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PEPERIKSAAN
SIJIL TINGGI PERSEKOLAHAN MALAYSIA
(*MALAYSIA HIGHER SCHOOL CERTIFICATE*)

BIOLOGY
Syllabus
Second Edition

This syllabus applies for the 2001 examination and thereafter until further notice. Teachers/candidates are advised to contact Majlis Peperiksaan Malaysia for the latest information about the syllabus.

MAJLIS PEPERIKSAAN MALAYSIA
(*MALAYSIAN EXAMINATION COUNCIL)*

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FALSAFAH PENDIDIKAN KEBANGSAAN

Pendidikan di Malaysia ialah suatu usaha yang berterusan ke arah memperkembang potensi individu secara menyeluruh dan bersepadu untuk melahirkan insan yang seimbang dan bersepadu dan harmonis dari segi intelek, rohani, emosi, dan jasmani berdasarkan kepercayaan dan kepatuhan kepada Tuhan. Usaha ini bertujuan untuk melahirkan warganegara Malaysia yang berilmu pengetahuan, berketrampilan, berakhlak mulia, bertanggungjawab, dan berkeupayaan mencapai kesejahteraan diri serta memberikan sumbangan terhadap keharmonian dan kemakmuran keluarga, masyarakat, dan negara.

CONTENTS

964 BIOLOGY

Aims

This syllabus aims to enhance students' knowledge and understanding of biology to enable them to further their studies at institutions of higher learning or to assist them to embark on related careers, and also to promote awareness among them of the role of biology in the universe.

Objectives

The objectives of this syllabus are to enable students to

1. know and use biological facts and principles;
2. interpret, synthesise, and evaluate biological information;
3. analyse, evaluate, and to deal with information and ideas logically and critically;
4. plan and carry out experiments scientifically and make deductions;
5. handle biological materials correctly and safely;
6. develop proper attitudes and values on social, technological, and environmental issues related to current biology.

Elementary Knowledge

Modern biology cannot effectively be studied without some understanding of the underlying physico-chemical principles. Candidates will therefore be expected to have an elementary knowledge of the topics set out below.

The electromagnetic spectrum

Energy concepts (laws of thermodynamics, potential energy, activation energy, chemical bond energy)

Ions, molecules, acids, bases, pH, buffers

Isotopes – stable and radioactive

The colloidal state

Oxidation, reduction, electron transfer, and hydrogen transfer

Hydrolysis, condensation, phosphorylation, decarboxylation, deamination, transamination

Large areas of genetics and ecology rely on statistical methods. Candidates will need the elementary knowledge of the topics listed below. Questions on genetics and ecology which involve the use of these concepts may be set.

Mean, mode, and median

Standard deviation and standard error

χ^2-test

Histograms and pie charts

Normal distribution and bimodal distribution curves

Content

A. THE BIOLOGY OF MOLECULES AND CELLS

Topic	*Explanatory notes*
1. Basic chemistry of a cell (*15 periods*)	
1.1 Physical and chemical properties and physiological role	
1.1.1 Water	
Its important properties as a constituent and medium for life	– Polarity, cohesiveness, density, surface tension, specific heat capacity, latent heat of vaporisation, and hydrogen bonding
1.1.2 Carbohydrates	
Monosaccharides: trioses, pentoses, hexoses	– Reducing and non-reducing sugars – Aldehyde and ketone groups – Structure of triose (glyceraldehyde), pentose ring (ribose and deoxyribose), hexose ring (glucose)
Disaccharides: maltose, sucrose, lactose	– Glycosidic bond
Polysaccharides: starch, cellulose, glycogen	– Polymerisation process (formation of starch and cellulose)
1.1.3 Lipids	
Triglycerides: fatty acids and glycerol	– Saturated fatty acids (stearic acid) and unsaturated fatty acids (oleic acid) – Ester bond and esterification process
Phospholipids	– Structure of lecithin and its importance in cell membrane structure
Steroids	– Structure of cholesterol and its importance in health – Steroid drug abuse
1.1.4 Proteins	
Amino acids	– Basic structure – Types based on side chain, polar (serine), non-polar (glycine), acidic (aspartic acid), and basic (lysine) – Peptide bond and polymerisation process

