

AM SYLLABUS (2008-2010)

BIOLOGY

AM 05

SYLLABUS

Biology AM 05 Syllabus	(Available in September) Paper I(3hrs)+Paper II(3 hrs)+Paper III(1½ hrs)+Paper IV: Practical(1½ hrs)
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The syllabus content is divided into 11 sections, which constitute the syllabus core. *(No options are required).*

Aims

To develop an understanding of biological facts, principles and concepts.

To promote an appreciation of the importance of observation and experimental work in the study of biology.

To train students to understand, select, organize and analyze relevant information and to communicate ideas coherently.

To help generate conceptual and practical skills as a result of involvement in scientific activity and experimentation.

To inculcate in students a respect for all forms of life and a respect for the uniqueness of individual organisms.

To promote an interest in, and enjoyment of the study of life processes and living organisms.

To develop an understanding of the technological applications and of the social, economic and environmental aspects of biology.

Scheme of Assessment

The examination will consist of four papers. In these papers the learning objectives will be as follows:

Knowledge of facts and theories;

Comprehension of this knowledge;

Application of knowledge to new and concrete situations;

Ability to analyze the subject matter and to deduce relationships between its component parts:

Synthesis of the above components into new and meaningful relationships:

Evaluation of material using coherent and explicit criteria.

Mathematical skills: to include the ability to display and interpret data in the form of bar graphs, histograms, pie charts and graphs, and scatter diagrams; a knowledge and application of the following concepts: correlation, normal distribution, mean and standard deviation, probability levels. Use of Chi Square and Student's t-test as specified in the respective sections 7.3.2 and 10.1.

Mathematical formulae will be included in the examination scripts. Candidates may make use of scientific calculators during all their examinations.

Paper 1- 3 hours

This will consist of a number of compulsory structured questions covering any section of the syllabus.

Paper 2 - 3 hours

This will consist of three sections.

Candidates will be required to answer two compulsory questions from Section A, one of which will be a comprehension.

They will be required to choose two out of four questions in Section B which will be of the essay type.

Section C will cover any section of the syllabus where candidates will be required to answer one out of two questions. These will be structured essay questions.

Paper 3 - 1.5 hours

Paper 3 will be based on practical work related to the theory sections of the syllabus. It will consist of a number of compulsory questions designed to test the candidates' experience of practical skills, techniques and investigations, data analysis as well as their ability to use particular items of laboratory equipment. Questions will test the ability to observe accurately, make drawings of biological material from photographs or diagrams and to demonstrate an understanding of practical techniques relevant to the syllabus. Candidates will be tested on their ability to plan and to carry out laboratory experiments, to design an investigation and to record and interpret the results obtained. They should show an ability to evaluate their work critically and to suggest improvements to the techniques used. Candidates may also be required to use or construct dichotomous keys and to classify organisms in accordance to Section 1 of the syllabus.

Paper 4 -1.5 hours

Candidates will be allowed to proceed with this paper only if they submit to the examiners their original laboratory and practical reports which have been properly certified by their tutors (See section on Practical Work below). These practical reports will be marked by MATSEC examiners so that a 10 mark allocation is given according to the quality of the practical workbook(s) as described below.

This practical Hands-on part of this paper will involve experimental work and observations to be carried out in a laboratory. It will consist of one question – involving an experiment to test the ability to follow laboratory instructions, to design experiments, to make accurate observations, to record their observations in an appropriate manner and to interpret and analyze, experimental data. Questions may require candidates to perform a simple experiment, to make observations from whole specimens or from microscopic preparations, to prepare temporary microscope mounts, to dissect parts of a flowering plant, fruit or a mammalian organ. Candidates are expected to know how to make good and effective use of both low and high power microscope.

Candidates are expected to bring their dissection kit to the examination.

Practical Work and Practical Workbook(s)

Both laboratory and field work should form the basis of the course. Candidates are required to submit their original practical reports (workbook(s)), properly certified by their tutors, to be examined by the MATSEC examiners, to the MATSEC Office or as instructed by a given date. They will not be allowed to proceed with Paper 4 if they fail to do so, or if they fail to satisfy the examiners that these practical reports are their own original work. 10/50marks will be allotted to the quality of the practical workbooks (*consisting of a minimum of 25 practicals*) in the following manner:

10 marks: Good Practical book(s), a record completely covering all sections of the syllabus but with a considerable amount of additional material, i.e. critical appreciation of physiological exercises is expected and fieldwork, if carried out, must be more than just an account of a field course.

8 marks: Above average practical book(s), a record completely covering all sections of the syllabus but showing evidence of additional effort extra notes, drawings, experiments or fieldwork.

6 marks: Average Practical book(s), a virtually complete record covering all sections of the syllabus. Labels complete and physiological exercises written up.

4 marks: Below average Practical book(s), a virtually complete record covering all sections of the syllabus but lacking in quality, care, labels or corrections.

2 marks: Poor Practical book(s), incomplete (i.e. does not cover all sections of the syllabus)

Private candidates should make arrangements with a school to gain the practical experience required.

