وزارة التعليم

الإطار المنهجي لمادة الأحياء

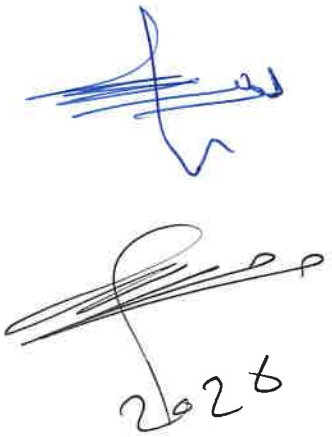
الصفوف (11–12) – البرنامج ثنائي اللغة

2027/2026م

Biology Curriculum Framework

Grades (11-12) - Bilingual Program

2026\2027



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Introduction

Science plays a major role in the evolution of knowledge. It empowers us to use creative and independent approaches to problem solving. It arouses our natural curiosity and enables us to meet diverse and ever-expanding challenges. It enhances our ability to inquire, seek answers, research, and interpret data. These skills lead to the construction of theories and laws that help us to explain natural phenomena and exercise control over our environment. Science is, thus, an integral component of a balanced education.

This curriculum framework focuses on the content essential for preparing students to be engaged and productive citizens. A good foundation in the sciences will help citizens to respond to the challenges of a rapidly changing world using the scientific approach. It addresses, in addition to a specific knowledge base, the development of related skills and attitudes. Critical thinking, enquiry and reasoning are emphasized to ensure that students develop the ability to work creatively, think analytically and solve problems. The curriculum also ensures that students become aware of their moral, social, and ethical responsibilities, as well as the benefits intrinsic to the practical application of scientific knowledge to careers in the scientific field. Teaching these standards requires teaching methods that are varied and experiential. Effective lessons will concert and incorporate with: Practical work and the science standards, the place of information and communications technology in the science standards, teaching about science, technology and society, the mathematical requirements of the science standards**.**

The overall aims of science standards are that students should:

1. develop and sustain an interest in science and its applications.
2. have a sound and systematic knowledge of important scientific facts, concepts, and principles, and possess the skills needed to apply these in new and changing situations in a range of personal, domestic, industrial, and environmental contexts.
3. recognize the importance of the application of scientific knowledge in the modern world and be aware of the moral, ethical, social and environmental implications.
4. develop relevant attitudes, such as a concern for accuracy and precision, objectivity, integrity, enquiry, initiative, and inventiveness.
5. develop an understanding of the scientific skills essential for both further study and everyday life.
6. plan, design and perform experiments to test theories and hypotheses.
7. be proficient in the use of a range of scientific methods and techniques and in handling apparatus.
8. develop the ability to work independently and collaboratively with others when necessary.
9. integrate Information and Communication Technology (ICT) tools and skills**.**

Important Skills

The Biology Curriculum aims to enable students to achieve academic success in science while equipping them with the skills needed to develop scientific thinking. It prepares them to pursue further studies and to participate effectively in a knowledge-based society, regardless of their future academic or career pathways.

- **Scientific enquiry skills:** Scientific enquiry, which ensures the development of scientific skills, intellectual and practical, should be integrated in the learning of the scientific content across all the science branches. Scientific enquiry skills include the following:

1. carry out the practical experiments to develop the practical skills which will be mentioned in detail below.
2. find secondary information sources such as the resources available in the public libraries and on the Internet and use these after validation and making sure of the suitability of the subject.
3. apply Scientific knowledge and procedures to the situations of the reality Life.
4. recognizes the importance of cooperative teamwork, put work plans, distributes responsibilities, and regulates and sets specific targets for work.

- **Know how scientists are working:**

1. realize that with science we can bring great benefits to humanity also if it is abused can cause serious damage to the environment.
2. know how scientists are carrying out their work, such as environmental monitoring and control of industrial processes.
3. know how scientists publish and present their ideas and results to encourage debate and development.
4. know that science could lead to the emergence of ethical considerations and discuss them.
5. know that there are many questions and considerations that cannot be answered by science.
6. trace the historical development of some key scientific models and knows what contributions Scientists presented in this development.

- **Processing and delivery of information**

1. present qualitative and quantitative data using a variety of methods, such as descriptive texts, graphics, images, tables, and maps with the use of technology methods and computer when it is appropriate, then analyse and explain this date to extract conclusions from them.
2. use mathematical relationships routinely to calculate the quantities.
3. do calculations based on data taken from the graphs and distinguishes between Independent and dependent variables.
4. handle data and writes reports about the results.
5. use symbolic equations to represent chemical reactions and simple physical relationships.
6. use the appropriate methods to deliver scientific information.

- **ICT application:**

This syllabus provides students with a wide range of opportunities to use ICT in their study of science to play a full part in modern society, students need to be confident and effective users of ICT. Opportunities for ICT include:

1. gathering information from the internet, DVDs, and CD-ROMs.
2. using spreadsheets and other software to process data.
3. using animations and simulations to visualize scientific ideas.
4. using software to present ideas and information on paper and on screen.

Skills and abilities to be assessed:

Students' learning is assessed based on the assessment objectives outlined in the Student Assessment Handbook for Science (Grades 11–12) for Private Schools, issued by the Directorate General of Educational Assessment. The handbook is circulated through the official correspondence system and is also available on the Educational Portal (www.moe.gov.om). It should be consulted when planning and implementing assessment practices in science subjects at this level (Grades 11-12).

Grade 11 Syllabus

The study of biology subject leads to an understanding and appreciation of the concept of life at all levels and, hence, to a greater respect and reverence for life. Students of Biology should recognize the enormous responsibility they must undertake to ensure the continuity of life in all its forms. It is incumbent on them to use this knowledge to protect, sustain, conserve, and improve the variety of life in the ecosphere. Additionally, the study of Biology prepares students for careers in biological, agricultural, environmental, medical, paramedical, and applied science.

Aims: Biology syllabus enables students to:

1. acquire a body of knowledge and develop an understanding of biological concepts and principles.
2. develop the ability to apply biological knowledge and skills essential for both further studies as well as in everyday life situations.
3. recognize the dynamic nature of the interrelationships between organisms and their environment.
4. develop a natural curiosity about living organisms and a respect for all living things and the environment.
5. understand how new information results in reformulation or rejection of earlier models and concepts.
6. recognize the scope of Biology from the molecular level to that of entire ecosystems.
7. develop an ability to communicate biological information in a variety of acceptable ways.
8. acquire an understanding of the scientific method and be able to apply it to solving problems, both in academic and non-academic settings.
9. appreciate the impact of biological knowledge on society and its relevance to ethical, economic, environmental, and technological issues.
10. acquire training in the practical skills and thought processes associated with the study of science.

