence grows. This in turn breeds positive feelings and motivation, resulting in effective learning. Collaborative learning that allows students to contribute various ideas at different levels should be encouraged. Learning from peers and collaboration provides the emotional basis to boost motivation and learning. Skills and habits developed in this active learning process are essential for students to become life-long learners.

**Teachers** should be well acquainted with the aims and objectives of the biology curriculum and plan meaningful learning activities for their fulfilment. Teachers play various roles in the learning and teaching processes, from a transmitter of knowledge to resource person, facilitator, consultant, counsellor, and assessor. They should employ a variety of teaching approaches and strategies to achieve the different purposes of learning. Teachers should motivate students through a variety of ways, such as sharing with them the learning intentions, encouraging the involvement of students in the learning and teaching processes, considering their emotional reactions, meeting their interest and building learning and teaching on their successful experiences.

**The Core and Extension** components in this curriculum provide a flexibility to cater for students of different abilities and needs. Students may choose to concentrate on the Core, or take the whole curriculum for a greater challenge. Appropriate adaptations should be made in the curriculum to cater for individual needs and, where appropriate, teachers may wish to provide additional materials for capable students who can quickly master all the concepts and processes required. Such materials may go beyond the confines of curriculum prescription and textbook, and enrich the quality of learning experiences for the gifted students and science enthusiasts.

## *Use of learning and teaching resources*

A diversity of learning and teaching resources should be used to enhance the effectiveness of learning. Life-wide learning opportunities should be provided to widen the exposure of students to the scientific world. Examples of learning programmes include popular science lectures, debates and forums, issue-based learning, co-curricular activities, field studies, museum visits, invention activities, science competitions, projects and exhibitions. Community resources, e.g. field studies centres, country and marine parks, education centres at Island House and Mai Po, government departments like the Environmental Protection Department, the Agriculture, Fisheries and Conservation Department, can provide life-wide learning contexts and rich learning resources to facilitate learning and to complement self-learning. Students with higher abilities or a strong interest in science may need more challenging learning experiences which can stretch their science capabilities and offer opportunities for them to reach the fullest potential.

The judicious use of audiovisual materials lets students experience a world beyond the classroom and gives visual realisations of abstract ideas and concepts. Many videotaped science programmes provide good teaching materials and help students keep abreast of the latest scientific and technological developments. Teachers are encouraged to bring these programmes to the attention of their students, and follow up with discussions that help them relate these to the curriculum and make learning more relevant and interesting. Newspaper articles are good resource materials. Students can collect cuttings on topics of interest such as ozone depletion in the earth's atmosphere, or the Human Genome Project, as an extension of their learning processes.

## *Information technology for interactive learning*

Information technology for interactive learning complements strategies of learning inside and outside the classroom. Computers can be used to support scientific investigations, e.g. data loggers can be used for data acquisition and analysis in biology experiments, both indoor and outdoor. Students can also create data tables, plot the results, and find out mathematical relationships, e.g. in measuring the growth rate or tropic movement of plants. Computer programmes may be used to simulate animal dissections, laboratory experiments or environmental scenarios, e.g. the process of natural selection could be simulated by using appropriate software. The Internet is a particularly valuable source of scientific information and resources that facilitates student learning. The Internet can provide opportunities for students to learn, sometimes collaboratively with students in another part of the world. The use of information technology in learning 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.

## *Contextual approach*

When the study of biology is related to students' everyday life, it will be more relevant and meaningful to them. Therefore, where possible, teachers should adopt a contextual approach, which helps students integrate their everyday life experiences into their learning of biological concepts, skills and attitudes. The STS Connections suggest ideas that link biology to technological applications, societal issues and daily experiences of students. It provides an excellent context where students will experience biology as interesting and dynamic. Teachers could introduce biology topics from areas of contact with students' lives, thus enhancing students' motivation to inquire, apply and reflect on what they have learned. Through a systematic inquiry as guided by teachers, students should be able to acquire, in a step-wise manner, the relevant concepts, skills and attitudes. To maximise learning effectiveness, both the learning contexts and inquiry activities should be built upon the existing knowledge, ideas and experiences of the students.