The whole examination assessment procedure is being summarized below:

PAPER	TIME	MAX %MARK
I	3 hr	100
II	3 hr	100
III	1.5 hr	50 (Written practical-based exam)
IV	1.5 hr	50 (Experiment exam (40) + Practical workbook (10))

The table below shows the estimated percentage weighing for each respective syllabus area. These estimated values are intended to offer some guidance as to the amount of time to be allotted to the theory to be taught, and to the approximate overall weighting to be given to these areas in examination papers 1 and 2.

SYLLABUS AREA	PERCENTAGE WEIGHTING
PLANT AND ANIMAL PHYSIOLOGY	30 %
GENETICS, BIOTECHNOLOGY AND EVOLUTION	24 %
BIOCHEMISTRY	15 %
CLASSIFICATION	6 %
CELL STRUCTURE, DIVISION AND MATERIAL	10 %
ECOLOGY	15%

SYLLABUS

The following sections of the syllabus are not meant to be treated separately and independently of each other. On the contrary, the teaching of Biology should aim at the appreciation of unified biological principles. The notes in italics are meant for general guidance only.

SECTION 1 – THE VARIETY OF LIVING ORGANISMS

1.1 An understanding of the term biological diversity as the variety of life in all its forms, levels and combinations [*See supplementary note at the end of syllabus*]. This understanding may be expressed at three levels: species diversity [*Section 1*]; Ecosystem diversity [*Section 11*] and genetic diversity [*Section 7*].

1.2 Definition of species according to the biological species concept. Principles of systematics and biological nomenclature. Use of and construction of dichotomous keys to identify organisms.

1.3 Viruses and virions. Structure of viruses using a bacteriophage and a retrovirus as examples. Main distinguishing features between viruses and living organisms. Details of lytic and lysogenic life cycles are expected.

1.4 The main characteristics of the five kingdoms: Prokaryota; Protoctista; Fungi; Plantae and Animalia (*Classification is human based and not a self-established natural condition. Thus it must be appreciated that it is only as accurate as the current knowledge of each group of organisms allows*). Three domain system of classification is not required.

1.5 Students should understand the meaning of and appreciate the evolutionary significance of the following terms:

- 1) radial and bilateral symmetry
- 2) diploblastic and triploblastic organisation
- 3) acoelomate and coelomate body plans
- 4) metameric segmentation
- 5) jointed appendages
- 6) the pentadactyl tetrapod limb
- 7) prokaryotic and eukaryotic cells
- 8) endosymbiotic origin of plastids and mitochondria.

1.6 Diagnostic structural features of different groups:

1.6.1 General features of prokaryotes as illustrated by *Escherichia coli*. *No reference to archaeans is required.*

1.6.2 General features of the protoctists should be illustrated through 1) algal protoctists to include a green and a brown alga and 2) protozoan protoctists to include a ciliate (*Life cycles are NOT required*).

1.6.3 The animal kingdom (Animalia): definition to include absence of cell walls, heterotrophy, motility, cephalisation, presence of blastula stage in early development (*only definition of blastula is required – further developmental stages, unless included below, not required*).

CNIDARIA: radial symmetry, diploblastic organisation, thread cells (nematocytes, cnidocytes) with thread capsules (nematoblasts, cnidoblasts), nervous system as a network of nerve fibres. Exemplified by a Hydrozoan such as *Obelia* with a polymorphic life cycle with dominant polyp stage where the medusa stage has no oral tentacles and a Scyphozoan such as *Aurelia* with a dominant medusoid stage having well developed oral tentacles.

PLATYHELMINTHES: simplest phylum with consistently bilateral symmetry and triploblastic acoelomate organisation, cephalisation, presence of flame cells (*details of function not required*), ciliated ectoderm. Exemplified by a parasitic form such as digenetic trematode OR a tapeworm and a free-living form such as a triclad.

ANNELIDA: Segmented coelomate organisation; chaetae. Exemplified by an Oligochaete with simple chaetae and poorly developed cephalisation and a Polychaete with well developed cephalisation often with cephalic tentacles and parapodia bearing numerous chaetae.

ARTHROPODA: Tagmatisation; haemocoel, exoskeleton and articulated appendages, compound eyes in most groups. Exemplified by the following groups:

Crustacea, with two pairs of antennae, normally having gills associated with paired appendages; exemplified by an aquatic type such as a crab or a shrimp and a terrestrial type such as the woodlouse.

Insecta, with three distinct tagmata, single pair of antennae, three pairs of thoracic walking limbs, generally, two pairs of wings emerging from the 2nd and 3rd thoracic segments and tracheal system; incomplete and complete metamorphosis as exemplified by a locust and a butterfly respectively.

Arachnida, with two tagmata, lack of antennae, simple eyes. Exemplified by a spider and a scorpion.

MOLLUSCA: Lack of visible segmentation, presence of shell in most forms. Exemplified by a Gastropod normally exhibiting marked torsion and a Bivalve having two hinged lateral shells and reduced cephalisation.

ECHINODERMATA: Secondary radial (pentamerous) symmetry, loss of cephalisation, dermal skeleton, tube feet. Exemplified by an Asteroid (starfish) with well developed “arms” and carnivorous habit and an Echinoid lacking “arms” and generally herbivorous and markedly spiny.