	Levels of structure	– Primary, secondary, tertiary, and quarternary structures with examples – Bonding involved in the formation of proteins
	Conjugated proteins	– Fibrous and globular proteins with examples
	Properties of proteins	– Amphoteric, buffer, and colloid – Factors causing denaturation of proteins
1.1.5	Nucleic acids	– Nucleotide structure – Phosphodiester bond in the formation of polynucleotide – Watson and Crick's model of DNA structure – Types of RNA: mRNA, rRNA, tRNA – Differences between DNA and RNA
1.1.6	Other biomolecules: ions and vitamins	– Examples and importance
1.2	Movement of substances through membrane	
1.2.1	Passive transport	– Definition and examples in living cells
	(i) Diffusion	– Process
	(ii) Facilitated diffusion	– Mechanism of action
	(iii) Osmosis and water potential	– Process – Calculations
1.2.2	Active transport	– Definition and mechanism with examples
1.2.3	Endocytosis (pinocytosis and phagocytosis)	– Process and examples
1.2.4	Exocytosis	– Process and examples
1.3	Techniques of analysis	– *Basic principles only*
1.3.1	Chromatography	– Examples of uses in the analysis of proteins and plant pigments
1.3.2	Electrophoresis	– Examples of uses in the analysis of proteins
1.3.3	X-ray diffraction	– Examples of uses in the determination of protein and DNA structures
2	**Structure of cells and organelles** (*14 periods*)	
2.1	Prokaryotic cells	– Differences between prokaryotic and eukaryotic cells

2.2	Generalised eukaryotic cells	– Structure of eukaryotic cells as seen under the electron microscope
2.2.1	Plant cells	– Differences between plant and animal cells
2.2.2	Animal cells	
2.3	Cellular components	
2.3.1	Membrane, cell wall, and cytoplasm	– Structure and functions of membrane based on the fluid-mosaic model of Singer
2.3.2	Organelles	– Structure, functions, and distribution
(i)	Nucleus: nucleolus, chromosomes, nucleoplasm, and nuclear membrane	– Organisation of chromosomes
(ii)	Rough and smooth endoplasmic reticulum	
(iii)	Mitochondria	
(iv)	Golgi apparatus	
(v)	Lysosomes	– Process of lysosome action
(vi)	Ribosomes	
(vii)	Chloroplasts	– Chloroplast of higher plants only
(viii)	Centrioles	
(ix)	Microtubules	
(x)	Microfilaments	
(xi)	Vacuoles	
2.4	Specialised cells	– *Structure, functions, and distribution*
2.4.1	Plant cells	– Detailed description
(i)	Meristem	
(ii)	Parenchyma	
(iii)	Collenchyma	
(iv)	Sclerenchyma	
(v)	Xylem, including tracheids and vessels	
(vi)	Phloem, including companion cells and sieve tubes	
2.4.2	Animal cells	– Definition, structure, functions, and distribution
(i)	Epithelium: squamous, cuboidal, and columnar	– Simple and stratified types – Formation of endocrine and exocrine glands
(ii)	Nerves	– General structure of neurons (sensory, interneuron, and motor)

(iii) Muscles: smooth, striated, and cardiac		– Differences between muscle types – Structure of striated muscles as seen under the electron microscope
(iv) Bone, cartilage, and blood		– Compact bone, hyaline cartilage, erythrocytes, and leucocytes
2.5 Analytical techniques		– *Basic principles only*
2.5.1 Ultracentrifugation		– Examples of uses in the isolation of cellular components
2.5.2 Microscopy: light and electron		– Phase-contrast microscopes, transmission and scanning electron microscopes, and examples of their uses
3. Control in cells (*7 periods*)		
3.1 Enzymes		– Definition and properties of enzymes
3.1.1 Catalysis and activation energy		– Meaning of catalysis – Lowering of activation energy by enzymes in a reaction
3.1.2 Mechanism of action and kinetics		– Lock-and-key model, affinity and Michaelis-Menten constant, and Lineweaver-Burk plot
3.1.3 Cofactors: metal ions, coenzymes, and prosthetic groups		– Definition, examples, and action
3.1.4 Inhibitors: competitive and non-competitive		– Definition, examples, and action
3.1.5 Classification		– Major types according to IUB system: hydrolases, lyases, transferases, isomerases, ligases/synthetases, oxydoreductases; examples of reactions
3.1.6 Technology: enzyme immobilisation and biosensing		– Meaning and examples of uses
3.2 DNA and protein synthesis		
3.2.1 DNA as genetic material		– Experiment of Avery and colleagues
3.2.2 Gene concept, one-gene-one-polypeptide hypothesis		– Experiment of Beadle and Tatum
3.2.3 DNA replication		– Experiment of Meselson and Stahl – Processes involved

3.2.4	Protein synthesis	– Transcription: processes of mRNA production – Translation: processes of polipeptide production

B. ENERGETICS

	Topic	*Explanatory notes*
4.	**Photosynthesis** (*9 periods*)	
4.1	Light reaction	– Reaction and detailed description – Photoactivation of photosystem I and photosystem II – Photolysis of water – Production and roles of NADPH and ATP – Cyclic and non-cyclic photophosphorylation
4.2	Dark reaction/Calvin cycle in C_3 and C_4 plants	– Reaction and detailed description – CO_2 fixation to RuDP – Production of PGAL until the formation of carbohydrates – Involvement in the formation of proteins and fatty acids – Anatomical and physiological differences between leaves of C_3 and C_4 plants – Krantz's anatomy – Hatch-Slack pathway – Crassulacean acid metabolism (CAM) – Example: cactus
4.3	Factors limiting the rate of photosynthesis	– Wavelength and intensity of light, temperature, and carbon dioxide concentration – Compensation point
5.	**Respiration** (*7 periods*)	
5.1	Aerobiosis	
	5.1.1 Glycolysis	– Glucose phosphorylation, fructose diphosphate production – Splitting into phosphoglyceraldehyde and dihydroxyacetone phosphate – Conversion of phosphoglyceraldehyde to pyruvate and production of ATP and NADH – Substrate level phosphorylation