How to use grade 11 syllabus

This syllabus is arranged according to the following manner:

- **Outcomes:**

Indicate the scope of the content, including practical work which will be examined as well. However, practical work should not necessarily be limited to these objectives.
The numbering key: [Unit–Learning outcome]
e.g., 2.1: Unit 2. (Biological molecules); and 1 is the first learning outcome (describe a semi-quantitative Benedict's test on a reducing sugar solution, including standardizing the test and using the results (time to first color change or comparison to color standards) to estimate the concentration).

- **Practical experiments and activities:**

Show some examples of active learning activities and do not represent full -scale activities can be done. It is recommended that all of the suggested laboratory-related activities, such as conducting experiments, must be done. Other activities like making field trips and viewing audio-visual materials, can be done also. Consider the sufficient time to carry out the practical experiments determined in this syllabus and explained in detail in the student textbook and in the teacher guide and training students in practical skills related to them. The teachers should get benefit from the student textbook, teacher's resources pack from Hodder Education and teacher's digital resources from Cambridge that are recommended by MOE in the approved books list.

- **Resources for teachers to upgrade their knowledge and skills**

The main resources for the teachers are the textbook and the teacher's guides. The two recommended teacher's guides in the approved books list (teacher's resource pack from Hodder Education and teacher's guide CD-ROM from Cambridge) provide the needed support for the teachers. They include the following:

1) Teaching guide for each chapter includes teaching plan for the chapter with resources available for each topic in the chapter, introduction about the topic, topic summary, suggested teaching methods, key terms, common misunderstandings and misconceptions, methods for supporting struggling students, methods for challenging high achievers, homework suggestions and suggested activities and practical.
2) Answers to examination style questions (end-of-chapter questions).
3) Extra activities.
4) Homework with answer scheme.
5) Practical guidance.

6) Suggested websites.
7) Revision checklist.
8) Interactive tests.
9) Copies of diagrams and tables from textbook.
10) Useful appendix.

There is also a list of approved supplementary resources for teachers that support them in their teaching. These resources include:

1) Cambridge International AS & A Level Complete Biology (Student Book) from Oxford University Press which is compulsory for all teachers.
2) Biology for Cambridge International AS & A Level Practical Workbook from Cambridge University Press which is compulsory for all teachers.
3) Biology for Cambridge International AS & A Level Workbook from Cambridge University Press which is optional for teachers.
4) Cambridge International AS & A Level Biology Practical Skills from Hodder Education which is optional for teachers.
5) Cambridge International AS & A Level Biology Students Book Whiteboard eTextbook from Hodder Education which is optional for teachers.

Some other resources as websites are listed in this syllabus can provide support for teachers for this syllabus. Some of these resources are interactive and the animations are suitable for this syllabus. The range of resources covers a large area of this syllabus so it is well worth exploring these sites before the course starts to discover relevant resources that can be used or recommended to students when appropriate.

Topics	Learning Outcomes – Semester One - Grade 11
1. **Cell structure**	1.1 Make temporary preparations of cellular material suitable for viewing with a light microscope. 1.2 Draw cells from light microscope slides and photomicrographs. 1.3 Calculate magnifications of drawings and images and calculate actual sizes of specimens from scale drawings, photomicrographs and electron micrographs (scanning and transmission). 1.4 Use an eyepiece graticule and stage micrometer scale to make measurements and use the appropriate units, millimeter (mm), micrometer (μm) and nanometer (nm). 1.5 Identify organelles and other cell structures found in eukaryotic cells that can be seen under a light microscope, and outline their structures and functions, limited to: • cell surface membrane • nucleus • Golgi apparatus • Mitochondria • Centrioles • Chloroplasts • cell wall • tonoplast and large permanent vacuole of plant cells 1.6 Identify the additional organelles and other cell structures found in eukaryotic cells that can be seen under an electron microscope, and outline their structures and functions, limited to: • nuclear envelope and nucleolus • rough endoplasmic reticulum • smooth endoplasmic reticulum • cristae and the presence of small circular DNA in mitochondria

Topics	Learning Outcomes – Semester One - Grade 11
	• ribosomes (80S in the cytoplasm and 70S in chloroplasts and mitochondria) • lysosomes • microtubules • cilia • microvilli • thylakoid membranes and the presence of small circular DNA in chloroplasts • plasmodesmata. 1.7 Describe and interpret photomicrographs, electron micrographs and drawings of typical plant and animal cells. 1.8 Compare the structure of typical plant and animal cells. 1.9 state that cells use ATP from respiration for energy-requiring processes. 1.10 Outline key structural features of a prokaryotic cell as found in a typical bacterium, including: • unicellular • generally, 1–5 μm diameter • peptidoglycan cell walls • circular DNA • 70S ribosomes • absence of organelles surrounded by double membranes.

Topics	Learning Outcomes – Semester One - Grade 11
	1.11 Compare the structure of a prokaryotic cell as found in a typical bacterium with the structures of typical eukaryotic cells in plants and animals. 1.12 State that all viruses are non-cellular structures with a nucleic acid core (either DNA or RNA) and a capsid made of protein, and that some viruses have an outer envelope made of phospholipids.
2. Biological molecules	2.1 Describe a semi-quantitative Benedict's test on a reducing sugar solution, including standardizing the test and using the results (time to first color change or comparison to color standards) to estimate the concentration. 2.2 Describe a test to identify the presence of non-reducing sugars, using acid hydrolysis and Benedict's solution. 2.3 Describe and draw the ring forms of α-glucose and β-glucose. 2.4 Define the terms *monomer*, *polymer*, *macromolecule*, *monosaccharide*, *disaccharide* and *polysaccharide.* 2.5 State the role of covalent bonds in joining smaller molecules together to form polymers. 2.6 State that glucose, fructose and maltose are reducing sugars and that sucrose is a non-reducing sugar. 2.7 Describe the formation of a glycosidic bond by condensation, with reference to disaccharides, including sucrose, and polysaccharides. 2.8 Describe the breakage of a glycosidic bond in polysaccharides and disaccharides by hydrolysis, with reference to the non-reducing sugar test. 2.9 Describe the molecular structure of the polysaccharides starch (amylose and amylopectin) and glycogen and relate their structures to their functions in living organisms. 2.10 Describe the molecular structure of the polysaccharide cellulose and outline how the arrangement of cellulose molecules contributes to the function of plant cell walls. 2.11 State that triglycerides are non-polar hydrophobic molecules and describe the molecular structure of triglycerides with reference to fatty acids (saturated and unsaturated), glycerol and the formation of ester bonds. 2.12 Relate the molecular structure of triglycerides to their functions in living organisms. 2.13 Describe the molecular structure of phospholipids with reference to their hydrophilic (polar) phosphate heads and hydrophobic (non-polar) fatty acid tails. 2.14 Describe and draw:

Topics	Learning Outcomes – Semester One - Grade 11
	• the general structure of an amino acid • the formation and breakage of a peptide bond 2.15 Explain the meaning of the terms *primary structure*, *secondary structure*, *tertiary structure* and *quaternary structure* of proteins. 2.16 Describe the types of interaction that hold protein molecules in shape: • hydrophobic interactions. • Hydrogen bonding. • Ionic bonding. • Covalent bonding including disulfide bonds. 2.17 State that globular proteins are generally soluble and have physiological roles and fibrous proteins are generally insoluble and have structural roles. 2.18 Describe the structure of a molecule of haemoglobin as an example of a globular protein, including the formation of its quaternary structure from two alpha (α) chains (α–globin), two beta (β) chains (β–globin) and a haem group. 2.19 Relate the structure of haemoglobin to its function, including the importance of iron in the haem group. 2.20 Describe the structure of a molecule of collagen as an example of a fibrous protein, and the arrangement of collagen molecules to form collagen fibers. 2.21 Relate the structures of collagen molecules and collagen fibers to their function. 2.22 Explain how hydrogen bonding occurs between water molecules and relate the properties of water to its roles in living organisms, limited to solvent action, high specific heat capacity and latent heat of vaporization.
3. Enzymes	3.1 State that enzymes are globular proteins that catalyze reactions inside cells or are secreted to catalyze reactions outside cells. 3.2 Explain the mode of action of enzymes in terms of an active site, enzyme–substrate complex, lowering of activation energy and enzyme specificity, in terms of the induced-fit hypothesis.

Topics	Learning Outcomes – Semester One - Grade 11
	3.3 Describe how to investigate the progress of enzyme-catalyzed reactions by measuring rates of formation of products using catalase and rates of disappearance of substrate using amylase. 3.4 Outline the use of a colorimeter for measuring the progress of enzyme-catalyzed reactions that involve color changes. 3.5 Explain and describe how to investigate the effects of the following factors on the rate of enzyme-catalyzed reactions: • enzyme concentration. • Substrate concentration. • Inhibitor concentration. 3.6 Explain that the maximum rate of reaction (V_{max}) is used to derive the Michaelis–Menten constant (K_m), which is used to compare the affinity of different enzymes for their substrates. 3.7 Explain the effects of reversible inhibitors, both competitive and non-competitive, on enzyme activity. 3.8 Describe the different modes of action an enzyme immobilized in alginate and the same enzyme free in solution and state the advantages of using immobilized enzymes.
4. The cell cycle and mitosis	4.1 Describe the structure of a chromosome, limited to: • DNA • Histon proteins • Sister chromatids • Centromere • Telomeres 4.2 Explain the importance of mitosis in the production of genetically identical daughter cells during: • growth of multicellular organisms.

Topics	Learning Outcomes – Semester One - Grade 11
	• Replacement of damaged or dead cells • Repair of tissues by cell replacement • Asexual reproduction. 4.3 Outline the cell cycle including: • interphase (G1, S, and G2 phases) • mitosis • cytokinesis. 4.4 Outline the role of telomeres in preventing the loss of genes from the ends of chromosomes during DNA replication. 4.5 Outline the role of stem cells in cell replacement and tissue repair by mitosis. 4.6 Explain how uncontrolled cell division can result in the formation of a tumor. 4.7 Describe the behavior of chromosomes in plant and animal cells during mitosis and the cell cycle and the associated behavior of the nuclear envelope, the cell surface membrane and the spindle (names of the main stages of mitosis are expected: *prophase*, *metaphase*, *anaphase* and *telophase*). 4.8 Interpret photomicrographs, diagrams and microscope slides of cells in different stages of a cell cycle including the main stages of mitosis.

Topics	Learning Outcomes – Semester Two – Grade 11
5. cell membrane and transport	5.1 Describe the fluid mosaic model of membrane structure with reference to the hydrophobic and hydrophilic interactions that account for the formation of the phospholipid bilayer and the arrangement of proteins. 5.2 Describe the arrangement of cholesterol, glycolipids and glycoproteins in cell surface membranes. 5.3 Describe the roles of phospholipids, cholesterol, glycolipids, proteins and glycoproteins in cell surface membranes, with reference to stability, fluidity, permeability, transport (carrier proteins and channel proteins), cell signaling (cell surface receptors) and cell recognition. 5.4 Outline the main stages in the process of cell signaling leading to specific responses: • secretion of specific chemicals (ligands) from cells • transport of ligands to target cell • binding of ligands to cell surface receptors on target cells. 5.5 Describe and explain the processes of simple diffusion, facilitated diffusion, osmosis, active transport, endocytosis and exocytosis. 5.6 Investigate simple diffusion and osmosis using plant tissue and non-living materials, including dialysis (Visking) tubing and agar. 5.7 Illustrate the principle that surface area to volume ratios decrease with increasing size by calculating surface areas and volumes of simple 3-D shapes. 5.8 Investigate the effect of changing surface area to volume ratio on diffusion using agar blocks of different sizes. 5.9 Investigate the effects of immersing plant tissues in solutions of different water potentials, using the results to estimate the water potential of the tissues. 5.10 Explain the movement of water between cells and solutions in terms of water potential and explain the different effects of the movement of water on plant cells and animal cells (knowledge of solute potential and pressure potential is not expected).