CHORDATA: Pharyngeal gill-slits, dorsal nerve cord, notochord and post-anal tail as basic characteristics. Exemplified by the following groups of Vertebrata:

Osteichthyes (bony fish), exemplified by a teleost with rayed fins, scaly skin, aquatic habit, swim bladder and gills.

Amphibia, with aquatic gilled larvae and air-breathing adults with lungs.

Reptilia, laying cleidoic eggs and with scaly skin.

Aves, with forelegs adapted into wings for flying, loss of teeth, hollow bones, air sacs.

Mammalia, with hairy skin and, generally viviparous development.

Internal structural features need only be considered if diagnostic of a group. In the case of vertebrates, the transition from finned aquatic types to tetrapods and of ectothermic to endothermic forms should be mentioned but without going into details for the purposes of this section.

1.6.3 The plant kingdom (*here restricted to the embryophytes*). Definition to include presence of cell-walls, plasmodesmata permitting intercellular exchange, plastids with double membrane and containing chlorophylls *a* and *b* (as in the green algae). Should also be studied, through examples, so as to illustrate (1) alternation of generations and (2) changes that are related to adaptation to terrestrial life.

Plant groups should include:

BRYOPHYTA: Dominant gametophyte with consequent dependence on open water. Exemplified by a moss.

TRACHEOPHYTA: With dominant sporophyte having a well developed vascular system and trend towards reduction of the gametophyte, thus increasing independence from open water. The concept, with definitions, of homosporous and heterosporous. To be exemplified by the following groups.

Polypodiophyta (= Filicophyta; the ferns), Vascular sporophytes but still “free sporing” with spores germinating into simple free-living gametophytes (prothalli). To be exemplified by a homosporous fern such as *Polypodium* or *Dryopteris*.

Pinophyta (conifers), gymnosperm characters, particularly pollen (containing male gametophyte) directly reaching the ovule, and “cones” (strobili) of two types: ovulate (“female”) and pollen bearing (“male”). To be exemplified by a pine (*Pinus*).

Magnoliophyta (angiosperms = flowering plants), angiosperm characters such as enclosed ovules, thus cannot be reached directly by the pollen, and the flower (as a mixed “cone”); definition of monocot and dicot.

Wherever possible, locally occurring species should be chosen to illustrate the variety within groups.

The system of classification proposed in R.S.K. Barnes (Ed.) The Diversity of Living Organisms, Blackwell Science Ltd. 1998, may be used as a guide for teachers.

SECTION 2 – CELLULAR ORGANIZATION AND FUNCTION

2.1 Cell structure and function. Prokaryotic and Eukaryotic cells. The structure of a generalized plant and animal cell should be understood as revealed by both light and electron microscopy.

Organelles should include the nucleus and nuclear envelope, centrioles, basal bodies, eukaryotic flagella (undulipodia), endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes, mitochondria, chloroplasts, ribosomes and cytoskeleton.

The fluid mosaic model of cellular membranes as revealed by freeze-etching (*knowledge of other cytological techniques is not required*). Movement of molecules across membranes. Diffusion, osmosis, primary and secondary active transport, endocytosis including (*excluding receptor-mediated endocytosis*) and exocytosis.

Experimental techniques used in cell study, to include use of the light microscope, preparation of temporary slides, hand sectioning of plant tissues, examination of permanent slides of plant and animal tissues using low and high power of the light microscope. Animal tissues to be examined should include the following epithelia: squamous, cuboidal, columnar, pseudostratified and stratified.

2.2 Basic biomolecules and their role in life processes. The unique properties of water, its dipolar nature, importance as a solvent and its biological significance. Carbohydrates to include monosaccharides (including hexoses and pentoses), disaccharides (including sucrose, maltose and lactose) and polysaccharides (including starch, glycogen and cellulose).

Lipids to include aliphatic acids (=fatty acids), propane-1,2, 3-triol (= glycerol), triglycerides and their roles as energy stores.

Phospholipids, hydrophilic and hydrophobic properties. Steroids.

Amino acids, peptide linkages and polypeptide chains, proteins. Primary, secondary, tertiary and quaternary structure of proteins. Importance of shape in protein function.

Practical work should include chemical tests for reducing and non-reducing sugars, starch, lipids and proteins.

Nucleic acids: DNA and RNA.

Vitamins and their roles as co-enzymes, NAD^+/NADH , $\text{NADP}^+/\text{NADPH}$, FAD/FADH_2 and CoA-SH.

Energy rich compounds especially ATP and creatine phosphate.

2.3 Enzymes as organic catalysts. Enzymes working in solution and as part of membranes (i.e. immobilised). Energy changes in chemical reactions and activation energy. Enzyme structure and function. Formation of enzyme substrate complexes. Factors affecting the rate of enzyme catalysed reactions. Allosteric control. Competitive and non-competitive inhibition. Feedback control, e.g. phosphofruuctose kinase.

Practical work should include experiments to investigate the effect of temperature, pH, enzyme and substrate concentration.