5.1.2	Krebs cycle/tricarboxylic acid cycle/citric acid cycle	– Formation of acetyl coenzyme A, formation of citrate, reformation of oxaloacetate from citrate via α-ketoglutarate and succinate, with emphasis on the formation of NADH, $FADH_2$, and GTP, and release of carbon dioxide – Calculations of total ATP production
5.1.3	Electron transport system	– Electron flow from NADH/$FADH_2$ via flavoprotein, coenzyme Q, and cytochrome to oxygen with the production of ATP and water – Effects of inhibitors (cyanide and carbon monoxide)
5.2	Anaerobiosis	– Differences between plants and animals: ethanol production in plants and lactic acid production in animals – Use of fermentation in industry with examples

6. Nutrition (*2 periods*)

6.1	Autotroph	
6.1.1	Chemosynthesis	– Concept with examples
6.1.2	Photosynthesis	– Refer to topic **4** (**Photosynthesis**) – Brief description of photosynthesis in bacteria
6.2	Heterotroph	– Concept with examples
6.2.1	Holozoic	
6.2.2	Saprophytic	
6.2.3	Parasitic	

C. GASEOUS EXCHANGE, TRANSPORT, AND HOMEOSTASIS

Topic		*Explanatory notes*
7.	**Gaseous exchange** (*4 periods*)	
7.1	Animals	
7.1.1	Gaseous exchange in mammals	– Processes and structures involved – Haemoglobin – Transport of oxygen and carbon dioxide – Partial pressure and Bohr effect – Oxygen dissociation curves

7.1.2 Breathing cycle		– Mechanism of breathing control – Chemoreceptor – Tidal volume, vital capacity, total lung capacity, inspiratory reserve volume, expiratory reserve volume, residual volume
7.2 Plants		
7.2.1 Stomata		– Structure and functions – Mechanism of stomatal opening and closing based on the starch-sugar hypothesis and K^+ ions accumulation hypothesis
8. Transport (*6 periods*)		
8.1 Animals		
8.1.1 Cardiac cycle		– Definition of systole and diastole – Changes in pressure and volume in aorta, left atrium, and left ventricle
8.1.2 Control of heart beat		– Sinoatrial and atrioventricular nodes – Sympathetic and parasympathetic nerves – Detailed description of heart beat
8.1.3 Cardiovascular diseases		– Hypertension, arterioschlerosis, and myocardial infarction – Meaning, causes, and prevention
8.2 Plants		
8.2.1 Xylem and ascent of sap		– Uptake of water and ions by roots – Transpiration – Root pressure and cohesion-tension theory – Mechanism of transport based on water potential – Pathways – apoplast, symplast, and vacuoles
8.2.2 Phloem and translocation		– Mass flow/pressure flow hypothesis (Münch model), electro-osmosis, cytoplasmic streaming, and peristaltic waves
9. Homeostasis (*6 periods*)		
9.1 Concept of homeostasis		– Definition and importance – Basis of control of biological systems – Positive and negative feedback mechanisms – Emphasis on temperature regulation (endothermic and ectothermic)

		– Emphasis on control of blood glucose level (role of insulin) and its relationship with diabetes mellitus – Calculation of pressure in movement of fluid between blood capillaries and tissues
9.2	Liver	– Structure and functions in mammals – Cori cycle and ornithine cycle; emphasis on the entrance of amino groups into the cycle and the production of urea
9.3	Osmoregulation	
9.3.1	Animals	
	(i) Kidney	– Detailed process of urine formation – Structure and functions of nephron and related blood vessels
	(ii) Antidiuretic hormone (ADH)	– Role and mechanism of action
	(iii) Control of blood Na^+ ions and pH	– Mechanism of control
9.3.2	Plants	
	(i) Role of stomata in the regulation of water loss	– Refer to topic **7.2.1 (Stomata)**
	(ii) Adaptation of plants to the environment	– Morphology, anatomy, and physiology of xerophytes, hydrophytes, halophytes, and mesophytes, with examples

