AM SYLLABUS (2022)

BIOLOGY **AM 05**

SYLLABUS

AM05 Biology

Syllabus Addendum

Mitigating factors for 2022 MATSEC Examinations Session

Changes in Subject Content	The following sections will **not** be assessed: • Section 4.6.2: Practical work may include use of simple respirometers and spirometer • Section 5.3: Thermoregulation • Section 5.5: Excretion and Osmoregulation • Section 6.2: Stimulus reception in animals • Section 6.3: Stimulus reception in plants • Section 7.2: Skeleton • Section 9.4.1: Types of flower - related practical work listed under 9.4.3 Practical work should include floral dissection, construction of floral diagrams and floral formulae. • Section 11.6: Ecological techniques • Section 12.2.4: Application of gene technology
Changes in Coursework	Candidates are **not** expected to present coursework.
Changes in Exam Paper(s)	Paper I: No change Paper II: No change Paper III: - Time: 3 hours - Max % mark: 90% - Further details below Paper IV – No practical. This paper will be replaced with a written paper and incorporated in Paper III (Section B) as exemplified in Sample Paper below. Paper III - 3 hours Paper III will consist of two compulsory sections – A and B. Section A will be allocated 50 marks and Section B will be allocated 40 marks. Section A – 50 marks Section A will be based on practical work related to the theory sections of the syllabus. It will consist of a number 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 may also be required to use or construct dichotomous keys and to classify organisms in accordance to Section 1 of the syllabus.

	Section B – 40 marks Section B will consist of one compulsory question designed to test the candidates' ability to: • plan and carry out laboratory experiments; • design an investigation; • record results; • interpret results; • predict results; • evaluate the above critically; • suggest improvements/modifications to the techniques used. Section B questions will be based on: • Section 2.1.4: Chemical tests for reducing and non-reducing sugars, starch, lipids and proteins; • Section 2.2.3: The effect on temperature, pH, enzyme concentration and substrate concentration on enzyme catalysed reactions; • Section 3.2.3: Movement of molecules across membranes (membrane permeability); • Section 4.1.5: The effects of light intensity and carbon dioxide concentration on the rate of photosynthesis; • Section 4.3.6: The determination of water potential and solute potential in plant tissues; • Section 4.3.6: Measurement of transpiration.

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION
CERTIFICATE EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
SPECIMEN PAPER

SUBJECT:	**Biology**
PAPER NUMBER:	III
DATE:	
TIME:	3 hours

Directions to Candidates

- Write your index number in the space at the top left-hand corner of this page.
- Answer all questions. Write all your answers in this booklet. Drawings of biological material and graphical representations of data are to be made on the appropriate pages within this booklet.
- The marks allotted to parts of question are indicated.
- You are reminded of the necessity for good English and orderly presentation in your answers.
- In calculations you are advised to show all the steps in your working, giving your answer at each stage.
- The use of electronic calculators is permitted.

For examiners' use only:

Question						**Total**
Score						
Maximum						**90**

Section A: Answer all questions

Questions in this Section will be set as per previous years in Paper III.

Section B

According to research, sports drinks should contain around 6 – 8 % carbohydrates to be beneficial to athletes. Glucose ($C_6H_{12}O_6$) is a monosaccharide reducing sugar which is commonly found in sports drinks. Glucose reacts with potassium permanganate and the purple pink solution of acidified potassium permanganate (MnO_4^-) is reduced to a colourless solution of manganese ions (Mn^{2+}) according to the equation below:

$$\underset{\text{(Pink)}}{MnO_4^-} + 8H^+ + 5e^- \rightarrow \underset{\text{(colourless)}}{Mn^{2+}} + 4H_2O$$

As a result of this reaction, the glucose is oxidised. The time taken for the loss of colour from a standardised solution of permanganate is directly related to the concentration of glucose present in solution.

You are required to devise and implement an experimental procedure to find levels of glucose in **THREE** different solutions.

Materials provided:

- glucose solutions (2.5%, 5%, 7.5%, 10%, 12.5%);
- three solutions of unknown glucose concentration (A, B, C);
- sulfuric acid;
- potassium permanganate;
- large test tubes;
- pipettes.

Important note:

The following volumes are available:

- Glucose solutions: 5 cm^3;
- Sulfuric acid: 2.5 cm^3;
- Potassium permanganate: 1 cm^3.

a. State the aim of your biological investigation.

_____

_____

_____ (1)

b. Using the material provided, devise and describe an experimental procedure that may be used in order to determine the concentration of glucose in the solutions provided.

_____

_____

_____

(10)

c. List and justify **TWO** precautions that should be taken before the start of the experiment.

(4)

d. The results obtained in an experiment showing the time taken for glucose to react with acidified potassium permanganate are shown in Table 1.

Table 1: Table showing the time taken for glucose to react with acidified potassium permanganate.

Glucose concentration (%)	Time 1 (min)	Time 2 (min)	Time 3 (min)
2.5	8.32	8.41	8.19
5.0	5.24	5.30	5.16
7.5	3.33	3.01	3.62
10.0	2.45	2.50	2.55
12.5	2.38	2.59	2.30
Unknown solution A	3.57	3.54	3.67
Unknown solution B	7.22	7.20	7.24
Unknown solution C	2.38	2.30	2.55

i. Which parameter can be added to Table 1 to represent the time taken for each concentration?

_____ (1)

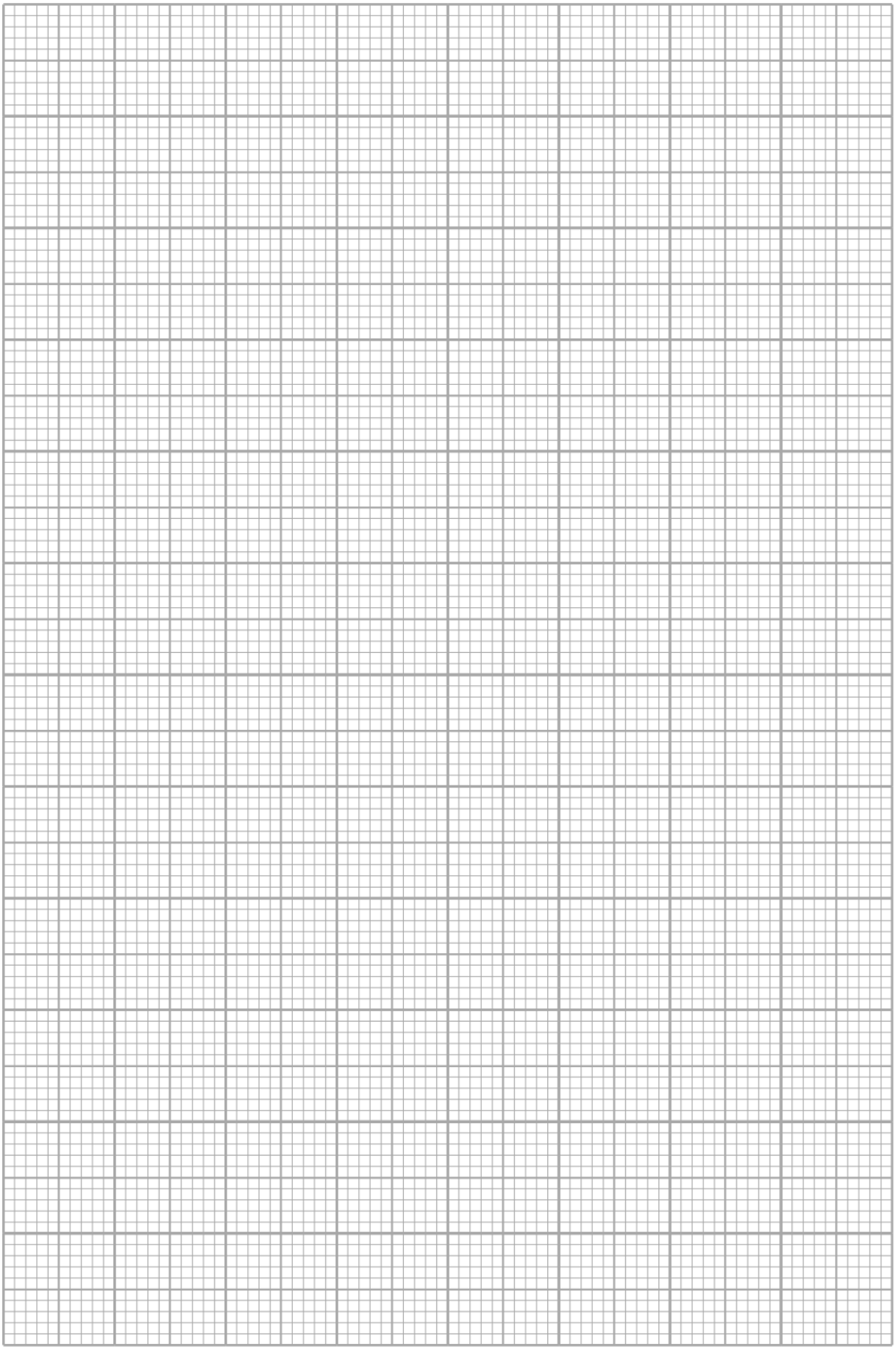
ii. Use Table 1 to calculate the parameter given as an answer to part (d) (i) above, for each of the glucose concentration. Input your results in Table 2 below.