SECTION 3 – MAINTENANCE OF LIFE

3.1 Nutrition

3.1.1 Autotrophic nutrition. Chemosynthesis and photosynthesis. Inorganic nutrient requirements of plants and their uptake. Synthesis of carbohydrates by photosynthesis including fixation and reduction of carbon dioxide. Chloroplasts and chloroplast pigments. The chloroplast envelope, stroma, grana and lamellar structure. Absorption and action spectra.

Practical work should include chromatography of chloroplast pigments and investigation of the effects of light intensity and carbon dioxide concentration on the rate of photosynthesis.

Light dependent and independent reactions. abbreviations used should be RUBP (ribulose bisphosphate), 3PG (3-Phosphoglycerate) and G3P (Glyceraldehyde 3-phosphate).

C3 and C4 pathways as examples of ecological adaptation. CAM plants. Brief outline of photorespiration (*details of full biochemical pathways not required*).

3.1.2 Heterotrophic nutrition. Human nutrition to include diet, ingestion (to include details of dentition), digestion, absorption and assimilation. Structure and function of the mammalian alimentary canal; histology of the ileum wall. The nervous and hormonal control of enzyme release and gut activity (*hormonal control to be exemplified by gastrin, CCK and secretin*).

Adaptation of ruminant mammals to their mode of nutrition:

- i) dentition, dental formulae and their interpretation.
- ii) alimentary tract, including modifications for mutualism
- iii) comparison of ruminants with hind-gut fermenters such as the rabbit.

Adaptations of carnivorous mammals to their mode of nutrition as shown by their dentition.

3.1.3 Saprophytic nutrition using *Rhizopus* as an example.

Practical work should include the examination of slides of sections of the ileum wall and of jaws to appreciate types of teeth.

3.2 Transport

3.2.1 Transport systems. The requirement of transport systems in multicellular organisms.

3.2.2 Transport in flowering plants. Histology of xylem and phloem in relation to their roles in transport.

Practical work to include the examination of slides (T.S. & L.S.) of plant vascular tissues.

3.2.3 Water relations of cells. Concept of water potential (ψ), pressure potential (ψ_p) and solute potential (ψ_s) including knowledge and understanding of the formula $\psi = \psi_p + \psi_s$. Water uptake in plants. Transpiration and the factors affecting it. Mesophytes, xerophytes, halophytes and hydrophytes. Tension-cohesion theory of transport in the xylem. Stomata: structure and physical changes involved in their opening and closing mechanisms.

Practical work should include the determination of water potential and solute potential in plant tissues; measurement of transpiration and water absorption; stomatal counts.

3.2.4 Translocation of organic solutes in plants. Mass-flow (= pressure flow) hypothesis. Brief treatment of loading and unloading to include mention of role of proton pumps.

3.2.5. The Circulatory systems of an insect, a fish and a human; these are to be used to explain the meanings of single, double, open and closed circulations. Circulation in mammals. Structure of the mammalian heart. Histology of cardiac muscle. The cardiac cycle. The role of the sinu-atrial node and atrioventricular node, bundle of His, and Purkinje fibres. Nervous and hormonal control of the rate and strength of heart beat (only the hormonal control by adrenalin is required). Arteries, capillaries and veins. Blood pressure and its regulation by vasoconstriction and vasodilation (*details of hormonal control not required*). Components of blood.

Tissue fluid and lymph. Interchange of materials between capillaries and tissue fluid. Formation and reabsorption of tissue fluid. The lymphatic system.

3.3 Respiration

3.3.1 Metabolic rates and factors affecting them: Metabolic pathways in cellular respiration. Glycolysis to include all the stages involved in the process, also indicating where NADH is produced and where substrate-level phosphorylation takes place. Conversion of pyruvate to acetyl CoA. An understanding of Krebs cycle [*Names and molecular structures of intermediate compounds are not examinable where Krebs cycle is concerned*].

The electron transport chain and ATP generation by the chemosmotic mechanism (*names of electron carriers not examinable*). Oxygen as a hydrogen acceptor. Role of inner and outer mitochondrial membranes in generation of a proton gradient.

Production of lactic acid and ethanol during anaerobic respiration.

3.3.2 Gaseous exchange in plants, insects, bony fish and mammals. Histology, structure and function of mammalian lungs. Control of the rate and depth of breathing.

3.3.3 Structure and function of mammalian red blood cells. Transport of oxygen and carbon dioxide. The role of respiratory pigments, as exemplified by haemoglobin, in increasing the oxygen-carrying capacity of the blood. Dissociation curves of haemoglobin: the adult haemoglobin, foetal haemoglobin and myoglobin; the Bohr effect.

Practical work may include use of simple respirometers, spirometers and estimation of RQ values and their interpretation.

SECTION 4 - ADJUSTMENT AND CONTROL

4.1 Homeostasis. The concept of homeostasis and the control of the internal environment. Control systems and the concept of negative feedback. Hormonal control in homeostasis including chemical nature of hormones and mode of action. The hypothalamus and the pituitary gland (histological details are not required).

Hormonal regulation of blood sugar levels to include role of pancreas (insulin and glucagon) and role of adrenals (adrenalin); diabetes – maturity onset and its control.

4.2 Thermoregulation. Ectothermy and endothermy. Behavioural mechanisms of thermoregulation in reptiles. The role of mammalian skin in thermoregulation. Structural, behavioural and physiological mechanisms of thermoregulation in mammals. Hibernation and resting stages in the life cycles of animals.