D. CONTROL AND COORDINATION

	Topic	***Explanatory notes***
10.	**Nervous system** (*6 periods*)	
10.1	(*a*) Generation, characteristics, and transmission of impulse	– Organisation of nervous system in mammals – Formation of resting and action potentials – Characteristics of nerve impulse and definition of related terms – Mechanism of transmission and spread of impulse along the axon
	(*b*) Synapses	– Structure of synapse and role of neurotransmitters such as acetylcholine and norepinephrine – Mechanism of impulse transmission across synapses – Comparison between mechanisms of impulse transmission across synapse and along the axon

	(*c*) Neuromuscular junctions	– Structure of neuromuscular junction and sarcomere – Roles of sarcoplasmic reticulum, Ca^{2+} ions, myofibril, and T tubule in muscle contraction – Sliding filament hypothesis – Mechanism of muscle contraction: roles of actin, myosin, and troponin
10.2	Autonomous nervous system in mammals	– Organisation of the sympathetic and parasympathetic nervous systems and their relationship with the central nervous system – Structure, functions, and examples – Comparison between the sympathetic and parasympathetic nervous systems
10.3	Drug abuse	– Mechanism of action of drug on nervous system and neuromuscular junctions – Examples: cocaine and kurare

11. Hormone/chemical coordination (*5 periods*)

11.1	Humans	
	11.1.1 Hormonal action	– Mechanism of hormone action via gene activation; examples of steroid hormones – Mechanism of non-steroid hormone via activation of cyclic AMP system (cascade effect); example: adrenaline – Comparison between the two action mechanisms
	11.1.2 Role of hormones in reproduction	– Site of production and role of hormones in oestrus cycle – Site of production and role of hormones during pregnancy
11.2	Plants	– *Role of hormones in plant growth and development* – Growth of organs – Root and shoot induction – Apex and bud dominance – Seed dormancy – Flowering – Defoliation – Senescense – Fruit ripening – Stomatal mechanism – Parthenocarpy – Interaction between hormones; example: apex dominancy
	11.2.1 Auxin	
	11.2.2 Gibberellin	
	11.2.3 Cytokinin	
	11.2.4 Abscisic acid (ABA)	
	11.2.5 Ethene	

11.3	Phytochromes and the effect of light on flowering	– Definition of phytochrome – Mechanism of phytochrome action – Photoperiodism – Role of phytochromes in photoperiodism and flowering

E. IMMUNE SYSTEM

Topic		*Explanatory notes*
12.	**Immunity** (*4 periods*)	
12.1	Antibody, antigen, epitope, cell-mediated response, humoral immune response	– Definition and description
12.2	Lymphatic system	– Organisation of lymphatic system and formation of lymphatic fluid – Relationship between lymphatic system and immunity
12.3	Development of immunity	– Roles of macrophages, T-cells, and B-cells – Mechanism of cell-mediated response (T-cells) and humoral immune response (plasma cells)
12.4	Concept of self and non-self	– Foreign tissue/graft rejection by the body – Application of concept in medicine (organ transplant)
12.5	Acquired Immune Deficiency Syndrome (AIDS)	– Causes, causing agent (HIV), symptoms, and prevention of AIDS – Mechanism of HIV infection

F. REPRODUCTION, DEVELOPMENT, AND GROWTH

Topic		*Explanatory notes*
13.	**Reproduction** (*7 periods*)	
13.1	Sexual reproduction	
	13.1.1 Plants (i) Algae: *Spirogyra* (ii) Bryophyta: *Marchantia* (iii) Filicinophyta: *Dryopteris* (iv) Coniferophyta: *Pinus* (v) Angiospermophyta: *Caesalpinia*	– Refer to topic **22** (**Biodiversity**) for morphological characteristics – Structure of sexual reproductive organ – Life cycle with emphasis on sexual reproduction

13.1.2	Fungi: *Mucor*	– Refer to topic **22** (**Biodiversity**) for morphological characteristics – Structure of sexual reproductive organ – Life cycle with emphasis on sexual reproduction
13.1.3	Animals	– Refer to topic **22** (**Biodiversity**) for morphological characteristics
	(i) Ciliophora: *Paramecium*	
	(ii) Cnidaria: *Hydra*	– Diversity of sexual reproductive systems and overall comparison
	(iii) Annelida: *Pheretima*	
	(iv) Arthropoda: *Periplaneta*	– Mechanism of fertilisation (internal and external)
	(v) Amphibia: *Rana*	– Oviparity, ovoviviparity, and viviparity
	(vi) Reptilia: *Naja*	
	(vii) Osteichthyes: *Tilapia*	
	(viii) Aves: *Columba*	
	(ix) Mammalia: *Rattus*	
13.2	Asexual reproduction	– *Definition and examples only*
13.2.1	Parthenogenesis	– *Aphis* and *Apis*
13.2.2	Pedogenesis	– *Amphioxus*
13.2.3	Polyembriony	– *Fasciola*
13.2.4	Sporulation	– *Dryopteris* and *Plasmodium*
13.2.5	Budding	– *Hydra* and *Saccharomyces*
13.2.6	Binary fision	– *Amoeba*
13.2.7	Regeneration	– *Planaria*
13.2.8	Vegetative	– *Allium*, *Solanum*, *Yucca*, *Zingiber*