*Example:*

In *Topic 2.3 The ecosystem*, the activities suggested in STS Connections are visiting Nature Reserves, marine parks and other local field sites. These activities let students come into close contact with real animals and plants in the field, and help them achieve a better understanding of the interactions of organisms and their environment in the habitat.

## *Historical approach*

Biology, as well as other disciplines of science, is built upon the combined efforts and the accumulated wisdom of scientists through scientific processes. Incorporating the historical development of biological knowledge in various parts of the biology curriculum provides students with a better understanding of the nature of science. By referring to the stories of some famous biologists, students can relive their lives: the ways they thought, the work they did, and the joy and frustrations they experienced. It is important that the focus of these studies should be on analyses and deductions using evidence derived from experimental work. Students should not be expected to study all these examples, or to link the names with particular pieces of work or to be familiar with details of techniques. Teachers can use historical stories to elaborate various aspects of scientific inquiry, and biology in different historical and cultural perspectives. This may foster a positive attitude towards the learning of biology. In addition, students should be aware of the contributions of other science disciplines, e.g. physics and chemistry, to the development of biological knowledge.

*Suggested areas for studying the historical development of biological ideas:*

- the work on vaccination by Jenner
- the experiments on garden peas by Mendel
- the work on the double helix model of DNA by Watson and Crick
- the theory of natural selection by Darwin and Wallace

## *Practical work and scientific investigations*

Biology is a practical subject and thus practical work is essential for students to gain personal experiences of science through hands-on activities, and to develop the skills and thinking processes associated with the practice of science. Participation in these activities encourages students to bring scientific thinking to the processes of problem-solving, decision-making and evaluation of evidence. Practical activities should be integrated with the learning of scientific principles as far as possible, so that students can associate their experimental findings with what they have learned. Teachers are encouraged to design a wide range of practical activities, from practical work such as dissection and observation of plant and animal cells to open-ended investigations into, for example, the effect of changing environmental conditions on the rate of photosynthesis.

Scientific investigations involve defining problems, formulating hypotheses, designing and conducting investigations, and interpreting results. Instead of solely for verification purposes, these kinds of activities allow students to understand how science is done, 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 the processes of inquiry, experimental design, investigation, and analysis are as important as finding correct answers. Students will master much more than facts and manipulative skills, and they will learn to be critical thinkers.

A balanced biology teaching schedule should be organised to have a significant amount of practical and investigative work so that students are provided with opportunities to develop their higher order thinking skills as well as practical skills. Teachers may design or adopt practical work and investigations to bring out the elements of learning in an effective manner. In particular, practical work and investigations closely related to relevant contexts will certainly 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 so that any potential risks can be revealed and avoided.

### *Group discussion/Role-play/Debate*

Group discussion, role-play and debate, which allow students to be actively engaged in the learning process, are effective ways to motivate learning and to develop generic skills such as collaboration, communication, critical thinking, and problem-solving. Students are involved in the processes of researching and analysing information, organising and presenting ideas in a clear and logical manner, and making judgements from arguments. It is 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 of a specific case and some time to do individual thinking. They are then divided into groups to express their opinions and exchange views. Students should be encouraged to interact with each other and the teacher plays the role of a facilitator who guides students to work along the right direction, and provides feedback on their performance. These activities provide meaningful contexts for students to explore the viewpoints of different roles. By role-playing different characters in some given situations involving biological, environmental or ethical issues, students can explore the experiences and viewpoints of these characters and, by trying to justify their behaviours, widen the perspective of the matter being considered.