4.3 The liver and its role in carbohydrate, protein and fat metabolism. Histology of the liver lobule.

4.4 Excretion and osmoregulation. Water and solute balance in a terrestrial insect, in a marine and a freshwater teleost, and in a mammal. The role of the mammalian kidney in excretion, osmoregulation and pH regulation. Urea formation and the ornithine cycle (*molecular structures are not required*). Structure and histology of the kidney and the nephron. Urine formation. The loop of Henle as a countercurrent multiplier and the vasa recta as countercurrent exchangers. The role of antidiuretic hormone and aldosterone.

The histology of the mammalian kidney should be studied in relation to its homeostatic function.

4.5 The immune system and disease. Defence mechanisms, to include humoral and cellular immunity, immunoglobulins and graft rejection. Adaptive (specific) defence mechanisms, to include phagocytosis, complement proteins, Natural Killer Cells (NKC), inflammation and fever. White blood cells. Disorders of the immune system as exemplified by the autoimmune disease juvenile diabetes and AIDS. Artificial immunity ABO and Rhesus blood groups in humans. Blood clotting (*in outline only*).

SECTION 5 - RESPONDING TO THE ENVIRONMENT

5.1 The structure and electrical properties of the neuron. Synaptic transmission, EPSPs and IPSPs and summation.

The role of neurotransmitters (acetylcholine and noradrenaline) and effects of drugs (as illustrated by nicotine and amphetamines) on synaptic transmission. The neuromuscular junction.

5.2 The autonomic nervous system. Autonomic control of the internal environment. Sympathetic and parasympathetic nervous systems.

5.3 The central nervous system. Gross structure of the brain, location and function of the medulla, pons, cerebellum, thalamus, hypothalamus and cerebral hemispheres (*to include sensory, motor and association areas*). Structure of the spinal cord as seen in transverse section. The reflex arc; monosynaptic and polysynaptic reflexes.

5.4 Stimulus reception in animals. Sense organs as energy transducers and as exemplified by the mammalian retina. A brief outline of image processing at the retinal level to include visual acuity and sensitivity of rods and cones. Monochromatic and trichromatic vision. The nocturnal eye.

5.5 Stimulus reception in plants as exemplified by phototropism including the role of auxins.

SECTION 6 - LOCOMOTION AND SUPPORT

6.1 Anatomy and histology of striated muscle: myofibrils and sarcomeres. Role of actin, myosin, tropomyosin, troponin and ATP in muscle contraction.

6.2 Hydrostatic skeletons, exoskeletons and endoskeletons: their definition and their roles in support and locomotion as illustrated by an earthworm, an insect and a mammal. Histology of compact bone. The distribution and role of compact and spongy bone with reference to the femur. *Details of synovial joints not required.*

6.3 Supporting tissue in plants. The structure and function of turgid parenchyma, collenchyma, sclerenchyma, and xylem elements. Their distribution in primary root and stem, and in the leaf in relation to their mechanical functions. Compare and contrast monocot and dicot support structures.

Practical work should include recognition of the main features of a generalised vertebra as exemplified by a lumbar vertebra; histology of supporting tissues in plants and of compact bone and striated muscle tissues in animals.

SECTION 7 – GENETICS AND ITS APPLICATIONS

7.1 Chromosomes and the genetic code.

7.1.1 Chromosome structure (*to include histones*).

7.1.2 Semiconservative DNA replication. The role of helicase, DNA polymerises, ligases, RNA polymerase and Okasaki fragments.

7.1.3 The genetic code. Degeneracy of the genetic code. Protein synthesis: transcription and translation; roles of mRNA, tRNA and ribosomes; codons and anticodons; post-transcriptional and post-translational processing.

7.1.4 Control of gene expression in prokaryotes: the lac operon.

7.1.5 Chromosome and gene mutations. Base deletions, insertions, substitutions and inversions. Aneuploidy and polyploidy.

7.1.6 Principles and techniques of gene technology:

The principles of genetic engineering illustrated by the use of restriction endonuclease enzymes exemplified by the action of *EcoRI* and the use of ligases in the formation of recombinant DNA.

Techniques for obtaining the required gene include: the use of restriction enzymes, direct synthesis and reverse transcription; selecting the vector and inserting foreign gene in vector using restriction enzymes and ligases; introducing vector DNA in the host cell and selecting the transferred cells by using marker genes and an adequate DNA probe. *Other methods of introducing foreign DNA in host cells, e.g. transformation,*

transfection, microprojectiles, electroporation and microinjection, should be appreciated but are not examinable.

The polymerase chain reaction (PCR) as a method of producing multiple copies of a particular gene.
Methods of analysing DNA organisation: separation of DNA fragments by gel electrophoresis; detection of fragments using Southern blotting and radioactive gene probes; localisation of genes on chromosomes using radioactive *in situ* hybridisation.

Practical work should include precipitation and spooling of DNA and gel electrophoresis of DNA fragments.