Topics	Learning Outcomes – Semester Two – Grade 11
6 transport in plant	6.6 Draw plan diagrams of transverse sections of stems, roots and leaves of herbaceous dicotyledonous plants from microscope slides and photomicrographs. 6.7 Describe the distribution of xylem and phloem in transverse sections of stems, roots and leaves of herbaceous dicotyledonous plants. 6.8 Draw and label xylem vessel elements, phloem sieve tube elements and companion cells from microscope slides, photomicrographs and electron micrographs. 6.9 Relate the structure of xylem vessel elements, phloem sieve tube elements and companion cells to their functions. 6.10 State that some mineral ions and organic compounds can be transported within plants dissolved in water. 6.11 Describe the transport of water from the soil to the xylem through the: • apoplast pathway, including reference to lignin and cellulose • symplast pathway, including reference to the endodermis, Casparian strip and suberin. 6.7 Explain that transpiration involves the evaporation of water from the internal surfaces of leaves followed by diffusion of water vapour to the atmosphere. 6.8 Explain how hydrogen bonding of water molecules is involved with movement of water in the xylem by cohesion-tension in transpiration pull and by adhesion to cellulose in cell walls. 6.9 Make annotated drawings of transverse sections of leaves from xerophytic plants to explain how they are adapted to reduce water loss by transpiration. 6.10 State that assimilates dissolved in water, such as sucrose and amino acids, move from sources to sinks in phloem sieve tubes. 6.11 Explain how companion cells transfer assimilates to phloem sieve tubes, with reference to proton pumps and cotransporter proteins. 6.12 Explain mass flow in phloem sieve tubes down a hydrostatic pressure gradient from source to sink.

Topics	Learning Outcomes – Semester Two – Grade 11
7 Transport in mammals	7.1 Recognize arteries, veins and capillaries from microscope slides, photomicrographs and electron micrographs and make plan diagrams showing the structure of arteries and veins in transverse section (TS) and longitudinal section (LS). 7.2 Explain how the structure of elastic arteries (e.g. aorta and pulmonary artery), muscular arteries, arterioles, capillaries, venules and veins (e.g. vena cava and pulmonary vein) are each related to their functions. 7.3 State the functions of tissue fluid and describe the formation of tissue fluid in a capillary network. 7.4 Recognize and draw red blood cells, monocytes, neutrophils and lymphocytes from microscope slides, photomicrographs and electron micrographs. 7.5 State that water is the main component of blood and tissue fluid and relate the properties of water to its role in transport in mammals, limited to solvent action and high specific heat capacity. 7.6 Describe the role of red blood cells in transporting oxygen and carbon dioxide with reference to the roles of: • haemoglobin • carbonic anhydrase • the formation of haemoglobinic acid • the formation of carbaminohaemoglobin. 7.7 Describe the chloride shift and explain the importance of the chloride shift. 7.8 Describe the role of plasma in the transport of carbon dioxide. 7.9 Describe and explain the oxygen dissociation curve of adult haemoglobin. 7.10 Explain the importance of the oxygen dissociation curve at partial pressures of oxygen found in the lungs and in respiring tissues. 7.11 Describe the Bohr shift and explain the importance of the Bohr shift. 7.12 Describe the external and internal structure of the mammalian heart. 7.13 Explain the differences in the thickness of the walls of the: • atria and ventricles • left ventricle and right ventricle. 7.14 Describe the cardiac cycle, with reference to the relationship between blood pressure changes during systole and diastole and the opening and closing of valves. 7.15 Explain the roles of the sinoatrial node, the atrioventricular node and the Purkyne tissue in the cardiac cycle.

Topics	Learning Outcomes – Semester Two – Grade 11
8 Gas exchange	8.1 Recognize trachea, bronchi, bronchioles and alveoli in microscope slides, photomicrographs and electron micrographs and make plan diagrams of transverse sections of the walls of the trachea and bronchus. 8.2 Describe the function and distribution of cartilage and smooth muscle in the gas exchange system. 8.3 Outline the distribution of ciliated epithelial cells, goblet cells and mucus and describe their function in maintaining the health of the gas exchange system. 8.4 Describe alveolar adaptations that promote gas exchange, with reference to elastic fibers, squamous epithelium, and the surrounding capillary network. 8.5 Recognize cartilage, ciliated epithelium, goblet cells, squamous epithelium of alveoli, smooth muscle and capillaries in microscope slides, photomicrographs and electron micrographs. 8.6 Describe gas exchange between air in the alveoli and blood in the capillaries, including the maintenance of concentration gradients.

Yearly plan for grade 11

	Grade 11– semester one	No. of Lessons		Grade 11– semester two	No. of Lessons
1	Cell structure	**22**	5	Cell membrane and transport	**20**
2	Biological molecules	**20**	6	Transport in plant	**20**
3	Enzymes	**18**	7	Transport in mammals	**22**
4	Cell cycle and mitosis	**20**	8	Gas exchange	**18**
Total		**80**	Total		**80**

Grade 12 Syllabus

The study of biology leads to an understanding and appreciation of the concept of life at all levels and, hence, to a greater respect and reverence for life. Students of Biology should recognize the enormous responsibility they must undertake to ensure the continuity of life in all its forms. It is incumbent on them to use this knowledge to protect, sustain, conserve, and improve the variety of life in the ecosphere. Additionally, the study of Biology prepares students for careers in biological, agricultural, environmental, medical, paramedical, and applied science.

Aims: Biology syllabus enables students to:

1. acquire a body of knowledge and develop an understanding of biological concepts and principles.
2. develop the ability to apply biological knowledge and skills essential for both further studies as well as in everyday life situations.
3. recognize the dynamic nature of the interrelationships between organisms and their environment.
4. develop a natural curiosity about living organisms and a respect for all living things and the environment.
5. understand how new information results in reformulation or rejection of earlier models and concepts.
6. recognize the scope of Biology from the molecular level to that of entire ecosystems.
7. develop an ability to communicate biological information in a variety of acceptable ways.
8. acquire an understanding of the scientific method and be able to apply it to solving problems, both in academic and non-academic settings.
9. appreciate the impact of biological knowledge on society and its relevance to ethical, economic, environmental, and technological issues.
10. acquire training in the practical skills and thought processes associated with the study of science.

How to use grade 12 syllabus

This syllabus is arranged according to the following manner:

- **Outcomes:**

Indicate the scope of the content, including practical work which will be examined as well. However, practical work should not necessarily be limited to these objectives.

The numbering key: [Unit – Topic –Learning outcome]
e.g., 1.1.1: **Unit 1**. (1. Nucleic Acids and protein synthesis**); Topic 1 (1.1 Structure of DNA and RNA); and 1 is the first learning outcome (1.1.1describe the structure of nucleotides, including the phosphorylated nucleotide ATP.).**

- **Practical experiments and activities:**

Show some examples of active learning activities and do not represent full -scale activities can be done. It is recommended that all of the suggested laboratory-related activities, such as conducting experiments, must be done. Other activities like making field trips and viewing audio-visual materials, can be done also. Consider the sufficient time to carry out the practical experiments determined in this syllabus and explained in detail in the student textbook and in the teacher guide and training students in practical skills related to them. The teachers should get benefit from the student textbook, teacher's guide (CD) from Hodder Education and teacher's resource CD-ROM from Cambridge that are recommended by MOE in the approved books list.