Table 2

Glucose concentration (%)	
2.5	
5.0	
7.5	
10.0	
12.5	
Unknown solution A	
Unknown solution B	
Unknown solution C	

(4)

e. Use the graph paper below to draw a calibration graph (6)



f. Interpret the calibration graph drawn in part (e).

_____

_____

_____

_____

_____ (2)

g. Use the calibration graph to determine the concentration of glucose in solutions A, B and C.

_____

_____

_____

_____

_____

_____

_____

_____

_____(6)

h. From the results obtained in part (g), determine which solution, from A, B and C, is ideal to use in the preparation of a sports drink. (Assume that glucose is the only source of carbohydrate used in the preparation).

_____(1)

i. How would this solution help an athlete achieve better performance?

_____

_____

_____

_____

_____(2)

j. Give **ONE** possible source of error in your investigation and explain how it will affect the results.

_____

_____

_____

_____

_____(2)

k. Briefly describe **ONE** modification you would do to your experimental set-up to produce more reliable results.

_____

_____

_____

_____

_____ (1)

(Total: 40 marks)

Sample Paper 3 Section B – Suggested marking scheme

Qn.	Suggested answer	Marks
a	To find levels of glucose in three different solutions	1
b	1. 5 mL of the 2.5% glucose solution added to a test tube.	1
	2. 2.5 mL of dilute sulfuric acid added to the test tube.	1
	3. 1 mL of potassium permanganate solution added to the test tube	1
	4. the timer immediately started	1
	5. the time taken for the pink colour to disappear recorded	1
	6. Repetition with the four other known glucose concentrations.	1
	Obtaining results to estimate the glucose concentrations of solutions A B C	
	7. 5 mL of solution **A added** to a test tube.	1
	8. Repetition steps 2 to 5.	1
	9. Repetition for the other two unknown solutions	1
	Experimental procedure explained in a clear and scientific way	1
c.	***Accept any TWO of the following***	2 marks each: 1 mark for precaution; 1 mark for justification
	Mixing/ stirring to ensure homogenous solution	
	Same volumes of glucose solution are used to be able to compare the levels of glucose	
	Make sure that the test-tubes are dried not to change concentrations (small volumes are used)	
	The use of a white sheet of paper to identify the endpoint due to contrast	
	Constant temperature to avoid changes in rate of reaction	
	Potassium permanganate stored in dark bottles to avoid photolysis	
d. i	average	1
ii.	8.307	0.5
	5.233	0.5
	3.320	0.5
	2.500	0.5
	2.423	0.5
	3.593	0.5
	7.220	0.5
	2.410	0.5
e	Graph showing % glucose vs time (or rate)	1
	Correct plotting	1
	title	1
	Axis titles	1
	Use of units	1
	Appropriate scales used and axis (glucose –x; time – y)	1
f.	Low concentrations of glucose take a long time for the reaction to take place	0.5
	As the concentration of glucose increases the rate of reaction is faster/ the reaction takes less time.	0.5
	Giving examples of the actual concentrations and times recorded	0.5
	This is because glucose is a reducing sugar and is reacting with the permanganate.	0.5

g.	Correct Reading from the graph: solution A (app 7%)	2
	Correct Reading from the graph: solution B (app 3%)	2
	Correct Reading from the graph: solution C (app 12%)	2
	N.B Values ranging +1/-1 from indicated values- 1 mark deducted. (half marks given)	
h.	Solution A	1
i.	Glucose is used in respiration to produce energy (ATP)	0.5
	During exercise glycogen in the muscle and liver can become depleted and fatigue can set.	1
	The solution would provide the body with glucose and hence fatigue can be delayed.	0.5
j.	***Accept any ONE of the following***	2
	End-point might not be clear / colour change is subjective	
	Temperature might not have been constant and affects the rate of reaction	
k.	***Accept any ONE of the following***	1
	Controlled temperature	
	Use colorimeter	
	titration	
	Total:	**40**

Biology AM 05	(Available in September)
Syllabus	Paper 1(3hrs) + Paper II(3 hrs) + Paper III(1½ hrs) + Paper IV: Practical(1½ hrs)

The syllabus content is divided into 12 sections, which constitute the syllabus core. (*No options are required*).

The material covered in this syllabus presumes a level of competence in the subject equivalent to that expected at Secondary Education Certificate (SEC) level.

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 consider ethical issues to help raise awareness of the decisions, which may be taken at a personal and wider national and international level, relating to the effects of human activities and the use and manipulation of biological systems.

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 Squared and Student's t-test as specified in Section 8.3.2 and Section 11.6.4 respectively.

Students should know how to work out t-test and Chi Squared test and their interpretation (excluding the expectation of working out standard deviation or other long calculations).

Use of the diversity index as specified in Section 11.6.4.

Simpson's reciprocal index:

$$D = \frac{N(N-1)}{\Sigma\, n(n-1)}$$

where N = the total number of organisms of all species and n= the total number of organisms of a particular species.

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

Paper I- 3 hours
This will consist of a number of compulsory structured questions covering any section of the syllabus. The questions will test both simple recall of information as well as application of biological principles.

Paper II - 3 hours
This will consist of three sections.

Candidates will be required to answer one compulsory question in Section A, which will involve comprehension and analysis of scientific data.

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.

In Essay writing marks will be awarded for logical flow of ideas, scientific content, and adequate structuring of the essay, to include introduction and conclusion.

Paper III - 1.5 hours
Paper III 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 IV -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 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.

Candidates are expected to bring their dissection kit, watch and calculator 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 IV 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.

Summary of the whole examination assessment procedure
The whole examination assessment procedure is 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 or module. These estimated values are intended to offer some guidance as to the amount of time to be allotted to each module and to the approximate overall weighting to be given to these areas in examination papers I, II and III.