## *Project learning*

Project work provides inviting and productive learning experiences, and bridges the gap between learning in school and learning in the real world. It enables students to connect knowledge, skills, values and attitudes, and to construct knowledge through a variety of learning experiences. Project work usually completes within a reasonable time frame, ranging from a week to a term, depending on its nature. It usually consists of several stages, including planning (goal setting, identifying foci of projects), gathering (researching, finding resources, collecting data), processing (analysing, sorting and synthesising information), and applying (prioritising tasks, reviewing, revising, evaluating), and the final stage of presentation may be done in the form of a book report, multimedia presentation, poster design or model construction. Group projects can be arranged to develop students' collaboration and study skills. Suggested project work ideas are listed in the STS Connections column of each section. Teachers should select some of these ideas to enhance biology learning in suitable contexts, and provide opportunities for students to learn by conducting individual or group project work on particular biology and cross-curricular topics or issues.

*Suggested ideas for project work:*

- discovery of cells or developments of the microscope
- the variety of living organisms found locally in Hong Kong
- ciguatoxin or pesticide poisoning
- biological pest control
- the effects of pollutants on air quality or water quality
- how a greenhouse works in enhancing plant growth
- the effects of drug abuse on body organs, particularly the brain
- health issues related to the skeleton and muscles
- the Human Genome Project

## *Problem-based learning*

Problem-based learning is an instructional method that challenges students to "learn to learn", and to work cooperatively in groups to seek solutions to real world problems. It allows students to think critically and analytically, and to find and use appropriate learning resources. Problems are used to engage students' curiosity and initiate learning of the subject matter. During the process of solving problems, students learn new knowledge, problem-solving skills and associated skills of teamwork, leadership, and communication. It may start with a

poorly defined or open-ended problem, or a real-life scenario. Students work collaboratively to define the problem, generate questions, hypothesise, anticipate needed information, generate alternatives, and develop solutions to the problem. Teachers become facilitators of learning and observers of students' contributions and participation. Students are motivated by actively engaging in the learning process and taking responsibility for their own learning.

*Example:*

In *Topic 8.1 Genes and inheritance*, teachers could use the following question as a starting point for discussion:

"The progress of the Human Genome Project is up to a stage that, perhaps in the not-so-distant future, geneticists are able to locate particular genes and decode their genetic information. People will have the option to find out if they have any genetic defects before they decide to have a child. Would you prefer to know the genome of yourself, your family members and 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, legal and societal issues related to the Human Genome Project?"

## *Issue-based learning*

Issues result from differences in opinion about what is true or what should be done. Issue-based learning allows students to learn in a meaningful context. The incorporation of the STS Connections in the study of biology helps students bring together the scientific knowledge or concepts they have acquired and the societal implications of using technology. These issues contain moral and value components that provide students with opportunities to consider the implications of various points of view in the light of fundamental societal values such as respect for life, respect for others, respect for the environment, freedom, justice, etc. Some issues may be rather sensitive, e.g. "the origins of life", which involve religious perspectives and deeply held viewpoints and beliefs. Teachers should ensure that the issues are treated sensitively and rationally, and provide ample opportunities for students to share their personal opinions and beliefs, rather than imposing their own values on their students who should be exposed to all other perspectives and viewpoints.

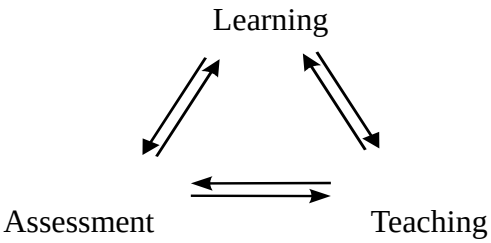
*Example:*

In *Topic 8.4 Genetic Engineering,* the issue "Should genetic engineering be supported or opposed?" could be raised for discussion.

This issue involves the concept of heredity, the principles, technology and applications of recombinant DNA, societal implications such as future benefits and potential hazards to health and environment, and the religious and ethical points of view.

# IV. ASSESSMENT

Assessment, the practice of collecting evidence of students' progress in learning, aims for the improvement of learning and teaching. As an integral part of the learning and teaching cycle, it should not be treated as a separate stage at the end of teaching, nor should it be taken as a synonym to "marking".