14. Development (*6 periods*)

14.1 Animals

14.1.1	Embryology	– Brief description of major stages – Beginning after fertilisation from cleavage to organogenesis (blastula and gastrula) – Organ formation from ectoderm, mesoderm, and endoderm
14.1.2	Human foetal development	– Roles of placenta, chorion, amniotic fluid, and allantois – Roles of progesterone and oestrogen
14.1.3	Parturition process in humans	– Roles of progesterone, oestrogen, oxytocin, and prolactin

14.2	Plants	
	14.2.1 Seed development	– Development of seeds and fruits after fertilisation – Structure of monocotyledonous and dicotyledonous seeds
	14.2.2 Seed germination	– Mobilisation of nutrients after imbibition (role of giberrelin)
15.	**Growth** (*5 periods*)	
15.1	Measurement	– Parameters and methods of measurement (suitabilities and problems)
15.2	Types of growth curve	– Absolute growth curve – Absolute growth rate curve – Relative growth rate curve
15.3	Growth pattern	– Limited growth (human) – Unlimited growth (perennial plants/woody saka) – Allometric growth (human) – Isometric growth (fish) – Intermittent growth (insect)
15.4	Ecdysis and metamorphosis	– Definition – Role of hormones (neurosecretion, juvenile hormone, and ecdysone) – Ecdysis and metamorphosis in insects
15.5	Dormancy	– *Concept, importance, and examples*
	15.5.1 Animals	– Hibernation, aestivation, and diapause
	15.5.2 Plants	– Seed dormancy – Factors affecting seed dormancy and methods of overcoming them

G. GENETICS

Topic		*Explanatory notes*
16.	**Transmission genetics** (*10 periods*)	
16.1	Mendelian genetics	– Definition of the terms gamete, gene, allele, dominant and recessive alleles, homozygote, heterozygote, fenotype, genotype, filial generation (P_1, P_2, F_1, F_2), types of crosses (test cross, back cross, reciprocal cross, selfing), and pure breeding

		– Mendel’s experiment on monohybrid and dihybrid crosses/inheritance – Characteristics of pea plants used by Mendel
	16.1.1 Monohybrid	– Monohybrid cross and its results – Mendel’s first law (Law of Segregation) and its relation to meiosis – Calculations of genotypic and phenotypic ratios (Punnett square method)
	16.1.2 Dihybrid	– Dihybrid cross and its results – Mendel’s second law (Law of Independent Assortment) and its relation with meiosis – Calculations of genotypic and phenotypic ratios until F_2 generation (Punnett square and branch/fork methods)
16.2	Modification of Mendelian genetics	– Crosses that result in ratios differing from the classic Mendelian 3:1 and 9:3:3:1 ratios
	16.2.1 Codominance	– Definition – Example of inheritance: MN blood group in humans – Calculations of genotypic and phenotypic ratios
	16.2.2 Incomplete dominance	– Definition – Example of inheritance: *Antirrhinum* (snapdragon) flower color – Calculations of genotypic and phenotypic ratios
	16.2.3 Multiple alleles	– Definition – Example of inheritance: human ABO blood group – Calculations of genotypic and phenotypic ratios
	16.2.4 Lethal genes	– Definition – Example of inheritance: coat color in mice – Calculations of genotypic and phenotypic ratios
	16.2.5 Polygenes	– Definition – Example of inheritance: height in humans
	16.2.6 Linked genes	– Definition of linked genes and sex-linked genes

		– Effect of crossing-over on ratio of dihybrid crosses – Parental and recombinant phenotypes – Examples: *Drosophila* eye color and haemophilia in humans – Calculations of genotypic and phenotypic ratios – Pedigree analysis – Sex determination in humans
	16.2.7 Epistasis	– Definition and examples only
16.3	Genetic mapping	– Calculations of distance between two loci based on percentage of crossing-over – Examples of calculations for *Drosophila* – Determining the relative position of a gene on a chromosome based on percentage of crossing-over
17.	**Mutation** (*4 periods*)	
17.1	Classification	– Spontaneous and induced – Examples of mutagens
17.2	Gene mutation	– Mutation at DNA level
	17.2.1 Substitution	– Definiton – Example: sickle-cell anaemia
	17.2.2 Insertion/Addition	– Definition – Frameshift mutation
	17.2.3 Deletion	– Definition – Frameshift mutation – Example: thalassaemia major
	17.2.4 Inversion	– Definition
17.3	Chromosomal mutation	– Chromosomal aberration
	17.3.1 Change in chromosome number	– Aneuploidy and euploidy/polyploidy – Definition of autosome and sex chromosome