Section number: Topics		Percentage weighting per module in papers I, II and III
1	Variety of living organisms	10
2	Biochemistry	11
3	Cellular function and organisation	
4	Maintenance of Life – Nutrition , transport and respiration	18
5	Adjustment and Control – Homeostasis (hormonal control, thermoregulation, liver, excretion, osmoregulation)and the immune system	19
6	Responding to the Environment (Nervous system and Stimulus reception in animals and plants)	
7	Locomotion and Support	
8	Genes, Cell Division and Genetics	13
9	Reproduction in Plants and Animals (human)	19
10	Evolution	
12	Biotechnology	
11	Environmental Biology	10
All Sections		**100**

Percentage time spent per module should include all learning objectives included under scheme of assessment.

A minimum of 25% of the marks of the overall examination (papers I, II, III and IV) will be dedicated towards higher order thinking skills such as data analysis, synthesis and problem solving situations as indicated in the scheme of assessment.

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.

SECTION 1: Biodiversity of Living Organisms		
Topic	**Subject Content**	**Knowledge expected**
1.1 General principles of classification	1.1.1 Biological Diversity	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; ecosystem diversity and genetic diversity.
	1.1.2 Species concept	Definition of species according to the biological species concept. Principles of systematics and biological nomenclature. Terms to be included are: Kingdom, phylum, class, order, family, genus and species; (*terms such as clade or cladogram are not expected).* Use of and construction of dichotomous keys to identify organisms.

	1.1.3 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.
	1.1.4 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.*
1.2 Classification	1.2.1 The meaning of and evolutionary significance of the following terms:	i) prokaryotic and eukaryotic cells ii) endosymbiotic origin of plastids and mitochondria iii) radial and bilateral symmetry iv) diploblastic and triploblastic organisation v) acoelomate and coelomate body plans vi) metameric segmentation vii) jointed appendages viii) the pentadactyl tetrapod limb ix) transition of gills to lungs x) cleidoic egg
1.3 Diagnostic structural features of different groups	1.3.1 Prokaryota	General features of prokaryotes as illustrated by *Escherichia coli. No reference to archaeans is required. Students should be aware of the existence of the two types of bacteria: gram positive and gram negative bacteria*
	1.3.2 Protoctista	General features of the protoctists should be illustrated through: i) algal protoctists to include a green and a brown alga and ii) protozoan protoctists to include a ciliate (*Life cycles are NOT required*).
	1.3.3 Fungi	General features of fungi. *Students are to appreciate that moulds and mushrooms are multicellular while yeasts are unicellular fungi (Life cycles are not required).*
1.4 The animal kingdom (Animalia)	1.4.1 Definition of an animal	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, are not required*). For this section, diagnostic features should be limited to visible external characteristics only. Life cycles are not required unless specified. Mode of life is to be limited to external features only. *The diversity of each phylum is to be appreciated by reference to examples of animals from different subgroups. However, students are expected to know the external features as related to function of ONLY those animals specified under each section.*
1.5 Major groups within the Animal Kingdom	1.5.1 CNIDARIA	Radial symmetry, diploblastic organisation; nervous system as a network of nerve fibres, the stinging cell or cnidocyte (cnidoblast when still developing) which discharges its thread organelle (cnida) once the trigger (cnidocil) is stimulated. 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.
	1.5.2 PLATYHELMINTHES	Simplest organisms with consistently bilateral symmetry and triploblastic acoelomate organisation, cephalisation, ciliated ectoderm. Exemplified by the external features of the tapeworm as a parasitic form and a free-living form such as a triclad.
	1.5.3 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.
	1.5.4 ARTHROPODA	Tagmatisation; exoskeleton and articulated appendages, compound eyes in most groups. (Note: *Arthropoda may be treated as a monophyletic group or as a grade of organisation; students are not expected to know the meaning of the term "monophyletic"*.) Exemplified by the following groups:
	1.5.5 Crustacea	With two pairs of antennae, normally having gills associated with paired appendages; exemplified by an aquatic type such as a crab and a terrestrial type such as the woodlouse.
	1.5.6 Insecta	With three distinct tagmata, single pair of antennae, three pairs of thoracic walking limbs, generally with 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. (*Detail of mouthparts are not required.*)
	1.5.7 Arachnida,	With two tagmata, lack of antennae, four pairs of legs, simple eyes, chelicerae and pedipalps; exemplified by a spider.
	1.5.8 MOLLUSCA	Lack of visible segmentation, presence of shell in most forms. Exemplified by a Gastropod normally exhibiting a spiral shell. (*Torsion is not required*).
	1.5.9 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.
	1.5.10 CHORDATA	Pharyngeal gill-slits, dorsal nerve cord, notochord and post-anal tail as basic characteristics. Definition of Vertebrata as having a vertebral column, pectoral and pelvic girdles (for attachment of fins or limbs), jaws, the cranium, sense organs (paired eyes, ears and olfactory organs) and a well-developed closed blood vascular system. Exemplified by the Vertebrata group of: *Mammalia*, with hairy skin and, generally viviparous development. *Internal structural features need only be considered if diagnostic of a group.* *While only external features of mammals are required, students are to be made aware (e.g. through the use of a flow chart) of other vertebrates such*

		as fish, amphibians, reptiles and birds in view of the evolutionary trends shown in vertebrates towards adaptation to a terrestrial mode of life. (*Recall details mentioned in evolutionary trends above)*
1.6 The Plant Kingdom (Plantae)	1.6.1 Diagnostic structural features	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*. Should also be studied, through examples, so as to illustrate (i) alternation of generations and (ii) changes that are related to adaptation to terrestrial life.
1.7 The major groups within the Plant Kingdom	1.7.1 BRYOPHYTA	Dominant gametophyte with consequent dependence on open water; exemplified by a moss.
	1.7.2 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 homospory and heterospory. 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.* • *Magnoliophyta* (angiosperms = flowering plants), angiosperm characters such as enclosed ovules, and the flower; 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- Biochemistry (Basic biomolecules and Enzymes)		
Topic	**Subject Content**	**Knowledge expected**
2.1 Basic biomolecules	2.1.1 Water	The dipole nature; an awareness that the collective effect of the hydogen bonds is responsible for the unique properties of water exemplified by importance of water as a solvent and its biological significance. A very brief mention of the other biologically significant properties of water.
	2.1.2 Carbohydrates	Monosacharides: pentoses (ribose, deoxyribose) *detail of structures not examinable*; hexoses (glucose, fructose and galactose), basic distinction between the structures of α-glucose and β –glucose. Disaccharides: (maltose, sucrose, lactose); 1,4 glycosidic linkages exemplified by maltose. Polysaccharides: Basic structure of starch, cellulose and glycogen related to function.
	2.1.3 Lipids	Formation of triglycerides from alkanoic acids (fatty acids) and propane-1,2,3 triol (glycerol). Their main role as energy stores. Phospholipids: hydrophilic and hydrophobic properties in formation of membranes. Steroids: cholesterol, steroid hormones and Vitamin D (Detailed structure is not required but only the skeleton of a steroid as a set of complex rings of carbon atoms.)
	2.1.4 Proteins	General structure of an aminoacid to include different properties of R groups and cysteine and methionine as examples of S- containing R groups; peptide linkage; primary structure; secondary structure to include α-helix and β-pleated sheet; tertiary structure involving H-bonding, ionic bonds, disulphide bridges and hydrophobic and hydrophilic interactions; quaternary structures of proteins. Importance of shape in protein function: fibrous proteins have a structural role e.g. collagen; globular proteins mostly function as enzymes, antibodies and hormones e.g. insulin.
		Practical work: Chemical tests for reducing and non-reducing sugars, starch, lipids and proteins.
	2.1.5 Nucleic acids	Nucleotides condense together by means of a phosphodiester bond to form a polynucleotide having a 5'end and a 3'end. 5 different nitrogenous bases: pyrimidines and purines. DNA: awareness that adenine and thymine have 2 hydrogen bonds and cytosine and guanine have 3 hydrogen bonds. The structures of DNA, mRNA and tRNA only in sufficient detail to provide an understanding of their roles in coding information and in protein synthesis. (Details of r-RNA structure is not required)
	2.1.6 Vitamins and their roles as co-enzymes	NAD^+/NADH; $NADP^+$/NADPH; FAD/$FADH_2$ and coenzyme A.
	2.1.7 Energy rich compounds	ATP and creatine phosphate.
2.2 Enzymes	2.2.1 Organic catalysts	Enzyme structure and function; Energy changes in chemical reactions and activation energy: lowering of activation energy through the formation of an enzyme-substrate complex.
	2.2.2 Site of enzymes	In solution and as part of cell membranes or organelle membranes.
	2.2.3 Factors affecting rate of enzyme catalysed reactions	Temperature, *p*H, enzyme and substrate concentration.
		Practical work: Experiments to investigate the effect of the above factors.
	2.2.4 Enzyme inhibition	Competitive and non-competitive inhibition. Differences to include definitions and graphs.
	2.2.5 Allosteric enzymes	Their role in regulating metabolic pathways by negative feedback inhibition as exemplified by phosphofructokinase.