- **Resources for teachers to upgrade their knowledge and skills**

The main resources for the teachers are the textbook and the teacher's guides. The two recommended teacher's guides in the approved books list (teacher's guide (CD) from Hodder Education and teacher's guide CD-ROM from Cambridge) provide the needed support for the teachers. They include the following:

11) Teaching guide for each chapter includes teaching plan for the chapter with resources available for each topic in the chapter, introduction about the topic, topic summary, suggested teaching methods, key terms, common misunderstandings and misconceptions, methods for supporting struggling students, methods for challenging high achievers, homework suggestions and suggested activities and practical.
12) Answers to examination style questions (end-of-chapter questions).

13) Extra activities.
14) Homework with answer scheme.
15) Practical guidance.
16) Suggested websites.
17) Revision checklist.
18) Interactive tests.
19) Copies of diagrams and tables from textbook.
20) Useful appendix.

Some other resources as websites are listed in this syllabus can provide support for teachers for this syllabus. Some of these resources are interactive and the animations are suitable for this syllabus. The range of resources covers a large area of this syllabus so it is well worth exploring these sites before the course starts to discover relevant resources that can be used or recommended to students when appropriate.

Subtopics	Learning Outcomes – Grade 12
Grade 12 - Semester 1	
1. Nucleic acids and protein synthesis	
1.1 Structure of DNA and RNA	1.1.1 Describe the structure of nucleotides, including the phosphorylated nucleotide ATP (structural formulae are not expected). 1.1.2 State that the bases adenine and guanine are purines with a double ring structure, and that the bases cytosine, thymine and uracil are pyrimidines with a single ring structure (structural formulae for bases are not expected). 1.1.3 Describe the structure of a DNA molecule as a double helix, including: • the importance of complementary base pairing between the 5′ to 3′ strand and the 3′ to 5′ strand (antiparallel strands). • differences in hydrogen bonding between C–G and A–T base pairs. • linking of nucleotides by phosphodiester bonds. 1.1.4 Describe the structure of an RNA molecule, using the example of messenger RNA (mRNA).
1.2 DNA replication	1.2.1 Describe the semi-conservative replication of DNA during the S phase of the cell cycle, including: • The roles of DNA polymerase and DNA ligase (knowledge of other enzymes in DNA replication in cells and different types of DNA polymerase is not expected) • The differences between leading strand and lagging strand. • Replication as a consequence of DNA polymerase adding nucleotides only in a 5′ to 3′ direction.
1.3 The genetic code	1.3.1 Describe the principle of the universal genetic code in which different triplets of DNA bases either code for specific amino acids or correspond to start and stop codons. 1.3.2 State that a polypeptide is coded for by a gene and that a gene is a sequence of nucleotides that forms part of a DNA molecule.

1.4 Protein synthesis	1.4.1 Describe how the information in DNA is used during transcription and translation to construct polypeptides, including the roles of: • RNA polymerase • messenger RNA (mRNA) • codons • transfer RNA (tRNA) • anticodons • ribosomes 1.4.2 State that the strand of a DNA molecule that is used in transcription is called the transcribed or template strand and that the other strand is called the non-transcribed or non-template strand. 1.4.3 Explain that, in eukaryotes, the RNA molecule formed following transcription (primary transcript) is modified by the removal of non-coding sequences (introns) and the joining together of coding sequences (exons) to form mRNA.

Subtopics	Learning Outcomes – Grade 12
Grade 12 - Semester 1	
1.5 Gene mutations	1.5.1 State that a gene mutation is a change in the sequence of base pairs in a DNA molecule that may result in an altered polypeptide. 1.5.2 Explain that a gene mutation is a result of substitution or deletion or insertion of nucleotides in DNA and outline how each of these types of mutation may affect the polypeptide produced.
2 Inheritance	
2.1 Gametes and reproduction	2.1.1 Explain the meanings of the terms gene, haploid (n) and diploid (2n). 2.1.2 Explain what is meant by homologous pairs of chromosomes. 2.1.3 Explain the need for a reduction division during meiosis in the production of gametes. 2.1.4 Describe the behavior of chromosomes in plant and animal cells during meiosis and the associated behavior of the nuclear envelope, the cell surface membrane, and the spindle (names of the main stages of meiosis, but not the sub-divisions of prophase I, are expected: prophase I, metaphase I, anaphase I, telophase I, prophase II, metaphase II, anaphase II and telophase II). 2.1.5 Interpret photomicrographs and diagrams of cells in different stages of meiosis and identify the main stages of meiosis.
2.2 The production of genetic variation	2.2.1 Explain that crossing over and random orientation (independent assortment) of pairs of homologous chromosomes and sister chromatids during meiosis produces genetically different gametes, with reference to alleles, linkage, and loci. 2.2.2 Explain that the random fusion of gametes at fertilization produces genetically different individuals.
2.3 Genetics	2.3.1 Explain the meaning of the term's dominant, recessive, codominant, phenotype, genotype, homozygous and heterozygous.
2.4 Inheritance and genetic diagrams	2.4.1 Explain the meaning of the terms test cross, F1, F2 and sex linkage. 2.4.2 Interpret and construct genetic diagrams, including Punnett squares, to explain and predict the results of monohybrid crosses and dihybrid crosses that involve dominance, codominance, multiple alleles, and sex linkage. 2.4.3 Interpret and construct genetic diagrams, including Punnett squares, to explain and predict the results of monohybrid crosses and dihybrid crosses that involve autosomal linkage and epistasis (knowledge of the expected ratios for different types of epistasis is not expected).