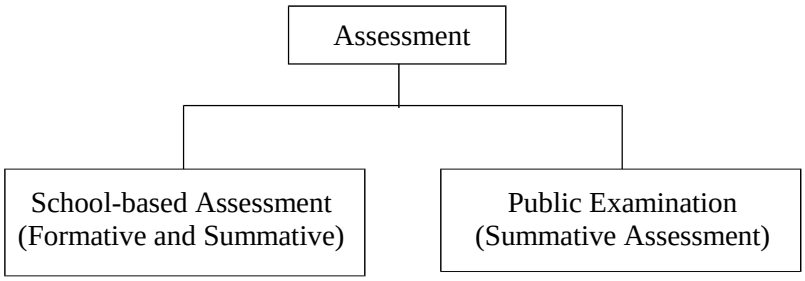



Assessment provides:

- information for teachers to help them identify students' needs and to assess the progress of students' development of skills, understanding, attitudes, and interest;
- information for students about their mastery and growth, and their strengths and weaknesses;
- a basis for grading students, reporting their progress, and helping them set realistic goals for future undertakings; and
- information that can be used to help revise teaching strategies and the curriculum.

## A. Formative assessment and summative assessment

There are various categorisations of types of assessment, formative assessment and summative assessment are two common types of assessment. Each type has its own niche and serves different and distinct purposes. However, they complement each other and should both be used to form a comprehensive profile of a student's achievements.



**Formative assessment is assessment for learning,** and is a day-to-day ongoing process happening all the time. Formative assessment should be based on learning intentions developed by the collaborative efforts of both students and teachers. The learning intentions should be geared to the aims and objectives of the curriculum. Specific comments and feedback should be made to students reflecting how well they have accomplished the learning intentions. Based on these comments and feedback, students would be able to develop plans for improvement and teachers would be able to adjust their teaching plans or strategies to enhance students' learning. Oral questioning, observation of students, project work, practical work and assignments are common modes of formative assessment. Written tests can also be a mode of formative assessment, provided that specific comments and feedback are given to the students.

**Summative assessment is assessment of learning.** It is usually applied at the end of a term or a unit. It provides information about what students have learned. Tests and examinations in schools as well as public examinations, which are common examples of summative assessment, measure students' standards or attainments, and report them in terms of marks or grades. However, since summative assessment could not provide an immediate feedback for improvement in learning and teaching, it should not be treated as the only means of assessment.

## B. School-based assessment and public examinations

School-based assessment refers to all sorts of assessment that are administered in schools. It has advantages of flexibility and intimacy with the learning and teaching processes. It could be more informative to students and teachers involved in the teaching and learning cycle than public examinations, as the assessment task can be designed to match students' learning experiences.

Public examinations provide information about the standards and achievements of students based on the aims and objectives of the curriculum guides. They are intended to provide fair testing of all students for the purposes of certification and selection. Apart from these functions, the public examinations can also have a positive backwash on learning and teaching by setting questions on authentic contexts and assessing higher order cognitive abilities, thus contributing to assessment for learning. Feedback provided in the annual subject reports provides valuable information for teachers to adjust teaching with a view to improving student learning.

## C. Guiding principles for assessment

1. Assessment should aim at enhancing the self-esteem and motivation of an individual student.

2. Teachers should develop a learning culture that values the attitudes to learning with trusting relationships.

3. Teachers should take into consideration the prior knowledge and previous learning experiences of students when setting assessment tasks.

4. Assessment tasks should take into account the aims and objectives outlined in the biology curriculum guide. In particular, the three domains of objectives: knowledge and understanding, skills and processes, and values and attitudes, should be addressed.

5. A variety of assessment modes should be adopted to cater for the diverse needs, abilities, strengths and weaknesses of students, e.g. projects, observation, tests, examinations, practical work, and portfolios.