Section 3: Cellular function and organisation		
Topic	**Subject Content**	**Knowledge expected**
3.1 Cells tissues and organs	3.1.1 Introduction of organisation in living organisms	Awareness that cells form tissues, which in turn make up organs and organ systems. A brief mention of principal types of tissues for practical work purposes.
3.2 Cell structure and function	3.2.1 The cell as the basic unit of living things.	Comparison of the principal features of prokaryotic and eukaryotic cells. The structure of a generalised plant and animal cell as revealed by both light and electron microscopy. Organelles should include the nucleus and nuclear envelope, nucleolus, centrioles, basal bodies, eukaryotic flagella (undulipodia), endoplasmic reticulum, ribosomes, Golgi apparatus, lysosomes, peroxisomes, mitochondria, chloroplasts and cytoskeleton.
	3.2.2 The fluid mosaic model of cellular membranes.	Structure as revealed by freeze- etching (knowledge of other cytological techniques is not required).
	3.2.3 Movement of molecules across membranes.	Diffusion, osmosis, facilitated diffusion, primary and secondary active transport, endocytosis including receptor-mediated endocytosis and exocytosis. (The use of the equation $\varphi = \varphi_s + \varphi_p$ is required; description of hypertonic, isotonic and hypotonic solutions on the effect of cells is expected).
		Practical Work: The use of the light microscope, preparation of temporary slides, examination of permanent slides using low and high power of the light micoscope. *Plant tissues should include parenchyma, collenchyma, sclerenchyma, xylem vessels, phloem sieve tubes and companion cells. Animal tissues should include the following epithelia: Squamous, cuboidal, columnar, ciliated, pseudostratified and stratified epithelium.*

SECTION 4: Maintenance of life (Nutrition, Transport and Respiration)		
Topic	**Subject Content**	**Knowledge expected**
4.1 Nutrition in Plants	4.1.1 Autotrophic nutrition.	Autotrophic nutrition: synthesis of an organic compound from an inorganic source of carbon. Chemosynthesis: using the oxidation of inorganic molecules as a source of energy; photosynthesis: using light as a source of energy.
	4.1.2 Details of leaf and chloroplast structure and their roles	Description of the internal structure of a dicotyledonous leaf; the location of the palisade tissue. Functions of leaf in relation to structure. Structure of a chloroplast as revealed by electron microscopy. To identify the envelope, stroma, grana and lamellar structure. The location of the chloroplast pigments. The role of chloroplast pigments (chlorophyll *a* and *b* and carotenoids in converting light energy into chemical energy; primary and accessory pigments) Distinction between absorption and action spectra.
	4.1.3 Details of Photosynthesis	Light-dependent reaction to include cyclic and non-cyclic photophosphorylation in the production of reduced $NADP^+$ ($NADPH + H^+$) and ATP; the evolution of oxygen. Role of the electron transport chain in ATP generation by chemiosmosis (names of carriers are not required). Light-independent reaction to include the fixation of carbon dioxide onto a 5C compound (ribulose bisphosphate – RuBP) to give 3-phosphoglycerate (3PG). The use of reduced $NADP^+$ and ATP from the light-dependent reaction in the synthesis of carbohydrate (glyceraldehyde 3-phosphate – G3P) from 3PG. The regeneration of RuBP.
	4.1.4 Factors affecting Photosynthesis	The effect of light intensity and wavelength, carbon dioxide concentration and temperature on the rate of photosynthesis. The concept of limiting factors; compensation point.
	4.1.5 C_3 and C_4 Plants	C_3 and C_4 Plants: Photorespiration (*details of full biochemical pathways not required*). C_3 and C_4 pathways as examples of ecological adaptation. CAM plants. Comparison of the internal leaf structure of C_4 as compared to that of the C_3 leaf. The two types of chloroplasts in a C_4 leaf.
		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.
4.2 Heterotrophic nutrition	4.2.1 Heterotrophic nutrition	Definition of heterotrophic nutrition. Description of the structure of the human alimentary canal in relation to digestion and absorption; histology of the ileum wall, to include the mucosa, submucosa, muscle layers and serosa. The sources and effects of secretions concerned with the digestion of carbohydrates, lipids and proteins.

		The nervous and hormonal control of enzyme release and gut activity (*hormonal control to be exemplified by gastrin, CCK and secretin*).
	4.2.2 Adaptations in herbivorous and carnivorous mammals	Adaptation of ruminant mammals to their mode of nutrition: i) dentition; ii) the 4- chambered stomach of the alimentary tract, including mutualistic interactions; 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.
		Practical work should include the examination of slides of sections of the ileum wall and of jaws to appreciate types of teeth.
	4.2.3 Saprophytic nutrition	Definition of saprophytic nutrition, using *Rhizopus* as an example.
4.3 Transport in plants	4.3.1 Transport systems	An understanding of the need for transport systems in relation to size and surface area to volume ratio; the concept of mass flow as seen in the mammalian circulatory system and translocation (defined as movement of solutes in phloem) in plants.
	4.3.2 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.
	4.3.3 Water relations of cells	Concept of water potential (ψ), pressure potential (ψp) and solute potential (ψs). Recall Section 3.2.3. Water uptake in plants to include transpiration- cohesion-tension mechanism, root pressure, apoplast, symplast and vacuolar pathways. Uptake of mineral ions by roots. The function of nitrate, phosphate and magnesium ions. *(Mineral deficiency symptoms are not required)*
	4.3.4 Stomata	Structure and physical changes in stomata involved in their opening and closing mechanisms.
	4.3.5 Factors affecting transpiration	Factors affecting transpiration to include climatic factors (light intensity, air currents, humidity, temperature) and structural adaptations.
	4.3.6 Leaf modifications .	Definition of mesophytes, xerophytes, halophytes and hydrophytes. Adaptations of xerophytes as exemplified by *Marram* grass and adaptations of hydrophytes as exemplified by *Nymphaea* (waterlily) and a locally available totally submerged hydrophyte as *Egeria* or *Elodea (available in pet shops). Note:* Egeria - *hydrophyte with aerenchyma, very thin leaves, minimal xylem with vascular tissue in the centre. Flower on surface of water.*
		Practical work should include the determination of water potential and solute potential in plant tissues.