7.1.7 Applications of gene technology:

Pharmaceutical products of gene technology: human protein replacement exemplified by the production of insulin by genetically modified microorganisms; advantages over traditional methods of treatment; use of transgenic animals in “pharming” as exemplified by genetically engineered sheep to produce α -1-antitrypsin.

Gene therapy: the use of gene technology to treat genetic diseases exemplified by the treatment of CF (cystic fibrosis).

Applications of gene technology in agriculture: the use of bST in the dairy industry, the production of pest and herbicide resistant crops, hence producing GMOs.

Genetic fingerprinting and DNA profiling and its application in forensic work and paternity cases.

Candidates should be able to evaluate the economic, environmental and ethical implications of the above applications of gene technology but these are not examinable.

7.2 Nuclear division

7.2.1 Haploid and diploid cells. The cell cycle. Mitosis. The significance of mitosis in growth and in the formation of genetically identical cells.

Practical work should include preparation of root tip squashes and identification of the various stages of mitosis (also from prepared slides)

7.2.3 Meiosis. First and second meiotic divisions. Synapsis, reduction in chromosome number and generation of diversity. The significance of meiosis and random fertilization in gamete and spore formation, and in the generation of diversity.

Practical work should include observation of microscope slides to study stages of meiosis.

7.3 Inheritance

7.3.1 Genes and alleles. Monohybrid inheritance. Homozygotes and heterozygotes, dominance and co-dominance, genotype phenotype. Multiple alleles, pedigree analysis.

7.3.2 Dihybrid inheritance. Gene linkage, crossing over and chromosome maps. Sex determination in mammals. Sex linkage, gene interaction, multiple alleles and polygenic inheritance.

Gene interactions to be exemplified by comb shape in poultry and by an example to show epistasis; Multiple alleles may be exemplified by human blood types while polygenic inheritance may be illustrated by the inheritance of skin pigmentation in man.

The analysis of both monohybrid and dihybrid crosses using the chi-squared test. [*Students will not be required to remember the formula for the examination.*]

Teachers may use The Cambridge Advanced Sciences series books entitled: “Biology 2” and “Applications of Genetics” as a guide.

SECTION 8 – BIOTECHNOLOGY

8.1 Definition of biotechnology in its broader sense to include both traditional as well as modern biotechnology processes.

8.2 Sterile techniques including growth in culture media and the production of pure cultures. Growth patterns of bacteria, unicellular algae and yeasts.

To include knowledge of methods of measuring culture growth including cell counts, dilution plating and turbidity measurements.

8.3. Industrial use of fermenters for batch and continuous culture: aseptic techniques; agitation, aeration, temperature and pH control; collection of products.

8.4 Large scale use of micro-organisms in the production of beer.

SECTION 9 - REPRODUCTION

9.1 Asexual reproduction. Natural cloning in plants and animals exemplified by vegetative propagation in plants (*one or two examples excluding histological detail*) and by binary fission as in protozoans and by budding as in *Hydra*. Sexual reproduction leading to genetic variation in the offspring. Transfer of gametes in relation to habitat. Internal and external fertilisation.

9.2 Life cycles in mosses, ferns and flowering plants. Alternation of generations. Morphology and relative importance of gametophyte and sporophyte phases. Mechanisms for the transfer of genetic material.

9.3 Diversity of floral morphology as illustrated by an actinomorphic dicot, a zygomorphic dicot and a petaloid monocot. Pollination and fertilisation. Adaptations for insect and wind pollination. Flowers of the Fabaceae (Leguminosae) and the Poaceae (Gramineae) as specialised for insect and wind pollination respectively. Seed formation (*details of germination not required*).

Practical work should include floral dissection, construction of floral diagrams and floral formulae.

9.4 Reproduction in humans. Structure and function of the male and female reproductive systems. Histology of the mammalian ovary and testis. Oogenesis and spermatogenesis. The menstrual cycle. Transfer of male gametes leading to fertilisation. Implantation. Functions of the human placenta. Birth and lactation.

Hormones in reproduction. Roles of luteinising hormone (LH), follicle stimulating hormone (FSH), testosterone, oestrogen, progesterone, oxytocin, prolactin and prostaglandins (*role in menstruation only*).

SECTION 10 - EVOLUTION

10.1 Sources of variation (genetic diversity). Continuous and discontinuous variation. Population genetics. The gene pool. Allele, genotype and phenotype frequencies. The Hardy-Weinberg equilibrium principle. Factors affecting this equilibrium.

10.2 Selection: artificial selection and natural selection; directional, disruptive and stabilising selection. Balanced and transient polymorphism. Gradualistic and punctuated equilibrium modes of evolution. Causes for extinction.

10.3 Isolating mechanisms. Behavioural and geographical isolation. Sympatric and allopatric speciation. Polyploidy Reproductive Isolating mechanisms: Pre-zygotic and post-zygotic isolating mechanisms.

SECTION 11 – ENVIRONMENTAL BIOLOGY

11.1 Basic ecological concepts

11.1.1 Define *ecology, population, community, ecosystem, biological species, habitat, niche, ecological species*.

11.1.2 Explain what is meant by the *biosphere* and *ecosystem diversity*, and give examples of some major biomes.

11.2 Population Ecology

11.2.1 Population growth:
Natality, mortality, immigration and emigration.

[A formula relating these is not required. The students should simply appreciate how natality and immigration result in an increase in population size while mortality and emigration result in a decrease.]