6. Self-assessment and peer assessment should be encouraged, with a view to empowering students to assess their own achievements and those of their peers against learning intentions. Self-assessment provides an insight into how students perceive their own progress, thus promoting reflective thinking and self-improvement, which are desirable qualities of independent learning. Peer assessment allows a student to reflect from other perspectives how well one has performed, and how to perform even better through learning from each other.

7. Unexpected outcomes should be anticipated from students who sometimes do not follow the prescribed path of learning. Assessment might lead to a disclosure of such unexpected learning outcomes.

## D. Assessment modes

A number of assessment modes can be used in the learning and teaching of secondary school biology. Teachers should have well-thought-out plans on how to assess students' achievements and let students know how they will be assessed.

### 1. Paper-and-pencil tests

Paper-and-pencil tests have been widely employed as the major methods of assessment within schools. However, the prolonged reliance on this type of assessment would have a narrowing effect on learning. Teachers should avoid testing only basic information recall and should try to construct test items that assess the understanding of concepts, and encourage problem-solving abilities and higher order thinking skills. Incorporation of open-ended questions in tests and examinations could help evaluating students' creative and critical thinking skills.

*Example:*

In *Topic 8.4 Genetic Engineering*, the following question could be set:

"*Discuss the use of genetically modified plants and animals in food production.*"

When answering the question, students might

- consider the scientific facts and evidence on genetically modified food;
- evaluate the potential benefits and hazards;
- evaluate the ethical issues associated with genetic modification; and
- make informed decisions.

Their critical thinking skills could thus be developed and assessed.

Teachers should analyse students' performance in tests and examinations, and use the information for future planning as well as helping students to identify what or where their strengths and weaknesses are.

## 2. Oral questioning

Oral questioning can provide teachers with specific information on how the students think in certain situations. Students' responses often provide clues to their strengths, weaknesses, misunderstanding, level of understanding, interest, attitudes and abilities. Teachers are encouraged to use a wide range of questions from fact finding, problem posing, reason seeking to those that promote higher levels of thinking, and allow for a variety of acceptable responses. Teachers should allow time for students to respond and listen carefully to their responses. Questions or problems, based on information which is unfamiliar to students, could be set. Such questions can assess students' abilities to apply principles and concepts they learned to a novel situation in a logical and deductive manner.

*Example:*

In *Section 2 Organisms and their environment*, teacher could raise the following questions:

- "Based on what you know about the energy flow between different trophic levels, what do you think about the efficiency of food production by growing crops and rearing livestock?"

- "What would happen in ten years' time if we do not take any measure to protect our environment now?"

## 3. Observation

While students are working in groups or individually, teachers could take the opportunity to observe and note various aspects of students' learning. Teachers should keep brief anecdotal records and use such information for making further judgements about students' learning.

Some suggested aspects that teachers could focus on during observation include:

*In practical sessions*

- the use of equipment and apparatus
- the safety measures and precautions taken
- the activities preferred
- how students collect, record and interpret data
- the interaction among students

*In other situations such as group discussions or presentations*

- the strategies students take to solve problems
- how students listen to, negotiate and compromise with others
- their attitudes to work, e.g. perseverance, organisation, initiative, independence, and willingness to address difficulties

## 4. Project work

Project work, a powerful learning and teaching strategy as well as assessment strategy, promotes self-directed, self-regulated and self-reflecting learning. It provides ample opportunities for students to apply what they have learned, and employ various skills and thinking processes such as identifying problems, formulating hypotheses, designing and implementing strategies and evaluation. It also provides a real context to authentically assess students' achievements in a variety of generic skills, e.g. student's creativity, communication skills, collaboration skills, willingness to share, to listen, and problem-solving abilities. Teachers can make use of the suggested project work listed in the STS Connections column of each section, and develop appropriate criteria to assess the ideas being formed, skills being developed, and values and attitudes being demonstrated by students during the process of doing project work.

