EDUCATIONAL QUALITY AND ASSESSMENT PROGRAMME [EQAP]

Pacific Community
Communauté du Pacifique

SOUTH PACIFIC FORM SEVEN CERTIFICATE [SPFSC]

BIOLOGY

PRESCRIPTION

GENERAL INFORMATION

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SOUTH PACIFIC FORM SEVEN CERTIFICATE
BIOLOGY

Contents

1. Preamble and Rationale

This prescription defines the requirements for the South Pacific Form Seven Certificate Biology course.

Each Major Learning Outcome for the course is to be read in conjunction with the Indicator Notes given for each outcome and the learning outcomes that follow. Students also require knowledge and understanding of outcomes from the national Year 12 or Form 6 qualification or its equivalent, which are related to the specific outcomes of SPFSC Biology.

This prescription is derived from a revision of the South Pacific Board for Educational Assessment (SPBEA) 2012 prescription and the New Zealand National Certificate of Educational Achievement (NCEA) Level 3 Biology Achievement Standards as published by the New Zealand Qualifications Authority (NZQA).

The SPFSC Biology course is designed for students who wish to undertake university studies in Biology and other related fields.

2. Course Aim

Students are expected to develop an understanding of:

- the interactions of organisms with their biotic and abiotic environment
- the process of evolution in producing the diversity of life forms
- the ways in which genes interact to determine the phenotype
- modern biotechnology and its role in our lives
- practical biological investigations
- researching and processing information
- scientific reporting

3. Prerequisites

Students are expected to have successfully completed the national Year 12 or Form 6 Biology course or its equivalent.

4. General Objectives

Students will be expected to demonstrate understanding of:

- aspects of animal behaviour
- process and patterns of evolution
- concepts and processes relating to gene expression
- applications in modern biotechnology
- planning, carrying out and reporting on a practical biological investigations
- researching and processing data to write a scientific report on a biological issue

5. Content Components

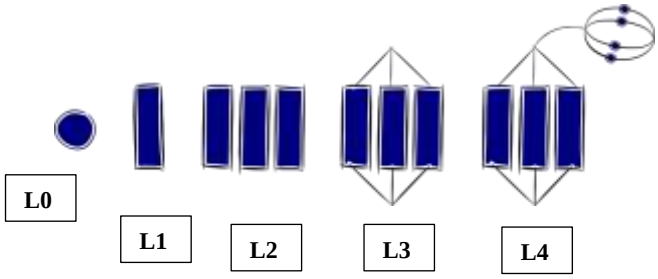
The content of the SPFSC Biology course is organised under four strands and a number of sub-strands under each strand. These are outlined below:

Strand Number	Strand Title	Sub strand number	Sub-strand title
1.	Animal behavior	1.1	Ecological Niche
		1.2	Orientation and Navigation
		1.3	Timing responses
		1.4	Interspecific interactions
		1.5	Intraspecific interactions
2.	Gene Expression	2.1	DNA structure and replication
		2.2	Protein structure, function, and synthesis
		2.3	Mutations
		2.4	Metabolic pathways, Linkages and Sex linkages
		2.5	Gene-gene interactions and Mendelian inheritance
		2.6	Environmental effect on phenotype
3.	Biotechnology Applications	3.1	Gene cloning, Trans genesis and DNA profiling
		3.2	Contemporary biotechnology issue
4.	Processes and Patterns of Evolution	4.1	Variation
		4.2	Natural selection
		4.3	Gene pool and allele frequency
		4.4	Speciation
		4.5	Patterns of evolution

6. Unpacking of Learning Outcomes

In this prescription, Learning Outcomes are stated at three levels of generality: Major Learning Outcomes (MLOs) are stated at the strand level, Key Learning Outcomes (KLOs) are stated at the sub-strand level, and Specific Learning Outcomes (SLOs) are unpacked from the Key Learning Outcomes. Each SLO is a combination of a cognitive skill and a specific content component. Each SLO is given a skill level, level 1 – 4, and this skill level results from the categorisation of the cognitive skill that is embedded in the SLO using the SOLO taxonomy[1].

The SOLO taxonomy provides a simple, reliable and robust model for three levels of understanding – surface, deep and conceptual (Biggs and Collis, 1982).