		Practical work should include measurement of transpiration and water absorption; stomatal counts.
	4.3.7 Translocation of organic solutes in plants	Mass-flow as explained by the pressure flow model in the translocation of phloem. Loading and unloading to include the relation of the structure and arrangement of sieve tube elements, companion cells and transfer cells to the movement of organic solutes; mention of role of proton pumps, in outline only.
4.4 Transport in animals	4.4.1 Circulatory systems	Definitions of open, closed, single and double circulation as found in insect, fish and human.
	4.4.2 Characteristics of circulation in mammals	Characteristics of circulation in mammals: closed and double. Appreciation that efficiency of a circulatory system depends on pressure differences and fast blood flow, which lead to steep concentration gradient and more efficient diffusion across the exchange surface. Advantages of the double circulation. An understanding of the outline functions of the circulatory system in mammals, in the transport of respiratory gases, metabolites, metabolic wastes and hormones.
	4.4.3 Structure and function of the mammalian heart	Structure of the mammalian heart. Histology of cardiac muscle. The cardiac cycle. Pressure curves in the left ventricle and the aorta. Volume changes in left ventricle. Appreciation that pressure in the right ventricle is lower than that of the left ventricle. Cardiac output as a function of heart rate and stroke volume; effect of exercise on cardiac output. The role of the sino-atrial node (in myogenic stimulation) 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).
	4.4.4 Structure of blood vessels and blood flow characteristics	Organization of blood vessels into arteries, arterioles, capillaries, venules and veins. Structure of arteries, capillaries and veins. Characteristics of blood flow in arteries: pulsatile and continuous. Pressure changes in arteries, capillaries and veins. Blood flow through veins: describe the effect of skeletal muscle contraction on venous blood flow. Regulation of blood pressure by vasoconstriction and vasodilation (*details of hormonal control not required*). *Measuring blood pressure and interpreting an ECG are NOT expected*
	4.4.5 Blood, tissue fluid and lymph	Components of blood. Description of the composition of blood as plasma and blood cells, to include erythrocytes and leucocytes (neutrophils, eosinophils, monocytes and lymphocytes) and platelets. Adaptations of erythrocytes to transport of oxygen. Recall structure and function of leucocytes (Section 5.6). Appreciation of formation of red blood cells from stem cells in bone marrow due to the effect of erythropoietin. Tissue fluid and lymph. Formation and reabsorption of tissue fluid: interchange of materials between capillaries and tissue fluid in terms of hydrostatic pressure and osmotic pressure.

		The lymphatic system: basic structure (to include vessels, glands and connections with the cardiovascular system) and functions. *Practical work to include the microscopic examination of stained blood films and the identification of cells.*
4.5 Respiration	4.5.1 Metabolic pathways in cellular respiration	Introduction to metabolic pathways: the concept of a metabolic pathway as a sequence of enzyme-controlled reactions; recall the roles of enzymes in the control of such pathways, as exemplified by phosphofructokinase (Section 2.2.5); anabolism and catabolism; understand the significance of ATP in metabolism as the immediate supply of energy for biological processes. Metabolic rates and factors affecting them. Respirometer - its use to find rate of respiration *(its use to find RQ and interpretation of RQ are not expected).*
	4.5.2 Cellular respiration	Cellular respiration: the conversion of monosaccharides to pyruvate during glycolysis; the phosphorylation of hexose molecules; breakdown to glyceraldehyde-3-phosphate (G3P); oxidation to 3-phosphoglycerate (3PG) (GP) with the production of reduced coenzyme ($NADH + H^+$); ATP as a result of substrate level phosphorylation. (Recall the role of PFK as an allosteric enzyme, in the control of ATP production; *details of intermediate compounds and reactions, other than those specified, are not required; names and structures of intermediate compounds and names of enzymes catalysing intermediate reactions other than PFK, are not required).*
	4.5.3 Aerobic respiration	Aerobic respiration: understand that during the complete oxidation of pyruvate, involving oxidation of pyruvate to acetyl co-enzyme A and the events of Krebs cycle result in the production of carbon dioxide, more reduced coenzyme ($NADH + H^+$), ($FADH_2$) and ATP (*detailed knowledge of the intermediate stages in the Krebs cycle is not required; names and structures of the intermediate stages in the Krebs cycle are not required, except for oxaloacetate).* The role of the electron-transport chain in generating ATP (oxidative phosphorylation and chemiosmosis); the role of molecular oxygen as a hydrogen acceptor forming water. Recall the structure of a typical mitochondrion; identify inner and outer membranes and the inter-membranal space; describe and understand the role of mitochondria as the site of Krebs cycle and electron-transport chain; understand the location of enzymes and electron carriers.
	4.5.4 Anaerobic respiration	Anaerobic respiration: understand the situations in which the pyruvate formed in glycolysis may not undergo complete oxidation; formation of lactic acid in muscle; formation of ethanol in yeast. Compare and explain the differences in the yields of ATP from the complete oxidation of glucose and from the fermentation of glucose to lactic acid or ethanol. Oxygen debt.
	4.5.5 The metabolic pool	The metabolic pool concept: to include, in outline only, fat respiration and synthesis, gluconeogenesis and amino acid metabolism.
4.6 Gaseous	4.6.1 Gaseous exchange in	Fick's Law as applied to respiratory surfaces in order to maximise rate

exchange	plants, insects, bony fish and mammals.	of diffusion *(only a qualitative approach is required)*. Respiratory surface of plants to include mesophyll layer and root epidermal cells. Tracheal system of insects. Structure of the gills of bony fish; ventilation; countercurrent exchange to maximise diffusion. The structure and function of mammalian lungs; ventilation; control of rate and depth of breathing. *When studying these respiratory organs emphasis must be given to how Fick's Law is being reflected.*
	4.6.2 Transport of respiratory gases	Adaptation of erythrocyte to its function of transport of oxygen and carbon dioxide; the chloride shift. The role of the respiratory pigment haemoglobin in increasing the oxygen-carrying capacity of the blood. Dissociation curves of adult haemoglobin, foetal haemoglobin and myoglobin; the Bohr effect.
		Practical work may include use of simple respirometers and spirometer.

SECTION 5: Adjustment and control		
Topic	**Subject Content**	**Knowledge expected**
5.1 Homeostasis	5.1.1 Concept of homeostasis	Maintenance and control of internal environment.
	5.1.2 Physiological regulation	Control systems and the concept of negative feedback. Example of a control system. *(Recall concept of positive feedback in menstrual cycle and parturition Section 9.5*)
5.2 Hormonal Control	5.2.1 The hypothalamus	Neurosecretory cells. *Histological details not required.* Release and release-inhibiting neurohormones and their action.
	5.2.2 Hormones	Chemical nature of hormones and their mode of action. Peptide, protein, amine and steroid hormones (examples, but chemical formulae not required). Secondary messenger mechanism and intracellular hormone-receptor complex formation.
	5.2.3 The pituitary gland	Anterior hormone-producing lobe; prolactin and tropic hormones. Posterior non-producing lobe; ADH and oxytocin. *Effects of these hormones only are required; detail of structure is not required.*
	5.2.4 Pancreas and adrenals	Regulation of blood glucose levels. Insulin and glucagon; site of secretion (beta and alpha cells). Regulatory processes in lowering or raising blood glucose. Diabetes – Type II (insulin-independent or maturity onset diabetes) and its control. Role of adrenalin in blood glucose regulation. *(Recall Type I [Juvenile or insulin-dependent] diabetes in Section 5.6.3]* Role of Adrenalin and Cortisol in blood glucose regulation.
5.3 Thermoregulation	5.3.1 Ectothermy and endothermy	Definition and examples. Behavioural mechanism of thermoregulation in reptiles. Role of mammalian skin as thermoregulatory organ. Structural, behavioural and physiological mechanisms of thermoregulation in mammals. Hibernation and Aestivation. Advantages and disadvantages of ectothermy and endothermy.
5.4 The Liver	5.4.1 Histology Metabolic role: Carbohydrate Protein Lipid	Detailed structure of liver lobule. Glycogenesis, glycogenolysis and gluconeogenesis. Deamination, urea formation, transamination, plasma protein synthesis. Production of bile. Lipid metabolism. Summary diagram of the ornithine cycle and urea formation (*molecular structures and site in the cell where each reaction takes place is not required*).
5.5 Excretion and Osmoregulation.	5.5.1 Water and solute balance	Definition and importance of excretion and osmoregulation. Osmoregulation in a terrestrial insect, a marine and freshwater teleost and a mammal. Gross structure of kidney and structure and histology of nephron in relation to its osmoregulatory functions. Role of the mammalian kidney in excretion, osmoregulation and pH regulation. Ultrafiltration, selective reabsorption and secretion. Countercurrent multiplier in the Loop of Henle and the vasa recta as countercurrent exchangers. Role of antidiuretic hormone and aldosterone.