Terms	*Meaning*
Aneuploidy	$2n \pm$ chromosome
Monosomy	$2n - 1$ chromosome
Trisomy	$2n + 1$ chromosome
Tetra-, penta-, …	$2n + 2$, $2n + 3$, …

Terms	*Meaning*
Euploidy Diploidy Triploidy Tetra-, penta-, … Polyploidy	Multiple of *n* 2*n* 3*n* 4*n*, 5*n*, … 3*n*, 4*n*, 5*n*, …
Autopolyploidy	Multiplication due to the same genome
Allopolyploidy	Multiplication due to different genome

(i) Aneuploidy
- Definition
- Non-disjunction during meiosis
- Abnormalities of autosome number
  - Monosomy – resulting in sterility and retarded growth
  - Trisomy: Down syndrome (trisomy 21)
- Abnormalities of sex chromosome number
  - Klinefelter syndrome (47,XXY)
  - Turner syndrome (45,X)

(ii) Euploidy/poliploidy
- Definition of euploidy/polyploidy, autopolyploidy, and allopolyploidy
- Examples in plants

17.3.2 Change in chromosome structure

(i) Inversion – Definition

(ii) Translocation – Definition

(iii) Deletion – Definition

(iv) Duplication/multiplication – Definition

18. Population genetics (*3 periods*)

18.1 Concept of gene pool
- Concept of gene pool, allele and genotype frequencies in a population
- Relationship between population genetics and evolution

18.2 Hardy-Weinberg law
- Genetic equilibrium and allele frequency
- Requirements for genetic equilibrium
  - Large-sized population
  - Random mating
  - No mutation
  - No migration
- Hardy-Weinberg equilibrium:
  $p^2 + 2pq + q^2 = 1$ and $p + q = 1$
- Calculations of allele and genotype frequencies in a population

19. Gene regulation and expression (*2 periods*)

19.1 Lactose operon

- Experiment of Jacob and Monod
- Induced and constitutive enzyme production
- Components of lactose operon and function of each component
  - Components of regulator genes: an inducer, a promoter, and an operator
  - Components of structural genes: genes *Z*, *Y*, and *A*
- Effect of presence or absence of lactose on lactose operon

20. Modern genetics technology (*8 periods*)

20.1 Genetic engineering/recombinant DNA technology

- Definition

20.1.1 Restriction endonuclease/ restriction enzymes

- Definition, importance (examples: *Eco*RI and *Bam*HI), and nomenclature
- Restriction site: palindrome

20.1.2 Vectors

- Definition
- Properties of cloning vectors
- Plasmid
- Phage λ (bacteriophage)

20.1.3 Cloning

- Definition
- Steps in cloning processes
  - Isolation of target DNA and vector DNA
  - Restriction of target DNA and vector DNA by restriction endonuclease/enzymes
  - Insertion of target DNA into vector DNA
  - Ligation of target DNA to vector DNA by DNA ligase
  - Transformation/transduction of recombinant DNA into host cells
  - Amplification
  - Screening for transformants
- Example: insulin production by *E. coli*

20.2 Gene libraries and gene banks

- Definition and use
- Gene libraries: genomic and cDNA
- Construction of genomic and cDNA libraries

20.3	Use of recombinant DNA technology	– Definition of transgenic organisms
		– Bacteria
		  – Insulin producers
		  – Oil composers
		  – Nitrogen fixation
		– Transgenic plants
		  – Plants resistant to herbicide
		  – Plants resistant to insect pests
		– Transgenic animals
		  – Producers of α-1-antitrypsin enzyme in milk
		  – Producers of tissue plasminogen activator in milk
		  – Producers of human growth hormone in milk

20.4	Other uses	– Definition and brief description
	20.4.1 Genetic screening	– Amniocentesis and chorionic villus sampling (CVS)
	20.4.2 Gene therapy	– Restoration of adenosine deaminase enzyme in infants
	20.4.3 DNA fingerprinting	– Use in forensic science in identification of individuals (criminal, death, and paternity suit) – Identification of carriers of defective genes
20.5	Ethics of modern genetics	– Advantages and disadvantages of recombinant DNA technology

H. TAXONOMY, BIODIVERSITY, AND THEORY OF EVOLUTION

	Topic	***Explanatory notes***
21.	**Taxonomy** (*3 periods*)	
21.1	Purpose and importance of taxonomy	– Brief description
21.2	Classification system	– Artificial classification system – Natural classification system
21.3	Taxonomic hierarchy	– Taxonomic rank – Meaning of taxonomic rank – Examples of taxonomic hierarchy for plants and animals