Subtopics	Learning Outcomes – Grade 12
Grade 12 - Semester 1	
	2.4.4 Interpret and construct genetic diagrams, including Punnett squares, to explain and predict the results of test crosses.
2.5 Genes, proteins, and phenotype	2.5.1 Explain the relationship between genes, proteins and phenotype. with respect to the: • *TYR* gene, tyrosinase and albinism • *HBB* gene, hemoglobin, and sickle cell anaemia • *F8* gene, factor VIII, and haemophilia • *HTT* gene, huntingtin and Huntington's disease
2.6 Control of gene expression	2.6.1 Describe the differences between structural genes and regulatory genes and the differences between repressible enzymes and inducible enzymes. 2.6.2 Describe genetic control of protein production in a prokaryote using the *lac* operon (knowledge of the role of cAMP is not expected). 2.6.3 State that transcription factors are proteins that bind to DNA and are involved in the control of gene expression in eukaryotes by decreasing or increasing the rate of transcription.
3 Genetic Technology	
3.1 Genetic engineering	3.1.1 Explain the meaning of the term recombinant DNA. 3.1.2 Explain that genetic engineering is the deliberate manipulation of genetic material to modify specific characteristics of an organism and that this may involve transferring a gene into an organism so that the gene is expressed. 3.1.3 Explain that genes to be transferred into an organism may be: • extracted from the DNA of a donor organism • synthesized from the mRNA of a donor organism • synthesized chemically from nucleotides

Subtopics	Learning Outcomes – Grade 12
Grade 12 - Semester 1	
3.2 Tools for the gene technologist	3.2.1 Explain the roles of restriction endonucleases, DNA ligase, plasmids, DNA polymerase and reverse transcriptase in the transfer of a gene into an organism. 3.2.2 Explain why a promoter may have to be transferred into an organism as well as the desired gene 3.2.3 Explain how gene expression may be confirmed using marker genes coding for fluorescent products.
3.3 Separating and amplifying DNA	3.3.1 Describe and explain the steps involved in the polymerase chain reaction (PCR) to clone and amplify DNA, including the role of *Taq* polymerase. 3.3.2. Describe and explain how gel electrophoresis is used to separate DNA fragments of different lengths.
3.4 Genetic technology and medicine	3.4.1 Explain the advantages of using recombinant human proteins to treat disease, using the examples insulin, factor VIII and adenosine deaminase. 3.4.2 Outline the advantages of genetic screening, using the examples of breast cancer (*BRCA1* and *BRCA2*), Huntington's disease and cystic fibrosis. 3.4.3 Discuss the social and ethical considerations of using genetic screening in medicine.
3.5 Genetic technology and agriculture	3.5.1 Explain that genetic engineering may help to solve the global demand for food by improving the quality and productivity of farmed animals and crop plants, using the examples of GM salmon, herbicide resistance in soybean and insect resistance in cotton. 3.5.2 Discuss the ethical and social implications of using genetically modified organisms (GMOs) in food production.

Subtopics	Learning Outcomes – Grade 12
Grade 12 - Semester 1	
4 **Homeostasis**	
4.1 The structure of Kidney	4.1.1 Define homeostasis and state the importance of homeostasis in mammals. 4.1.2 State the principles of homeostasis in terms of internal and external stimuli, receptors, coordination systems (nervous system and endocrine system), effectors (muscles and glands) and negative feedback. 4.1.3 State that urea is produced in the liver from the deamination of excess amino acids. 4.1.4 Describe the structure of the human kidney, limited to: • fibrous capsule • cortex • medulla • renal pelvis • ureter • branches of the renal artery and renal vein 4.1.5 Identify, in diagrams, photomicrographs and electron micrographs, the parts of a nephron and its associated blood vessels and structures, limited to: • Glomerulus • Bowman's capsule • proximal convoluted tubule • loop of Henle • distal convoluted tubule • collecting duct

Subtopics	Learning Outcomes – Grade 12
Grade 12 - Semester 1	
	4.1.6 Describe and explain the formation of urine in the nephron, limited to: • the formation of glomerular filtrate by ultrafiltration in the Bowman's capsule. • selective reabsorption in the proximal convoluted tubule. 4.1.7 Outline how the concentration of urine is regulated, with reference to the loop of Henle, distal convoluted tubule and collecting duct. 4.1.8 Relate the detailed structure of the Bowman's capsule and proximal convoluted tubule to their functions in the formation of urine.
4.2 Control of water content	4.2.1 Describe the roles of the hypothalamus, posterior pituitary gland, antidiuretic hormone (ADH), aquaporins and collecting ducts in osmoregulation.
4.3 The control of blood glucose concentration	4.3.1 Explain how negative feedback control mechanisms regulate blood glucose concentration, with reference to the effects of insulin on muscle cells and liver cells and the effect of glucagon on liver cells. 4.3.2 Describe the principles of cell signaling using the example of the control of blood glucose concentration by glucagon, limited to: • binding of hormone to cell surface receptor causing conformational change • activation of G-protein leading to stimulation of adenylyl cyclase • formation of the second messenger, cyclic AMP (cAMP) • activation of protein kinase A by cAMP leading to initiation of an enzyme cascade. • amplification of the signal through the enzyme cascade as a result of activation of more and more enzymes by phosphorylation. • cellular response in which the final enzyme in the pathway is activated, catalysing the breakdown of glycogen.

Subtopics	Learning Outcomes – Grade 12
Grade 12 - Semester 1	
	4.3.3 Explain the principles of operation of test strips and biosensors for measuring the concentration of glucose in blood and urine, with reference to glucose oxidase and peroxidase enzymes.
4.4 Homeostasis in plants	4.4.1 Describe the structure and function of guard cells. 4.4.2 Explain that stomata respond to changes in environmental conditions by opening and closing and that regulation of stomatal aperture balances the need for carbon dioxide uptake by diffusion with the need to minimize water loss by transpiration. 4.4.3 Describe the mechanism by which stomata open and close (the role of abscisic acid in condition of water stress is not required)
5 Control and coordination	
5.1 Comparing the endocrine and nervous system	5.1.1 Compare the features of the nervous system and the endocrine system

Subtopics	Learning Outcomes – Grade 12
Grade 12 - Semester 1	
5.2 Nervous communication	5.2.1 Describe the structure and function of a sensory neurone and a motor neurone and state that intermediate neurones connect sensory neurons and motor neurons. 5.2.2 Outline the role of sensory receptor cells in detecting stimuli and stimulating the transmission of impulses in sensory neurons. 5.2.3 Describe the sequence of events that results in an action potential in a sensory neurone, using a chemoreceptor cell in a human taste bud as an example. 5.2.4 Describe and explain changes to the membrane potential of neurones, including: • how the resting potential is maintained. • the events that occur during an action potential how the resting potential is restored during the refractory period. • how the resting potential is restored during the refractory period 5.2.5 Describe and explain the rapid transmission of an impulse in a myelinated neurone with reference to saltatory conduction. 5.2.6 Explain the importance of the refractory period in determining the frequency of impulses 5.2.7 Describe the structure of a cholinergic synapse and explain how it functions, including the role of calcium ions.
5.3 Muscle contraction	5.3.1 Describe the ultrastructure of striated muscle with reference to sarcomere structure using electron micrographs and diagrams. 5.3.2 Explain the sliding filament model of muscular contraction including the roles of troponin, tropomyosin, calcium ions and ATP.
5.4 Control and coordination in plants	5.4.1 Explain the role of auxin in elongation growth by stimulating proton pumping to acidify cell walls.