At the **prestructural** level (L0) of understanding, the task is inappropriately attacked, and the student has missed the point or needs help to start. The next two levels, unistructural and

[1] Structure of Observed Learning Outcomes by Biggs and Collis (1982)

multistructural are associated with bringing in information (surface understanding). At the **unistructural** level (L1), one aspect of the task is picked up, and student understanding is disconnected and limited. The jump to the multistructural level is quantitative.

At the **multistuctural** level (L2), several aspects of the task are known but their relationships to each other and the whole are missed. The progression to relational and extended abstract outcomes is qualitative. At the **relational** level (L3), the aspects are linked and integrated, and contribute to a deeper and more coherent understanding of the whole. At the **extended abstract** level (L4), the new understanding at the relational level is re-thought at another conceptual level, looked at in a new way, and used as the basis for prediction, generalisation, reflection, or creation of new understanding (adapted from Hook and Mills 2011). [http://pamhook.com/solo-taxonomy/..]

The progression from Level 1 to Level 4 is exemplified in the progression from *define* →*describe* → *explain* → *discuss* with each succeeding level indicating a *higher level of understanding,* as follows:

- **define** – to state a basic definition of a concept [Unistructural or L1]
- **describe** – to give the characteristics of, or give an account of, or provide annotated diagrams. [Multistructural or L2]
- **explain** – to provide a reason for a relationship – an event and its impact, a cause and an effect, as to *how* or *why* something occurs. [Relational or L3]
- **discuss** – this means *linking biological ideas* (descriptions, explanations) to make generalisations or predictions or evaluations. It may involve relating, comparing, analysing, and justifying.

7. Learning Outcomes

Strand 1: Animal Behaviour

Major Learning Outcome

Students are able to demonstrate understanding of **biological concepts and processes** relating animal behaviour to biotic and abiotic environmental factors and how the behaviour **contributes to the organism's survival.**

Sub-strand 1.1 Ecological Niche

Key Learning Outcome: Students are able to demonstrate understanding of ecological niche and its impact on animal behaviour

- ecological niches (fundamental / actual niche and realised niche) in terms of an organism's adaptations (structural, behavioural, physiological) to its habitat and way of life – revision of form 6.

SLO#	**Specific Learning Outcomes:** Students are able to	Skill level	SLO code
1	Define the term 'ecological niche'	1	Bio1.1.1.1
2	Describe an ecological niche in terms of an organism's adaptations to its habitat and way of life	2	Bio1.1.2.1
3	Outline the different parts of the environment for a niche	2	Bio1.1.2.2
4	Explain the relationships within an ecological niche in terms of an organism's adaptations to its habitat and way of life	3	Bio1.1.3.1
5	Discuss the impact of an organism's adaptations to its habitat and way of life on its ecological niche using specific examples	4	Bio1.1.4.1
6	Explain the effect of an aspect being investigated to the overall niche	3	Bio1.1.3.2
7	State aim and/or hypothesis for an investigation into ecological niches of named plants or animals	1	Bio1.1.1.2
8	Describe niche accurately and relate it to the aspect being investigated	2	Bio1.1.2.3
9	List step by step the procedure of the investigation	2	Bio1.1.2.4
10	Provide an independent variable with min of 3 values given (fair test) or repeat samples taken (pattern seeking)	1	Bio1.1.1.3
11	Measure or calculate value of dependent variable and give units	3	Bio1.1.3.3
12	Collect and tabulate and graph results	3	Bio1.1.3.4
14	Draw valid conclusion from data	2	Bio1.1.2.5
15	Describe the findings of the investigation	2	Bio1.1.2.6
16	Explain findings in relation to the niche and the biology of the species	3	Bio1.1.3.5
17	Discuss results of the investigation in relation to the niche and the biology of the species and how these can be used to make predictions for other communities	4	Bio1.1.4.2
18	Explain how problems with validity were overcome and how reliability is maintained using appropriate statistical procedure	3	Bio1.1.3.6
19	Evaluate by discussing how problems with validity were overcome or explains reliability using appropriate statistical procedure	4	Bio1.1.4.3
20	Structure report for comprehension	1	Bio1.1.1.4
21	Make recommendations on ways to improve research process	3	Bio1.1.3.7

Sub-strand 1.2 Orientation and Navigation

Key Learning Outcome: Students are able to demonstrate understanding of animal orientation and navigation processes and how these influence movement and survival.