S-shaped growth curves.

The lag, log, deceleration and stationary phases.

The carrying capacity of the environment and density-dependent factors.

Biotic potential and its constituents.

J-shaped growth curves.

Population crashes and density-independent factors.

[Symbols r and K to be used for intrinsic rate of increase and carrying capacity respectively but no mathematical formulae for growth curves are required.]

11.2.2 Intraspecific interactions that limit population size: Competition, overcrowding, territoriality.

11.3 Community Ecology

11.3.1 Interspecific interactions within a community:

Allelopathy.

Interspecific competition: *The Gause's principle of competitive exclusion exemplified by experiments with Paramecium.*

The fundamental niche and the realized niche exemplified by the interaction between *Semibalanus* and *Chthamalus*.

11.3.2 Types of symbiotic relationships:

Amensalism e.g. cattle and ground-nesting birds.

Commensalism: e.g. epiphytes, sessile organisms, pilot-fish and clown-fish, cattle egrets.

Mutualism: exemplified by nitrogen-fixing bacteria in root nodules of leguminous plants, lichens, ectotrophic mycorrhizae as exemplified by the pine/*Boletus* association, gut organisms, plants and their pollinators e.g. the Joshua tree and the Yucca moth, Bee Orchids (*Ophrys* spp.), Figs (*only one example need be covered*).

[The above-mentioned examples are given only as an illustration. Students are free to study other examples to illustrate their understanding of the different types of symbiotic relationships.]

Parasitism: methods of transmission; morphological, physiological and reproductive adaptations of parasites as exemplified by an ectoparasite such as the dodder (*Cuscuta*) or Broomrape (*Orobanche*) and an endoparasite: the pork tapeworm (*Taenia solium*).

11.3.3 Predator-prey interactions and cyclic patterns in population growth: Application in biological pest control e.g. the control of white-fly by a parasitoid.

11.3.4 Ecological succession.

Pioneer communities, seral communities and climax communities.

Primary succession.

Secondary succession exemplified by the vegetation of disturbed habitats in Malta.

11.4 Ecosystem Ecology

11.4.1 Overall structure of ecosystems.
Abiotic components: edaphic and climatic.
Biotic components: producers, primary consumers, higher consumers, detritivores and decomposers.

11.4.2 Energy and carbon sources for organisms.
Phototrophs and chemotrophs, autotrophs and heterotrophs.
Food chains and food webs.

11.4.3 Ecological pyramids.
Pyramids of numbers, biomass and energy.

11.4.4 Production ecology.
Energy flow in ecosystems.

[Students are expected to define gross primary production and net primary production, and calculate these values from given data. They should also be able to work out the efficiency of energy transfer between trophic levels.]

11.4.5 The biogeochemical cycles.
The carbon cycle.
The nitrogen cycle and the role of different types of soil bacteria.

11.5 Local Ecology

11.5.1 Maltese habitats and vegetation types:
Vegetation of the garigue, maquis and wood, steppe and the disturbed areas.

*An appreciation of specialised habitats e.g. cliffsides and screes, watercourses.
Coastal vegetation: maritime garigue, salt marshes and sand dunes.*

11.5.2 The effects of human activity on the local environment.
Students should be able to discuss the effects of waste disposal, deforestation and afforestation, and the construction industry on the Maltese environment.

11.6 Global Effects on the Environment

11.6.1 Development and climate change:
Ozone depletion, greenhouse effect and acid rain.

11.6.2 Water pollution:
Sewage: inadequate treatment leading to contamination of water and depletion of oxygen (BOD);
Eutrophication and algal blooms.

11.7 Ecological techniques

11.7.1 The capture-recapture method for estimating animal population size.

[Students should be able to understand the underlying assumptions of this Index.]

11.7.2 Define *random sample* and describe one method of random sampling used to compare the population numbers of two plant species based on the quadrat method.

11.7.3 Present ecological data in table form and evaluate graphical presentations of ecological data.

11.7.4 Analyse data by working out species frequency, species density, and species cover. Use of the t-test to compare means between two independent samples.

[Estimates of species cover should be carried out using grid quadrats.]

11.7.5 Compare two areas by calculating species richness and species diversity estimated by Simpson's Index.

[Students are not expected to remember the Simpson formula but they should know how to calculate it given a set of data and the formula and how to interpret the index.]

11.7.6 Line transects and ladder (belt) transects.

BIOLOGY TEXTS – A TEACHERS’ GUIDE

Textbooks

Audesirk, T. & Audesirk, G. & B. Byres (2006). *Biology: Life on Earth*. Prentice Hall.

Baker, M., Indge, B. & Rowland, M. (2002). *A New Introduction to Biology & Further Studies in Biology*. Hodder & Staughton.

Jones, M., Fosberg, R. & Taylor, D. (2000). *Cambridge Advanced Sciences – Biology 1 & 2*. Cambridge University Press. (Including Biology Option Titles)

Purves, W.K.; Orians, G. H. & Heller, H.C. (1992). *Life: the Science of Biology* (6th edition or later). Sinauer Associates.