Subtopics	Learning Outcomes – Grade 12
Semester 2	
6. Energy and respiration	
6.1 The need for energy in the living organisms	6.1.1 Outline the need for energy in living organisms, as illustrated by active transport, movement and anabolic reactions, such as those occurring in DNA replication and protein synthesis. 6.1.2 Describe the features of ATP that make it suitable as the universal energy currency. 6.1.3 Explain that ATP is synthesized by: • transfer of phosphate in substrate-linked reactions. • chemiosmosis in membranes of mitochondria and chloroplasts
6.2 Aerobic respiration	6.2.1 State where each of the four stages in aerobic respiration occurs in eukaryotic cells: • glycolysis in the cytoplasm • link reaction in the mitochondrial matrix • Krebs cycle in the mitochondrial matrix • oxidative phosphorylation on the inner membrane of mitochondria. 6.2.2 Outline glycolysis as phosphorylation of glucose and the subsequent splitting of fructose 1,6-bisphosphate (6C) into two triose phosphate molecules (3C), which are then further oxidized to pyruvate (3C), with the production of ATP and reduced NAD. 6.2.3 Explain that, when oxygen is available, pyruvate enters mitochondria to take part in the link reaction. 6.2.4 Describe the link reaction, including the role of coenzyme A in the transfer of acetyl (2C) groups. 6.2.5 Outline the Krebs cycle, explaining that oxaloacetate (4C) acts as an acceptor of the 2C fragment from acetyl coenzyme A to form citrate (6C), which is converted back to oxaloacetate in a series of small steps. 6.2.6 Explain that reactions in the Krebs cycle involve: • decarboxylation • dehydrogenation • the reduction of the coenzymes NAD and FAD • phosphorylation of ADP. 6.2.7 Describe the role of NAD and FAD in transferring hydrogen to carriers in the inner mitochondrial membrane. 6.2.8 Explain that during oxidative phosphorylation: • hydrogen atoms split into protons and energetic electrons. • energetic electrons release energy as they pass through the electron transport chain (details of carriers are not expected) • the released energy is used to transfer protons across the inner mitochondrial membrane.

Subtopics	Learning Outcomes – Grade 12
	Semester 2
	• protons return to the mitochondrial matrix by facilitated diffusion through ATP synthase, providing energy for ATP synthesis (details of ATP synthase are not expected) • oxygen acts as the final electron acceptor to form water. 6.2.9 Describe and interpret investigations using simple respirometers to determine the effect of temperature on the rate of respiration.
6.3 Mitochondrial structure and function	6.3.1 Describe the relationship between the structure and function of mitochondria using diagrams and electron micrographs.
6.4 Respiration without oxygen	6.4.1 Outline respiration in anaerobic conditions in mammals (lactate fermentation) and in yeast, some other microorganisms and some plant cells (ethanol fermentation). 6.4.2 Explain why the energy yield from respiration in aerobic conditions is much greater than the energy yield from respiration in anaerobic conditions (a detailed account of the total yield of ATP from the aerobic respiration of glucose is not expected). 6.4.3 Explain how rice is adapted to grow with its roots submerged in water, limited to the development of aerenchyma in roots, ethanol fermentation in roots and faster growth of stems. 6.4.4 Describe and interpret investigations using redox indicators, including DCPIP and methylene blue, to determine the effects of temperature and substrate concentration on the rate of respiration of yeast.

Subtopics	Learning Outcomes – Grade 12
Semester 2	
7 Photosynthesis	
7.1 The structure and function of chloroplast	7.1.1 Describe the relationship between the structure of chloroplasts, as shown in diagrams and electron micrographs, and their functions. 7.1.2 State that within a chloroplast, the thylakoids (thylakoid membranes and thylakoid spaces), which occur in stacks called grana, are the site of the light-dependent stage and the stroma is the site of the light-independent stage. 7.1.3 Describe the role of chloroplast pigments (chlorophyll a, chlorophyll b, carotene and xanthophyll) in light absorption in thylakoids. 7.1.4 Interpret absorption spectra of chloroplast pigments and action spectra for photosynthesis. 7.1.5 Describe and use chromatography to separate and identify chloroplast pigments (reference should be made to Rf values in identification of chloroplast pigments) and interpret results.
7.2 The light-dependent stage of photosynthesis	7.2.1 State that cyclic photophosphorylation and non-cyclic photophosphorylation occur during the light-dependent stage of photosynthesis. 7.2.2 Explain that in cyclic photophosphorylation: • only photosystem I (PS I) is involved. • photoactivation of chlorophyll occurs. • ATP is synthesized. 7.2.3 Explain that during photophosphorylation: • energetic electrons release energy as they pass through the electron transport chain (details of carriers are not expected) • the released energy is used to transfer protons across the thylakoid membrane. • protons return to the stroma from the thylakoid space by facilitated diffusion through ATP synthase, (chemiosmosis), providing energy for ATP synthesis (details of ATP synthase are not expected). 7.2.4 Explain that in non-cyclic photophosphorylation: • photosystem I (PSI) and photosystem II (PSII) are both involved. • photoactivation of chlorophyll occurs. • the oxygen-evolving complex catalysis the photolysis of water.

Subtopics	Learning Outcomes – Grade 12
Semester 2	
	• ATP and reduced NADP are synthesized. 7.2.5 Explain that energy transferred as ATP and reduced NADP from the light-dependent stage is used during the light-independent stage (Calvin cycle) of photosynthesis to produce complex organic molecules
7.3 The light-independent stage of photosynthesis	7.3.1 Outline the three main stages of the Calvin cycle: • rubisco catalysis the fixation of carbon dioxide by combination with a molecule of ribulose bisphosphate (RuBP), a 5C compound, to yield two molecules of glycerate 3-phosphate (GP), a 3C compound. • GP is reduced to triose phosphate (TP) in reactions involving reduced NADP and ATP. • RuBP is regenerated from TP in reactions that use ATP. 7.3.2 State that Calvin cycle intermediates are used to produce other molecules, limited to GP to produce some amino acids and TP to produce carbohydrates, lipids and amino acids.
7.4 Limiting factors in photosynthesis	7.4.1 Explain the effects of changes in light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis, with reference to limiting factors. 7.4.2 Describe and interpret investigations using whole plants, including aquatic plants, to determine the effects carbon dioxide concentration on the rate of photosynthesis. 7.4.3 Describe and interpret investigations using redox indicators, including DCPIP and methylene blue, and a suspension of chloroplasts to determine the effects of light wavelength on the rate of photosynthesis.