- innate and learnt behaviour
- taxes (hydro, geo, chemo, photo, thigmo)
- kineses (ortho, klino)
- navigation using solar / sun compass, stellar / star patterns, magnetic field lines, chemical trails / scent, landmarks
- homing (the regular return of an animal to a nest site)
- migration (long distance return migration between breeding and feeding / overwintering grounds)

SLO#	**Specific Learning Outcomes:** *Students are able to*	Skill level	SLO code
1	Define innate and learnt behaviour	1	Bio1.2.1.1
2	Identify/State an example of innate or learnt behaviour in a given context	1	Bio1.2.1.2
3	Describe the features of innate behaviour, giving an example	2	Bio1.2.2.1
4	Describe the features of learnt behaviour, giving an example	2	Bio1.2.2.2
5	Describe navigation systems using solar / sun compass, stellar / star patterns, magnetic field lines, chemical trails / scent, landmarks	2	Bio1.2.2.3
6	Explain how navigation using solar / sun compass, stellar / star patterns, magnetic field lines, chemical trails / scent, landmarks contribute to migration and survival	3	Bio1.2.3.1
7	Discuss the effectiveness of navigation using solar / sun compass, stellar / star patterns, magnetic field lines, chemical trails / scent, landmarks for named animals	4	Bio1.2.4.1
8	Define homing	1	Bio1.2.1.3
9	Identify a feature or example of homing in a given context	1	Bio1.2.1.4
10	Define true navigation/celestial navigation/magnetic orientation/olfaction/topographic memory	1	Bio1.2.1.5
11	Describe the features of homing	2	Bio1.2.2.4
12	Discuss the impacts and issues related to homing using named animals	4	Bio1.2.4.2
13	Describe the features of migration (long distance return migration between breeding and feeding / overwintering grounds)	2	Bio1.2.2.5
14	Explain the interrelationships that contribute to migration (long distance return migration between breeding and feeding / overwintering grounds)	3	Bio1.2.3.2
15	Discuss the impacts and effects of migration (long distance return migration between breeding and feeding / overwintering grounds) using named examples	4	Bio1.2.4.3
16	Explain relationships within innate and learnt behaviour	3	Bio1.2.3.3
17	Discuss consequences and impacts of innate and learnt behaviour	4	Bio1.2.4.4
18	Define taxes/kinesis	1	Bio1.2.1.6
19	Identify a feature or example of taxes in a given context	1	Bio1.2.1.7
20	Describe the features of taxes (hydro, geo, chemo, photo, thigmo)	2	Bio1.2.2.6
21	Explain relationships within taxes (hydro, geo, chemo, photo, thigmo)	3	Bio1.2.3.4
22	Discuss effects and impacts of taxes (hydro, geo, chemo, photo, thigmo)	4	Bio1.2.4.5
23	Describe the features of kineses (ortho, klino)	2	Bio1.2.2.7
24	Explain the interrelationships within kineses (ortho, klino)	3	Bio1.2.3.5

Sub-strand 1.3 Timing Responses

Key Learning outcome: Students are able to demonstrate understanding of timing responses and ways of representing and interpreting timing responses.

- timing responses (daily, tidal, lunar, annual) as determined by movement of earth, sun, moon; diurnal, nocturnal, crepuscular
- biological rhythms (circadian, circatidal, circalunar, circannual)
- biological clock (in brain) providing endogenous control (via melatonin) of rhythms and which is set by environmental cues (zeitgebers).
- interpretation of actograms : periodicity, free running period, phase shifting, entrainment, arrhythmic activity