## 5. Assignment

The assignment, widely used in the learning and teaching processes, is a good tool of formative assessment as it continuously reflects students' efforts, achievements, strengths and weaknesses. A variety of assignment tasks should be designed to allow students to express their thoughts, ideas, creativity and originality upon their understanding of concepts. These include essays, laboratory reports, exercises, poster or leaflet design, and model construction. The assignment tasks should be aligned with the learning objectives, instructional strategies and learning activities. Specific comments, feedback and suggestions for improvement should be given to inform students of their progress.

Teachers could ask students to select a topic of interest among the STS Connections for information search. Students are required to summarise their findings and devise their own ways to present their work, e.g. role play, essay, poster design. Teachers should take note of how students organise the materials, the language used, the breadth and depth of the treatment, and the clarity of concepts. As a means of evaluation, assignment can also reflect the

effectiveness of teaching, and provide feedback upon which teachers can set further target for students, and make appropriate adjustments in their teaching.

## 6. Practical work and scientific investigation

Practical work, an essential element in the study of biology, provides a meaningful context for students to apply their knowledge and skills. It offers students hands-on experiences to explore or investigate, and opportunities to show their resourcefulness, interest, ingenuity, originality, creativity, appreciation and perseverance. Teachers can use appropriate criteria and standards to assess students' scientific knowledge, application of the scientific method, ability to handle data, awareness of safety, as well as interest and enthusiasm in the work being done. Students' written laboratory or investigation reports can serve as an effective means of assessing students' performance in scientific activities and provide a more complete picture about student learning.

## 7. Concept mapping

Concept mapping is an effective way of allowing students to think aloud and actively make sense of what they have learned. Concept maps are useful in providing teachers and students with an understanding of prior knowledge, and the conceptual gains that are made during a unit of study.

*Example:*

In *Topic 2.2 Classification of organisms*, teachers could ask students to

- brainstorm ideas in the mind,
- write down what they know about living things and the diversity of organisms, and
- use a concept map to relate these ideas.

Teachers then use the concept maps constructed as a starting point for discussion and teaching. The maps are then revised and refined throughout the learning process, and used as a tool to clarify and organise the concepts formed.

## 8. Portfolio

Portfolio is a way of documenting students' learning and keeping records of students' work as they progress throughout the year. It aims to show the continuous effort of the students. Samples of student work should be collected at regular intervals and dated, forming a cumulative file. A student's work folder provides evidence of student achievements of specified competencies, and information on the level of understanding, the logical thought processes, and the need for remediation, consolidation or extension work. It also allows students to discuss their achievements and difficulties with their teachers, parents and fellow students. Laboratory reports, biological drawings, newspaper cuttings, concept maps, projects, exercises and written assignments could all be included in the portfolio to document changes in breadth and depth of students' understanding.

## 9. Computer-based assessment

Computer-based assessment is a tool that promotes self-directed and self-reflecting learning. The use of computer programmes enables students to choose among a question bank, and assess what they have learned throughout the learning and teaching processes. The computer-marked assessment on screen allows students to make decisions at their own pace and in the comfort of privacy. Students can gain an instant feedback on whether the choices were the best ones, and why other choices were not so good or entirely wrong, and learn from their mistakes.

The modes of assessment suggested above are by no means exhaustive. All assessment data collected should be treated as valuable information and contribute to the improvement of learning and teaching. Adopting a combination of assessment modes enables teachers to build up a comprehensive picture of students' achievements. Teachers should explore other assessment opportunities to best suit the needs of their schools and students.