Knox, B., Ladices, P. & Evans, B. , (eds) (1994 and later editions). , *Biology* McGraw-Hill Book Company.

Soper, R. (ed.): *Biological Sciences* (3rd or later edition). Cambridge University Press.

Reference source works for Local/Mediterranean Biodiversity and Environmental issues

Blamey, M. & Grey-Wilson, C. (1993), *Mediterranean Wild Flowers* Harper Collins.

Burnie D. (1995), *Wild Flowers of the Mediterranean*. Eyewitness Handbooks - Dorling Kindersley.

Haslam S.M. & Borg J. (1998)., *The River Valleys of the Maltese Islands: Environment and Human Impact*. Islands and Small States Institute, FIS, Malta & CIHEAM, Italy.

Lanfranco, E. & Lanfranco, G. (2003). , *Il-Flora Maltija*. Kullana Kulturali. PIN. Malta.

Lanfranco, S. (2003), *L-Ambjent Naturali tal-Gżejjer Maltin*. Kullana Kulturali. PIN, Malta.

Riedl, R. (1991), *Fauna e Flora del Mediterraneo*. ranco Muzzo Editore, Padova.

Schembri, P.J. & Baldacchino, A.E., *Ilma, Blat u Hajja, is-sisien tal-ambjent naturali Malti, [it- tieni edizioni riveduta]*. (1998). Malta University Publishers Ltd.

Sultana J. & Falzon V. (eds.), *Wildlife of the Maltese Islands*. (1996, reprint 2001). Environment Protection Department (reprint: Birdlife Malta & Nature Trust).

Schembri, P.J. & Lanfranco, E. (1993), *Development and the Natural Environment in the Maltese Islands*, in: D.G. Lockhart, D. Drakakis-Smith & J. Schembri – *The Development Process in Small Island States*: 247-266. Routledge, London & New York.

Vujicic R., Lanfranco E., & Vella A. (eds.), *SOS for Maltese Flora – Proceedings of a National Seminar 1999*. Department of Biology, University of Malta.

Selected papers from the “*Proceedings of the Atmospheric Pollution Seminar – 9th April 1999*”, Malta, Physics Department, University of Malta (available at the University library for reference).

SUPPLEMENTARY NOTE ON BIOLOGICAL DIVERSITY

Biological diversity refers to the variety of life in all its forms, levels and combinations. It may be expressed at three levels: ecosystem diversity, species diversity and genetic diversity.

Ecosystem diversity refers to the variety and frequency of different ecosystems such as marine coasts, grasslands and forests.

Microorganisms, plants and animals are the living components of an ecosystem. They interact with each other, in for example, food webs, and with light, water, air, minerals and nutrients. These interactions are the basis of an ecosystem's 'functioning' which together with the functions of other ecosystems, provide 'services' upon which all life on earth depends. These services include maintaining atmospheric composition, nutrient recycling climate regulation, pollination and soil formation.

Ecosystems are threatened by development projects, habitat loss and fragmentation from urbanization, trade, introduction of alien species, and global atmospheric changes such as climate change and stratospheric ozone depletion. Air, water and soil pollution are the major threats in the industrialized world.

Species diversity refers to the frequency and diversity of different species including domesticated and cultivated ones. A species represents a group of organisms which have evolved distinct inheritable features and which occupy a unique geographical area. Species usually do not freely interbreed with other species for a number of reasons. In addition to being a biological concept, the term species can be used in a taxonomic sense: it is one of the levels used by biologists to describe the hierarchy of the forms of life and attempts to reflect evolutionary descent.

Genetic diversity refers to the genetic differences between individuals within a population and between populations of a single species. Genetic diversity allows species to adapt over time to the environmental stresses they face. Loss of individuals and populations narrows the gene pool of a species and restricts its adaptational or evolutionary options. Genetic diversity has been used by humans for thousands of years especially in agriculture.

Farmers have domesticated wild animals and have bred them for desirable characteristics such as size, coat thickness or disease resistance. Similarly, plants have been bred for seed colour, flavour, fruit size or disease resistance. Modern plant and animal breeding tends to narrow down their genetic diversity and make them susceptible to disease. This happened for example with the Asian hybrid rice crop which became susceptible to Grassy Stunt Virus. Luckily one small population of related wild rice provided the gene for resistance to this disease and saved the crop.

SUPPLEMENTARY NOTE ON STATISTICS

The following are conditions for using various statistical tests.

t-Test (Independent samples)

1. Interval level data.
2. Independent samples
3. Populations should be approximately normally distributed.
4. Populations should have approximately the same standard deviation.
5. Samples contain less than 30 values each.

Degrees of freedom (df) for the two samples is the total number of samples minus two.

t-Test (Matched samples)

1. Matched paired samples
2. Interval level data
3. Population of differences should be normally distributed.
4. Samples contain less than 30 values.

Degrees of freedom = $df = (\text{numbers of pairs of values}) - 1$

Chi-Square (χ^2) Test

1. Nominal level data
2. The expected frequency should not fall below 5 in more than 20% of the cells.

Degrees of freedom = $df = (\text{number of columns}) - 1$