Subtopics	Learning Outcomes – Grade 12
Semester 2	
8 Infectious Diseases and Immunity	
8.1 Infectious diseases	8.1.1 State that infectious diseases are caused by pathogens and are transmissible. 8.1.2 State the name and type of pathogen that causes each of the following diseases: • malaria – caused by eucaryotic *Plasmodium* parasites • HIV/AIDS – caused by the human immunodeficiency virus (HIV) • tuberculosis (TB) – caused by *Mycobacterium* bacteria. 8.1.3 Explain how malaria, TB and HIV are transmitted. 8.1.4 Discuss the biological, social and economic factors that need to be considered in the prevention and control of malaria, TB and HIV (details of the life cycle of the malarial parasite are not expected).
8.2 Antibiotics	8.2.1 Outline how penicillin acts on bacteria and why antibiotics do not affect viruses 8.2.2 Discuss the consequences of antibiotic resistance and the steps that can be taken to reduce its impact.
8.3 Defense against disease	8.3.1 Explain what is meant by an antigen and state the difference between self-antigens and non-self-antigens.
8.4 Cells of the immune system	8.4.1 Describe the mode of action of phagocytes (macrophages and neutrophils). 8.4.2 Describe the sequence of events that occurs during a primary immune response with reference to the roles of: • macrophages • B-lymphocytes, including plasma cells. • T-lymphocytes, limited to T-helper cells and T-killer cells. 8.4.3 Explain the role of memory cells in the secondary immune response and in long-term immunity. 8.4.4 Relate the molecular structure of antibodies to their functions
8.5 Active and passive immunity	8.5.1 Describe the differences between active immunity and passive immunity and between natural immunity and artificial immunity. 8.5.2 Explain that many vaccines contain antigens that stimulate immune responses to provide long-term immunity.

Subtopics	Learning Outcomes – Grade 12
Semester 2	
	8.5.3 Explain how vaccination programs can help to control the spread of infectious diseases.
9 Classification, biodiversity and conservation	
9.1 Classification	9.1.1 Discuss the meaning of the term species, limited to the biological species concept, morphological species concept and ecological species concept. 9.1.2 Describe the classification of organisms in the Eukarya domain into the taxonomic hierarchy of kingdom, phylum, class, order, family, genus and species. 9.1.3 Describe the classification of organisms into three domains: Archaea, Bacteria and Eukarya. 9.1.4 Describe that Archaea and Bacteria are prokaryotes and that there are differences between them, limited to differences in membrane lipids, ribosomal RNA and composition of cell walls. 9.1.5 Outline the characteristic features of the kingdoms Protista, Fungi, Plantae and Animalia. 9.1.6 Outline how viruses are classified, limited to the type of nucleic acid (RNA or DNA) and whether this is single stranded or double stranded.
9.2 Biodiversity	9.2.1 Explain that biodiversity can be assessed at different levels, including: • the number and range of different ecosystems and habitats • the number of species and their relative abundance • the genetic variation within each species. 9.2.2 Explain the meaning of the terms ecosystem and niche. 9.2.3 Explain the importance of random sampling in determining the biodiversity of an area. 9.2.4 Describe and use suitable methods to assess the distribution and abundance of organisms in an area, limited to line transects, and mark-release-recapture using the Lincoln index (the formula for the Lincoln index will be provided).

Subtopics	Learning Outcomes – Grade 12
Semester 2	
9.3 Maintaining Biodiversity	9.3.1 Explain why populations and species can become endangered or extinct as a result of: • climate change • competition • hunting by humans • degradation and loss of habitats. 9.3.2 Outline reasons for the need to maintain biodiversity.
9.4 Maintaining species numbers	9.4.1 Outline the roles of zoos, botanic gardens, conserved areas (including national parks and marine parks), frozen zoos' and seed banks, in the conservation of species. 9.4.2 Describe methods of assisted reproduction used in the conservation of mammals, limited to IVF, embryo transfer and surrogacy. 9.4.3 Explain reasons for controlling invasive alien species.
9.5 International conservation Organizations	9.5.1 Outline the role in conservation of the International Union for the Conservation of Nature (IUCN) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Yearly plan for grade 12

	Grade 12– semester one	No. of Lessons		Grade 12– semester two	No. of Lessons
1	Nucleic Acids and protein synthesis	**15**	**6**	Energy and respiration	**20**
2	Inheritance	**20**	**7**	Photosynthesis	**18**
3	Gene Technology	**20**	**8**	Infectious Diseases and Immunity	**22**
4	Homeostasis	**12**	**9**	Classification, Biodiversity and conservation	**20**
5	Control and Coordination	**13**			
Total		**80**	**Total**		**80**

General Important notes:

- **Each teacher must ensure that he/she has the two approved books for GED in biology, Cambridge and Hodder.**
- **Each teacher must cover all the outcomes of this syllabus using the two approved books Cambridge and Hodder**
- **Each student must have one of the approved books either Cambridge or Hodder**

Resources for teachers to upgrade their knowledge and skills

Teacher support	http://www.cie.org.uk/teaching-and-learning/
How to teach	https://www.international.heacademy.ac.uk/
Past paper resource	http://papers.xtremepapers.com/CIE http://papers.xtremepapers.com/CIE/Cambridge%20International%20A%20and%20AS%20Level/

Teaching strategies	http://www.teachthought.com/pedagogy/instructional-strategies/50-teaching-strategies-to-jumpstart-your-teacher-brain/
Syllabus topics and interactive resources	1. www.abpischools.org.uk/age-range/16-19 2. www.bbsrc.ac.uk/engagement/schools/keystage5/ 3. www.johnkyrk.com 4. www.cellsalive.com 5. www.dnalc.org 6. www.garlandscience.com 7. biology-pages.info 8. illuminatepublishing.com 9. www.microbiologyonline.org.uk 10. www.nuffieldfoundation.org/practical-biology 11. www.hoddereducation.co.uk 12. www2.estrellamountain.edu/faculty/farabee/biobk/biobooktoc.html 13. www.saps.org.uk/secondary 14. www.biology.arizona.edu 15. www.cellimagelibrary.org 16. www.rothamsted.ac.uk/notebook/index.php?area=&page 17. www.arkive.org

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End of Biology Syllabus