5.6 Immune System	5.6.1 Innate (Non-specific) defence mechanisms	First Line of defence: The skin, mucous membranes and their secretions. Second line of defence: Phagocytic leucocytes (neutrophils and monocytes). Natural killer cells (NKC's). Antimicrobial proteins (compliment and cytokines). Mode of action of complement proteins. The inflammatory response (outline of the activity of mast cells, histamine, complement proteins and phagocytic leucocytes). Major stages involved in blood clotting.
	5.6.2 Adaptive (specific) defence mechanisms	Third line of defence: Humoral and Cell-Mediated Immunity. Lymphocytes: B and T cells. Humoral Immune response to include Helper cells (T_H-CD4); activation of B cells to antibody- secreting plasma cells; immunoglobulins/ antibodies; generalised structure of immunoglobulins. Specificity of antigen/antibody interaction. Cellular immune response to include Helper (T_H-CD4) and Cytotoxic (T_c-CD8) cells. Cytokines, lymphokines, and interleukins can be used interchangeably.
	5.6.3 Disorders	An autoimmune disease exemplified by juvenile diabetes (Type I or insulin-dependent diabetes). AIDS.
	5.6.4 Immune reactions	Transfusion and ABO, Rhesus blood grouping. Haemolytic disease of the newborn.
	5.6.5 Natural immunity	Passive: maternal-foetal exchange. Active: Contracting the disease (recall adaptive defence mechanisms Section 5.6.2.
	5.6.6 Artificial immunity	Passive: antibody injection. Active: Vaccination (different types of vaccines are not required).

Section 6: Responding to the Environment		
Topic	**Subject content**	**Knowledge expected**
6.1 Transmitting information through the nervous system.	6.1.1 The neuron	Structure and electrical properties of a myelinated motor neuron; the resting potential; generation and propagation of an action potential; factors affecting the speed of conductance in neurones (myelination, diameter and temperature); refractory period (absolute and relative refractory periods).
	6.1.2 Synaptic transmission	The structure of the synapse; mechanism of transmission; EPSP's, IPSP's and temporal and spatial summation. The role of neurotransmitters limited to acetylcholine and noradrenaline and effect of drugs (illustrated by nicotine and amphetamines); the neuromuscular junction.
	6.1.3 The autonomic nervous system	Autonomic control of the internal environment; only an outline of the positions of ganglia and functions of the sympathetic and parasympathetic divisions of the autonomic nervous system is required. A specific physiological knowledge will be required only in the context of the control of heart rate (Section 4.4.3)
	6.1.4 The central nervous system	Gross structure of the brain; location and function limited to the medulla, pons, cerebellum, thalamus, hypothalamus and cerebral hemispheres (*including sensory ,motor and association areas*). Structure of the spinal cord as seen in transverse section. The reflex arc; monosynaptic as exemplified by the knee-jerk reflex and polysynaptic reflex as exemplified by the withdrawl of hand from pin.
6.2 Stimulus reception in animals	6.2.1 Sense organs as energy transducers	Exemplified by the mammalian retina; the other parts of the eye acting as ancillary structures to ensure optimum operation of the retina. A brief outline of image processing at the retinal level to include the absorption of light by rhodopsin causing the change of the *cis* to the *trans* form of the isomer, resulting in a change in sodium permeability creating a generator potential *(cGMP to keep sodium channels open is not required)*. Differences in visual acuity and sensitivity of rods and cones. The role of rod cells and cone cells in affecting monochromatic and trichromatic vision. The nocturnal eye.
6.3 Stimulus reception in plants	6.3.1 Phototropism in shoots	Understand experiments on phototropism – as exemplified by Went and Darwin's experiments; the role of auxin, IAA and mechanism of how auxin affects cell elongation. (*Graph showing the effect of Auxin concentration on growth response of shoots is not expected).*

Section 7: Locomotion and Support		
Topic	**Subject Content**	**Knowledge expected**
7.1 Striated muscle in mammals	7.1.1 Anatomy	Attachment of muscles to bones via tendons at origin and insertion. Muscle fibres as being made up of myofibrils.
	7.1.2 Histology	Muscle fibres as muscle cells made up of myofibrils and bound by a sarcolemma. Muscle histology is to include the ultrastructure of myofibrils i.e. the arrangement of actin and myosin filaments to form I-bands, A-bands and the H-zone. Z-line, M-line and the sarcomere as the functional unit within myofibrils. Arrangement of troponin, tropomyosin around the actin filaments. The arrangement of the sarcoplasmic reticulum and T-tubules around myofibrils.
	7.1.3 Contracting mechanism	The role of actin, myosin, tropomyosin and troponin in controlling and bringing about contraction. Sliding filament theory. Cross bridge formation and the role of ATP in cross bridge breakdown.
7.2 Skeleton	7.2.1 Hydrostatic skeleton	Definition and role of hydroskeleton in movement and support as exemplified by the earthworm. (*The role of chaetae and circular and longitudinal muscle in forward movement.)*
	7.2.2 Exoskeleton	Definition and role of exoskeleton in movement and support as exemplified by an insect. The arrangement of flexor and extensor muscles, as examples of antagonistic muscles, to bring about limb bending and extending in the insect.
	7.2.3 Endoskeleton	Definition and role in movement and support of endoskeleton. Bipedal gait. Gross structure of a bone including the distribution of spongy and compact bone e.g. femur. The function of synovial joints. *(Details of synovial joints not required.)* Histology of compact bone. General structure of a vertebra including the centrum, transverse processes, central canal, prezygapophysis and postzygapophysis.
		Practical work should include the histology of compact bone and striated muscle tissue in animals. *Practical work should include recognition of the main features of a generalised vertebra as exemplified by the lumbar vertebra*.
7.3 Plant support	7.3.1 Supporting tissue	The structure and function of parenchyma, collenchyma, sclerenchyma tissue and the xylem elements. (Recall 3.1.1) The distribution of the above tissues 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 histology of supporting tissues in plants in monocotyledonous and dicotyledonous stems and roots.