SLO #	Specific Learning Outcomes: *Students are able to*	Skill level	SLO code
1	Define timing responses/arrhythmic activity	1	Bio1.3.1.1
2	Define diurnal/nocturnal/crepuscular	1	Bio1.3.1.2
3	Define endogenous/exogenous rhythmic activity/zeitgeber/actograms	1	Bio1.3.1.3
4	State/Identify a feature or example of arrhythmic activity in a given context	1	Bio1.3.1.4
5	State/Identify a feature or example of diurnal/nocturnal/crepuscular activity in a given context	1	Bio1.3.1.5
6	State/Identify a feature or example of endogenous/exogenous rhythmic activity/zeitgeber in a given context	1	Bio1.3.1.6
7	Describe the features of the following timing responses - daily, tidal, lunar, annual	2	Bio1.3.2.1
8	Compare the features of one timing response against another	3	Bio1.3.3.1
9	Describe interpretation of actograms : periodicity, free running period, phase shifting, entrainment, arrhythmic activity	2	Bio1.3.2.2
10	Compare the different interpretation of actograms : periodicity, free running period, phase shifting, entrainment, arrhythmic activity	3	Bio1.3.3.2
11	Discuss the impact of different types of activity rhythms on survival of a named species : periodicity, free running period, phase shifting, entrainment, arrhythmic activity	4	Bio1.3.4.1
12	Explain the effects of timing responses (daily, tidal, lunar, annual) as determined by movement of earth, sun, moon; diurnal, nocturnal, crepuscular	3	Bio1.3.3.3
13	Explain the effects of timing responses (daily, tidal, lunar, annual) as determined by movement of earth, sun, moon on the life cycle of an organism	3	Bio1.3.3.4
14	Define circadian, circa tidal/circalunar/circannual biological rhythms	1	Bio1.3.1.7
15	State/Identify a feature or an example of circadian, circa tidal/circalunar/circannual biological rhythms in a given context	1	Bio1.3.1.8
16	Describe the features of circadian/circa tidal/circalunar/circannual biological rhythms	2	Bio1.3.2.3
17	Compare and contrast the different biological rhythms (circadian, circa tidal, circalunar, circannual)	3	Bio1.3.3.5
18	Evaluate the effectiveness of different biological rhythms (circadian, circa tidal, circalunar, circannual) for named organisms	4	Bio1.3.4.2
19	Describe how biological clock (in brain) provide endogenous control (via melatonin) of rhythms and which is set by environmental cues (zeitgebers).	2	Bio1.3.2.4
20	Explain the relationship between biological clock (in brain) providing endogenous control (via melatonin) of rhythms and which is set by environmental cues (zeitgebers).	3	Bio1.3.3.6
21	Discuss the implications of environmental destruction on biological clocks and survival of named organisms	4	Bio1.3.4.3

Sub-strand 1.4 Interspecific Interactions

Key Learning outcome: Students are able to demonstrate understanding of interspecific interactions and ways in which these interactions influence survival in the niches

- competition for resources (named e.g. food, living space, etc.) acting to limit numbers and distribution (fundamental niche versus realised / actual niche; zonation) of competing species; out-competition leading to niche differentiation
- predator – prey relationships and cycles acting to control numbers and distribution (fundamental niche versus realised / actual niche; zonation) of both predator and prey species

SLO#	**Specific Learning Outcomes:** *Students are able to:*	Skill level	SLO code
1	Define niche differentiation/out-competition/interspecific competition	1	Bio1.4.1.1
2	State the competitive exclusion principle	1	Bio1.4.1.2
3	Identify/state a feature or an example of niche differentiation in a given context	1	Bio1.4.1.3
4	Identify/state a feature or an example of interspecific competition in a given context	1	Bio1.4.1.4
5	Identify/state a feature or an example of out-competition in a given context	1	Bio1.4.1.5
6	Describe the features of competitions	2	Bio1.4.2.1
7	Explain how competition limit numbers of a population	3	Bio1.4.3.1
8	Explain how competition lead to niche differentiation	3	Bio1.4.3.2
9	Explain how competition lead to species distribution	3	Bio1.4.3.3
10	Discuss the various types of competitions and how these collectively contribute to species redistribution, population numbers and niche differentiation using named examples	4	Bio1.4.4.1
11	Describe the features of predator – prey relationships	2	Bio1.4.2.2
12	Explain how predator – prey relationships contribute to cycles acting to control numbers and distribution of both predator and prey species	3	Bio1.4.3.4
13	Discuss the impacts of a number of predator – prey relationships working together within a population on population numbers, food availability, distribution etc.	4	Bio1.4.4.2

Sub-strand 1.5 Intraspecific interactions

Key Learning outcome: Students are able to demonstrate understanding of intraspecific interactions and ways in which these interactions influence survival in the niches

- advantages (eg co-operative behaviour such as hunting / defence / detecting predators; finding food; parental care; mate availability) and disadvantages (eg increased intraspecific competition / aggressive encounters) of group living
- social organisation; hierarchies (linear and complex); advantages (reduction of serious aggression; controlled access to resources) and disadvantages (uneven access to resources); dominance and submissive behaviours in maintaining hierarchies
- territory and home range
- reproductive behaviour : r and k strategies; monogamous and polygynous mating; courtship, mating, and parental care

SLO #	**Specific Learning Outcomes:** *Students are able to*	Skill level	SLO code