21.4	Dichotomous keys	– Methods of constructing dichotomous keys – Use of dichotomous keys for the purpose of identification of organisms – Examples of dichotomous keys
21.5	Biological nomenclature	– Binomial system with examples
22.	**Biodiversity** (*16 periods*)	
22.1	Five kingdom systems	– Definition of biodiversity
22.1.1	Kingdom Prokaryotae: viruses and bacteria	– Morphological characteristics with examples
22.1.2	Kingdom Protoctista: (i) Chlorophyta: one example of unicellular and one example of filamentous (ii) Phaeophyta: one example of fucoid (iii) Rhizopoda: *Amoeba* (iv) Ciliophora: *Paramecium* (v) Zoomastigina: *Euglena*	– *Morphological characteristics at the phylum level*
22.1.3	Kingdom Fungi: *Mucor*	– Morphological characteristics at the kingdom level
22.1.4	Kingdom Plantae: (i) Bryophyta: *Marchantia* (ii) Filicinophyta: *Dryopteris* (iii) Coniferophyta: *Pinus* (iv) Angiospermophyta: *Zea mays* and *Helianthus*	– *Morphological characteristics at the phylum level*
22.1.5	Kingdom Animalia: (i) Porifera: S*ycon* (ii) Cnidaria: *Obelia* (iii) Platyhelminthes: *Taenia* (iv) Nematoda: *Ascaris* (v) Annelida: *Pheretima* (vi) Arthropoda: Insecta: *Periplaneta* Arachnida: *Lycosa* Crustacea: *Penaeus* Chilopoda: *Lithobius* Diplopoda: *Iulus* Merostomata: *Limulus* (vii) Mollusca: *Helix* (viii) Echinodermata: *Holothuria*	– *Morphological characteristics at the phylum and class levels* – *Morphological characteristics at the phylum and class levels*

	(ix) Chordata: Chondrichthyes: *Carcharodon* Osteichthyes: *Tilapia* Amphibia: *Rana* Reptilia: *Naja* Aves: *Columba* Mammalia: *Rattus*	– *Morphological characteristics at the phylum and class levels*
22.2	Biodiversity in Malaysia	– Definition
	22.2.1 Ecosystem diversity	– Types of ecosystem found in Malaysia: tropical forest, mangrove swamp forest, and coastal
	22.2.2 Species diversity	– Diversity of plant (flora) and animal (fauna) species with examples: ferns and insects
	22.2.3 Genetic diversity	– Genetic variation between population in humans, and plant and animal species
22.3	Threat of extinction to biodiversity in Malaysia	– Factors which threaten the extinction of biodiversity such as excessive and illegal logging, pollution of rivers and beaches, fish bombing, and the exploitation of mangrove in an unsustainable way – Implications of the extinction of ecosystem, species, and genetic diversities on human life and the environment
22.4	Conservation of biodiversity	– Steps in the conservation of biodiversity in terms of ecosystem, species, and genetics
	22.4.1 *In situ* conservation	– Example: Taman Negara
	22.4.2 *Ex situ* conservation	– Examples: botanical garden, zoo, gene and germplasm banks

23. Variation and theory of evolution (*10 periods*)

23.1	Variation	– Definition and importance
	23.1.1 Continuous and discontinuous variation	– Definition, differences, and examples
	23.1.2 Source	
	(i) Genetic	– Sexual reproduction – Random assortment of homologous chromosomes during meiosis

		– Crossing-over, chromosome mutation, gene mutation, polygenes, dominant and recessive genes/alleles – Hybridisation
	(ii) Environment	– Factors and influences
23.2	Selection	– Definition, description, importance, and examples – Relationship between selection and variation
	23.2.1 Natural selection	– Stabilising selection – Directional selection – Disruptive selection – Sexual selection – Polymorphism
	23.2.2 Artificial selection	– Breeding of farm animals and crop plants – Controlled/selective breeding (inbreeding, outbreeding) – Human and animal sperm banks
23.3	Speciation	– Definition, description, importance, and examples
	23.3.1 Concept of species	– Problems in defining species
	23.3.2 Speciation process	– Formation of new species – Isolation, genetic drift, hybridisation, and adaptive radiation
23.4	Evolution	– Definition, description, importance, and examples
	23.4.1 Lamarck's Theory	– Theory and examples
	23.4.2 Darwin-Wallace's Theory	– Theory and examples
	23.4.3 Evidence supporting theory of evolution	– Paleontology – Geographical distribution – Comparative anatomy – Comparative embryology – Biochemistry – DNA homology