Section 8: Genes, Cell division and Genetics		
Topic	**Subject Content**	**Knowledge expected**
8.1 Chromosomes and the genetic code	8.1.1 Chromosome structure	To include histones.
	8.1.2 Semi-conservative DNA replication	The basic principles underlying the Meselson and Stahl experiment to support semi conservative replication. The role of helicase, DNA polymerases III and I, DNA ligase, primase and Okazaki fragments (*knowledge of other enzymes and telomeres are not required).*
	8.1.3 The genetic code	The basic principles underlying the Hershey and Chase experiment to prove that DNA is the genetic material. Characteristics of genetic code to include: triplet code, specificity, degeneracy, universality, non-overlapping and punctuated.
	8.1.4 Protein synthesis	Central Dogma: Transcription: definition of template and non-template strand; to include promoter and termination site. Role of RNA polymerase. Post-transcriptional processing: pre-mRNA and mature mRNA, introns and exons; splicing to include only removal of introns. Charging tRNA to include role of activating enzymes (*no names required).* Translation: to include initiation, elongation and termination from a 5' to a 3' direction along the mRNA molecule - roles of mRNA, tRNA, and ribosomes (*only knowledge of P and A site is required*). Codon and anticodon interactions. Idea of polysome. Appreciation of post-translational processing.
	8.1.5 Control of gene expression in prokaryotes	Definition of constitutive and inducible enzymes. Organization of lac operon: expression of lac operon to include only the effect of the repressor protein. (*The effect of glucose on lac operon is not required*.)
	8.1.6 Gene and chromosome mutations	Point mutations to include base deletion, insertion, substitution and inversion. Insertion and deletion leading to frame shift mutations. Chromosome mutations to include only aneuploidy and polyploidy. Awareness that mutations are an important source of genetic variation that may occur during DNA replication and cell division.
8.2 Nuclear division	8.2.1 The cell cycle	The life of a cell to be described as consisting of three phases: (1) nuclear division (mitosis or meiosis); (2) cell division (cytokinesis); (3) interphase [consisting of three subphases: G1, S and G2]. *Candidates are not expected to know what controls the transition from one phase to another of the cell cycle although candidates should appreciate the fact that the length of the various phases depends on the type of cell.*

	8.2.2 Mitosis	The significance of mitosis in growth and replacement of cells, regeneration of body parts, asexual reproduction and gamete production in plants. Appreciate the fact that the nuclei of the daughter cells produced are genetically identical to the parent cell nucleus. The events occurring during prophase, metaphase, anaphase and telophase. *Candidates are not expected to differentiate between early and late stages of prophase, metaphase, anaphase and telophase.* The process of cytokinesis in animal and plant cells.
		Practical work should include preparation of root tip squashes and identification of the various stages of mitosis (also from prepared slides).
	8.2.3 Meiosis	The significance of meiosis in production of gametes in animals and spores in plants. Meiosis as a reduction division to produce haploid cells. The events occurring during the first and second meiotic divisions. *Candidates are not expected to differentiate between early and late stages of prophase I/II, metaphase I/II, anaphase I/II and telophase I/II. Differences between I and II for each stage (prophase, metaphase, anaphase and telophase) is expected.* The significance of meiosis in generating genetic diversity through: (1) synapsis and crossing over at chiasmata during prophase I; (2) random alignment of maternal and paternal chromosomes at the equator during metaphase I and independent assortment of chromosomes during anaphase I; (3) random alignment of chromosomes at the equator during metaphase II and independent assortment of chromatids during anaphase II. The significance of random fertilization in generating diversity. Candidates should be able to compare and contrast mitosis and meiosis.
		Practical work should include observation of microscope slides to study stages of meiosis.
8.3 Inheritance	8.3.1 Genes and alleles	Define gene and allele; dominant and recessive allele; homozygote and heterozygote; genotype and phenotype. Monohybrid inheritance; test cross. *(Recall the significance of meiosis and random fertilisation in sexual reproduction, in which gametes fuse to form a zygote, leading to genetic variation).* Codominance, and incomplete dominance [*codominance as illustrated by the MN or ABO blood group system and incomplete dominance as illustrated by flower colour in Antirrhinium (snapdragon)]*. Multiple alleles *e.g. ABO blood group system (I^A, I^B, I^O alleles).* Pedigree analysis.

	8.3.2 Dihybrid inheritance	Explain the inheritance of two non-interacting unlinked genes; test cross for dihybrid inheritance. Autosomal linkage, crossing over and recombinants in relation to events of meiosis. Chromosome maps. Sex determination in mammals and sex linkage. Inactivation of the X chromosome (Barr body). *Tortoise shell cats or calico cats to illustrate its phenotypic expression.* *(Sex-limited inheritance is not required.)* Gene interaction between two unlinked genes. *Gene interactions may be illustrated by comb shape in poultry and by an example to show epistasis.* Polygenic inheritance, leading to normal or Gaussian frequency distribution curve in a population. *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.*]

Section 9: Reproduction		
Topic	**Subject Content**	**Knowledge expected**
9.1 Asexual Reproduction	9.1.1 Asexual Reproduction	Definition; advantages and disadvantages of asexual reproduction.
	9.1.2 Natural cloning in plants	Vegetative propagation – *one example excluding histological detail.*
	9.1.3 Natural cloning in other kingdoms	Binary fission in a protozoan. Budding as exemplified by *Hydra*.
9.2 Sexual Reproduction	9.2.1 Sexual Reproduction	Definition; advantages and disadvantages of sexual reproduction.
	9.2.2 Genetic variation	Features which promote genetic variation – independent assortment, crossing-over, genetic recombination; mutation.
	9.2.3 Gamete transfer in relation to habitat	Gamete transfer in plants and animals. External fertilisation and internal fertilisation.
	9.2.4 Sexual and asexual reproduction	Compare and contrast sexual and asexual reproduction.
9.3 Life cycles – Kingdom Plantae	9.3.1 Alternation of generation	Generalised life cycle of plant showing alternation of generation. Gametophyte/ sporophyte stages.
	9.3.2 Life cycle of a Moss	General characteristics, morphology and relative importance of gametophyte, sporophyte stages. Mechanisms for the transfer of spores. *Funaria* can be used as a local example.
	9.3.3 Life cycle of a Fern with named homosporous example	General characteristics, morphology and relative importance of gametophyte and sporophyte stages. Mechanisms for the transfer of spores. *Dryopteris* may be used as an example.
	9.3.4 Life cycle of a flowering plant	General characteristics, formation of embryo sac and pollen; morphology and relative importance of gametophyte and sporophyte stages. (*Recall difference between homospory and heterospory)*

9.4 Floral morphology	9.4.1 Types of flower	Actinomorphic dicot, Zygomorphic dicot and petaloid monocot. General diagram of flower, half-flower, floral diagram and floral formula.
	9.4.2 Pollination	Pollination as the transfer of microspores to a receptive stigma; differences between entomophilous and anemophilous flowers; adaptations for insect and wind pollination. *Flowers of the Fabaceae (Leguminosae) and the Poaceae (Gramineae) as specialised for insect and wind pollination.* Self and cross pollination. Adaptations to promote cross-fertilisation, to include self-incompatability genes, protandry and protogyny.
	9.4.3 Fertilisation	Double Fertilisation. Seed and fruit formation. *Details of germination not required.*
		Practical work should include floral dissection, construction of floral diagrams and floral formulae.
9.5 Human reproduction	9.5.1 Male human reproductive system	Structure and function of reproductive system. Histology of testis. Spermatogenesis.
	9.5.2 Female human reproductive system	Structure and function of reproductive system. Histology of ovary. Oogenesis. The menstrual cycle.
	9.5.3 Fertilisation	Transfer of male gametes to female gametes, leading to fertilization. Capactiation; sperm penetration in oocyte to include acrosome reaction.
	9.5.4 Human development	Cleavage, morula, blastula formation, implantation, leading to the formation of the placenta.
	9.5.5 Human Placenta	Structure and functions of human placenta.
	9.5.6 Birth	Three stages of parturition.
	9.5.7 Lactation	Colostrum, nutritional importance and passive immunity.
	9.5.8 Hormones	Roles of luteinising hormone (LH) also known as interstitial cell stimulating hormone (ICSH) in males, follicle stimulating hormone (FSH), testosterone, oestrogen, progesterone, human choronic gonadotropin (hCG), oxytocin, prolactin and prostaglandins *(role of prostaglandins in menstruation only)*.