# Appendix: Reference Books

| Title | Author | Publisher | Year of Publication |
|---|---|---|---|
| An Introduction to Genetic Engineering (Studies in Biology) | Nicholl, D.S. | Cambridge University Press | 1994 |
| Anatomy and Physiology in Health and Illness (8th Edition) | Wilson, K.J.W. & Waugh, A. | Churchill Livingstone | 1996 |
| Animal Biology | Jurd, R.D. | BIOS Scientific Publishers | 1997 |
| Applied Ecology | Allen, D., Jones, M. & Williams, G. | Cambridge University Press | 2001 |
| Assessing Student Learning: from Grading to Understanding | Allen, D. (Ed.) | Teachers College Press | 1998 |
| Biodiversity | Wilson, E.O. | National Academic Press | 1989 |
| Biological Science 1 & 2 (3rd Edition) | Green, N.P.O., Stout, G.W., Taylor, D.J. & Soper, R. | Cambridge University Press | 1998 |
| Biology | Mawby, P.J. & Roberts, M.B.V. | Longman | 1991 |
| Biology (4th Edition) | Solomon, E.P., Berg, L.R., Martin, D.W. & Villee, C. | Saunders College | 1998 |
| Biology 1 & 2 | Jones, M. & Gregor, J. | Cambridge University Press | 2001 |
| Biology AS | Baile, M. & Hirst, K. | Collins | 2001 |
| Biology Now! | Riley, P.D. | John Murray | 1998 |
| Biology: A Functional Approach (4th Edition) | Roberts, M.B.V. | Thomas Nelson | 1991 |
| Biology: Principles and Processes | Roberts, M., Reiss, M. & Monger, G. | Thomas Nelson | 1993 |
| Biology: The Network of Life | Mix, M.C., Farber, P. & King, K.I. | Harper Collins | 1992 |
| Biotechnology: Selected Topics | Teasdale, J. | Cheltenham Thornes | 1987 |

| Title | Author | Publisher | Year of Publication |
|---|---|---|---|
| Chemistry for Biologists | Fisher, J. & Arnold, J.R.P. | BIOS Scientific Publishers | 1999 |
| Complete Biology | Pickering, W.R. | Oxford University Press | 2000 |
| Current Trends in Biology | Riggs, A., Farmer, B. & Olejnik, I. M. | Stanley Thornes | 1993 |
| DNA Fingerprinting (2nd Edition) | Krawczak, M. & Schmidtke, J. | BIOS Scientific Publishers | 1998 |
| DNA Sequencing: From Experimental methods to Bioinformatics | Alphey, L. | BIOS Scientific Publishers | 1997 |
| Ecology | Mackenzie, A., Ball, A.S. & Virdee, S.R. | BIOS Scientific Publishers | 1998 |
| Evolution | Gamlin, L. | Dorling Kindersley | 1993 |
| Five Kingdoms: An Illustrated guide to the Phyla of Life on Earth (3rd Edition) | Margulis, L. & Schwartz, K.V. | Freeman | 1998 |
| GCSE Science Double Award Biology | Gater, S. & Wood-Robinson, V. | John Murray | 1996 |
| Genetics | Winter, P.C., Hickey, G.I. & Fletcher, H.L. | BIOS Scientific Publishers | 1998 |
| Good Practice in Science Teaching: What research has to say | Monk, M. & Osborne, J. (Ed.) | Open University Press | 2000 |
| Growth, Development and Reproduction | Taylor, D. | Cambridge University Press | 2001 |
| How Nature Works | Burnie, D. | Dorling Kindersley | 1999 |
| Human Anatomy & Physiology (2nd Edition) | Carola, R., Harley, J.P. & Noback, C.R. | McGraw-Hill | 1992 |
| Immunology | Lydyard, P.M., Whelan, A. & Fanger, M.W. | BIOS Scientific Publishers | 2000 |
| Investigating formative assessment | Torrance, H. & Pryor, J. | Open University Press | 1998 |

| Title | Author | Publisher | Year of Publication |
|---|---|---|---|
| Investigations | Kanuffman, S.A. | Oxford University Press | 2000 |
| Issues in Science Education | Rhoton, J. & Bowers, P. (Ed.) | The National Science Teachers Association | 1996 |
| Laboratory Manual for Human Anatomy & Physiology | Bruce, A.S., Cocanour, B., Namm, T. & Farina, J.P. | McGraw-Hill | 1992 |
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