I. ECOLOGY

Topic	*Explanatory notes*
24. Ecosystem (*6 periods*)	
24.1 Organisation of life	– Concept, hierarchy, and interaction
24.1.1 Components of life: organisms, populations and communities, ecosystems, biomes, and biospheres	– Definition and examples – Emphasis on the dynamism of ecosystems
24.1.2 Niche and habitat	– Definition and examples – Relationship between niche, habitat, and environment
24.2 Biogeochemical cycles	– Sulphur and phosphorus cycles
24.3 Energy	– First and second laws of thermodynamics
24.3.1 Flow	– Definition, one example of ecosystem: pond/ forest
24.3.2 Transfer	– Efficiency of energy transfer by producers, consumers, and composers – One example of ecosystem: pond/forest
25. Quantitative ecology (*12 periods*)	
25.1 Population ecology	– Biotic potential – Natality – Mortality – Migration – Survivorship – *r* and *K* strategies – Population growth – Factors limiting population size and distribution – Liebig's law – Shelford's law
25.2 Applied ecology	– Carrying capacity – Management and conservation of ecosystems – Sustainable development; examples: forestry, agriculture, and fishery
25.3 Quantitative methods	
25.3.1 Sampling theories	– Definition, description, importance, and examples
(i) Central limit theorem	– Practical application
(ii) Optimum sample size	– Practical application

25.3.2 Types of estimation (i) Absolute (ii) Relative	– Examples and calculations
25.3.3 Sampling methods	– Quadrat – Line transect – Belt transect – Capture-recapture/mark-release-recapture method
25.3.4 Sampling parameters	– Frequency – Density – Coverage

Practical Syllabus

School-based Assessment of Practical (Paper 3)

School-based assessment of practical work will only be carried out during the school term of form six for candidates from government and private schools which have been approved by the Malaysian Examinations Council to carry out the school-based assessment. *Individual private candidates, candidates from private schools which have no permission to carry out the school-based assessment of practical work, candidates who repeat upper six (in government or private schools), and candidates who do* **not** *attend classes of lower six and upper six for two* **consecutive** *years (in government or private schools) are* **not** *allowed to take this paper.*

The Malaysian Examinations Council will specify 13 compulsory experiments (including three projects) to be carried out by candidates and to be assessed by subject teachers in schools. Candidates are required to carry out the projects individually or in groups as stipulated. Details of the topic, aim, theory, apparatus, and method of each of the experiments will be compiled and distributed to all schools.

Students should be supplied with a work scheme before the day of the compulsory experiment so as to enable them to plan their practical work. Each experiment is expected to last one school double period. Assessment of the students' practical work will be done by the teacher during the practical session and will also be based on the students' practical report. The assessment should comply with the assessment guidelines prepared by the Malaysian Examinations Council.

Written Practical Test (Paper 4)

Individual private candidates, candidates from private schools which have no permission to carry out the school-based assessment of practical work, candidates who repeat upper six (in government or private schools), and candidates who do **not** attend classes of lower six and upper six for two **consecutive** years (in government or private schools) are required to take this paper.

Two structured questions on routine practical work will be set. The Malaysian Examinations Council will not be strictly bound by the syllabus in setting questions. Where appropriate, candidates will be given sufficient information to enable them to answer the questions. Only knowledge of theory within the syllabus and knowledge of usual laboratory pratical procedures will be expected.

Questions to be set will test candidates' ability to

(*a*) record readings from diagrams of apparatus;

(*b*) describe, explain, suggest, and comment on the experimental arrangements, techniques, and procedures;

(*c*) interpret, draw conclusion from, and evaluate observations and experimental data or diagrams of specimens;

(*d*) suggest precautions or safety measures;

(*e*) use theories to explain the results of experiments;

(*f*) perform simple calculations based on experiments.

Form of Examination

Candidates are required to enter for Papers 1, 2, and either Paper 3 or Paper 4.

Paper	*Format of paper*	*Marks*	*Duration*
Paper 1	50 compulsory multiple-choice questions are to be answered.	50 (to be scaled to 60)	1¾ hours
Paper 2	*Section A:* 4 compulsory short structured questions are to be answered. *Section B:* 4 questions are to be answered out of 6 essay questions.	40 60 (15 per question) Total: 100 (to be scaled to 120)	2½ hours
Paper 3	School-based Assessment of Practical: 13 compulsory experiments are to be carried out.	20	School term
Paper 4	Written Practical Test: 2 compulsory structured questions are to be answered.	30 (to be scaled to 20)	1 hour

Reference Books

1. Audesirk, T., Audesirk, G. & Bayers, B.E., *Biology: Life on Earth*, (6th ed.), Prentice-Hall, 2002.
2. Campbell, N. A. & Reece, J. B., *Biology*, (6th ed.), Benjamin Cummings, 2002.
3. Clegg, C. J. & Mackean, D. G., *Advanced Biology: Principles and Applications*, John Murray, 2000.
4. Green, N. P. O., Stout, G. W., & Taylor, D. J., *Biological Science 1 & 2* (2nd ed.), Cambridge University Press, 1990.
5. Jones, M. & Jones, G., *Advanced Biology*, Cambridge University Press, 1997.
6. Solomon, E., P., Berg, L. R., & Martin, D. W., *Biology*, (6th ed.), Thomson Learning, 2002.
7. Starr C. & Taggart R., *Biology: The Unity and Diversity of Life*, (9th ed.), Von Hoffmen Press, 2000.