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SECTION 10: Evolution		
Topic	**Subject Content**	**Knowledge expected**
10.1 Genetic diversity	10.1.1 Sources of genetic variation	Recall Section 9.2.2 and 8.2.3.
	10.1.2 Types of variation	Continuous and discontinuous variation; discontinuous variation to include bar-charts showing the distribution of a particular characteristic in a population; continuous variation to include Gaussian distribution curve (Recall Section 8.3.2).
	10.1.3 Population genetics	The gene pool; definitions of allele, genotype and phenotype frequencies; the Hardy-Weinberg equilibrium principle.
	10.1.4 Agents of evolutionary change in bringing about changes in allele frequencies.	Factors affecting the Hardy-Weinberg equilibrium to include mutations, gene flow, non-random mating, genetic drift *(founder and bottleneck effect)* and selection.
10.2 Selection	10.2.1 Types of selection	Artificial and natural; directional, disruptive and stabilising selection. Balanced and transient polymorphism. Gradualistic and punctuated equilibrium modes of evolution.
10.3 Isolating mechanisms	10.3.1 Isolation leading to Speciation	Geographical isolation leading to allopatric speciation. Behavioural isolation and polyploidy leading to sympatric speciation. Reproductive Isolating mechanisms: pre-zygotic and post-zygotic isolating mechanisms.

Section 11: Environmental Biology		
Topic	**Subject content**	**Knowledge expected**
11.1 Ecological Concepts	11.1.1 Definitions	Definition of biosphere, ecology, population, community, ecosystem, habitat.
11.2 Population Ecology	11.2.1 Factors governing population size	Natality, mortality, immigration and emigration. Recruitment as the proportion of offspring that attains sexual maturity in the population. Biotic potential and environmental resistance. The carrying capacity of the environment as the maximum population size that can be sustained in the long term under the prevailing conditions. Density-dependent factors and density- independent factors affecting population growth. *[Treatment should be qualitative; no mathematical formulae are required.]*
	11.2.2 Selected models of population growth	S-shaped growth curve: the lag, log, deceleration and stationary phases. J-shaped growth curves. 'Boom and bust' curves and population crashes. *[No mathematical formulae for growth curves are required.]*
	11.2.3 Intraspecific interactions that limit population size	Competition and overcrowding.
11.3 Processes in ecological communities	11.3.1 Types of interspecific interactions	Definitions of predation, parasitism, mutualism, commensalism and Amensalism.
	11.3.2 Competition	Gause's principle of competitive exclusion exemplified by experiments with *Paramecium.* Resource partitioning.
	11.3.3 Ecological niche	Concept of ecological niche. The fundamental niche and the realized niche exemplified by the interaction between *Semibalanus* and *Chthamalus*. Relative niche breadths of generalist and specialist species to illustrate the advantages and disadvantages of both strategies.

	11.3.4 Ecological succession	The mechanism of ecological succession. Pioneer communities, seral stages and climax communities. Primary succession. Secondary succession exemplified by old fields
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. Definition of gross primary production and net primary production; calculation of these values from given data; calculation of 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	Terrestrial habitat types: Vegetation of the garigue, maquis and wood, steppe and the disturbed areas; specialised habitats e.g. cliffsides and screes, watercourses; coastal vegetation: maritime garigue, salt marshes and sand dunes. Marine habitat types: coastal habitats to include the supralittoral, mediolittoral and infralittoral zones. Students are expected to quote examples from each habitat type.
11.6 Ecological techniques	11.6.1 The capture-recapture method for estimating animal population size	Students should be able to understand the underlying assumptions of the Lincoln Index.

	11.6.2 Random Sampling	Define *random sample* and describe one method of random sampling used to compare the population sizes of two plant species based on the quadrat method.
	11.6.3 Non-random sampling	Line transects and ladder (belt) transects.
	11.6.4 Treatment of data.	Present ecological data in table form and evaluate graphical presentations of ecological data. Analysis of data by working out species frequency, species density, and species cover. Use of the t-test to compare means between two independent samples. Compare species diversity of two areas in terms of species richness and evenness by calculating Simpson's reciprocal 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.]*
		Practical work to include fieldwork; use of random and non-random techniques.

Section 12: Biotechnology		
Topic	**Subject content**	**Knowledge expected**
12.1 Biotechnology	12.1.1 Definition of biotechnology	Definition of biotechnology in its broader sense to include both traditional as well as modern biotechnology processes.
12.2 Principles and techniques of gene technology	12.2.1 Principles of gene technology	The principles of genetic engineering illustrated by the use of restriction endonuclease enzymes exemplified by *Eco*RI and ligases in the formation of recombinant DNA.
	12.2.2 Techniques of gene technology	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 (*characteristics of plasmid vectors are required but details of phage and cosmid vectors are not needed*); Introducing vector DNA in the host cell ; selecting the transformed cells by using marker genes and an adequate DNA probe – *(in this context the terms genetic selection, genetic screening and replica plating should be used).* *Other methods of introducing foreign DNA in host cells, e.g. transformation, transfection, microprojectiles, electroporation and microinjection, are not expected except in outline only where relevant for understanding of applications listed below.* The polymerase chain reaction (PCR) as a method of producing multiple copies of a particular gene.
	12.2.3 Analytical techniques of gene technology	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 hybridization is not examinable).*
		Practical work should include precipitation and spooling of DNA and gel electrophoresis of DNA fragments.
	12.2.4 Applications of gene technology	*Knowledge of the following applications is needed though details of the specific processes are not required.* Genetic fingerprinting and DNA profiling and its application in forensic work and paternity cases. Pharmaceutical products of gene technology: human protein replacement as exemplified by the production of either insulin or human growth hormone (somatropin or somatotrophin) by genetically modified microorganisms; advantages over traditional methods of treatment (e.g. *somatropin from farm animals might result in persons developing CJD up to 30 years after receiving hormonal treatment)* Use of agricultural animals in transgenic technology as exemplified by genetically modified goats to produce a recombinant form of *human antithrombin* (ATryn®), having anticoagulant and anti-inflammatory

		properties for the treatment of patients with hereditary antithrombin deficiency. Gene therapy: Use of bone marrow stem cells in the treatment of X-linked SCID (severe combined immuno-deficiency). Awareness of the limited success of treatment obtained so far with gene therapy. Applications of gene technology in agriculture: the production of pest resistant crops e.g *Bt maize*. *Note: Alternatives to the traditional textbook examples of gene technology are being suggested as gene therapy for cystic fibrosis has had very limited success; the use of bovine somatotropin (bST) in dairy herds is not approved in the EU.* *Candidates should be able to evaluate briefly the environmental implications of GM plants and ethical implications of the use of stem cells and gene therapy.*

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.*Franco Muzzo Editore, Padova.
Schembri, P.J. & Baldacchino, A.E. (1998). *Ilma, Blat u Ħajja, is-sisien tal-ambjent naturali Malti, [it- tieni edizjoni riveduta]*. Malta University Publishers Ltd.
Sultana J. & Falzon V. (1996, reprint 2001). (eds.), *Wildlife of the Maltese Islands.* 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 arc 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 adaptation 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.

Chi-Squared 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 = (number of columns) – 1