1	Define *r* and *k* strategies/monogamous and polygamous mating/social organisations	1	Bio1.5.1.1
2	Identify/state a feature or an example of *r* or *k* strategies in a given context	1	Bio1.5.1.2
3	Identify/state a feature or an example of monogamous or polygamous mating in a given context	1	Bio1.5.1.3
4	Identify/state a feature or an example of social organisation in a given context	1	Bio1.5.1.4
5	List the advantages and disadvantages of group living	2	Bio1.5.2.1
6	Explain how group living influence survival of members group	3	Bio1.5.3.1
7	Describe the features of *r* and *k* strategies	2	Bio1.5.2.2
8	Explain how reproductive behaviour influence survival	3	Bio1.5.3.2
9	Discuss how the different reproductive behaviours (*r* and *k* strategies; monogamous and polygynous mating; courtship, mating, and parental care) work together to influence the survival of a named species, using examples	4	Bio1.5.4.1
10	List the advantages and disadvantages of different types of parental care	2	Bio1.5.2.3
11	Describe the features of different types of social organisations	2	Bio1.5.2.4
12	Outline the reasons for different types of social organisations	2	Bio1.5.2.5
13	Discuss the evolution of group living and evaluate whether group living continues to be an advantage under changing social and environmental conditions	4	Bio1.5.4.2
14	Describe the features of social organisation in terms of hierarchies and dominance and submissive behaviours	2	Bio1.5.2.6
15	Outline the advantages and disadvantages of different types of social organisations	2	Bio1.5.2.7
16	Explain how dominance and submissive behaviours maintain hierarchies social organisation	3	Bio1.5.3.3
17	Analyse / sequence the hierarchal order of social organisations.	3	Bio 1.5.3.5
18	Define territory and home range	1	Bio1.5.1.5
19	Explain how the establishment of territory and home range increase survival of a species	3	Bio1.5.3.4
20	Discuss the social organisations of a number of species living together within an area and how these organisation support survival or threaten extinction, and how do members of these species cope	4	Bio1.5.4.3

Strand 2: Gene Expression

Major Learning Outcome 2:
Students are able to describe, explain and discuss **biological concepts and processes** relating to gene expression.

Sub-strand 2.1 DNA structure and replication

Key Learning outcome: Students are able to demonstrate understanding of the DNA structure and replication and ways in which these influence DNA functioning

- genome
- structure and replication of DNA – revision and extension of form 6 to include : semiconservative replication, enzyme control (helicase, DNA polymerase, ligase), antiparallel 3' – 5' strands, leading and lagging strands, Okazaki fragments

SLO#	**Specific Learning Outcomes:** *Students are able to*	Skill level	SLO code
1	Define genome	1	Bio2.1.1.1

2	Identify / State a feature or example of a genome in a given context	1	Bio2.1.1.2
3	Describe the composition of a genome	2	Bio2.1.2.1
4	Define semi-conservative replication	1	Bio2.1.1.3
5	Identify semi-conservative replication or antiparallel 3' – 5' strands, in a DNA replication representation	1	Bio2.1.1.4
6	Explain how the genome determines the full characteristics of an organism	3	Bio2.1.3.1
7	Describe the structure and replication of DNA in terms of semi-conservative replication, enzyme control, antiparallel 3' – 5' strands	2	Bio2.1.2.2
8	Describe the structure and replication of DNA in terms of leading and lagging strands, Okazaki fragments	2	Bio2.1.2.3
9	Explain how the structure of DNA relates to the process of replication	3	Bio2.1.3.2
10	Describe the features of different types of DNA replication problems	2	Bio2.1.2.4
11	Explain the causes of DNA replication problems	3	Bio2.1.3.3
12	Discuss the importance of proper DNA replication for life and the impacts of faulty DNA replication, using examples	4	Bio2.1.4.1

Sub-strand 2.2 Protein structure, function, and synthesis

Key Learning outcome: Students are able to demonstrate understanding of protein structure, functions and synthesis and how these contribute to forms and functions

- protein structure (primary, secondary, tertiary) and function (structural e.g. collagen, keratin, and regulatory e.g. enzymes, hormones)
- protein synthesis; transcription and translation – revision and extension of form 6 to include role of DNA (triplets), mRNA (codons), tRNA (anticodons), ribosomes; use of codon dictionary to identify amino acids; redundant nature of the genetic code
- protein structure (primary, secondary, tertiary) and function (structural e.g. collagen, keratin, and regulatory eg enzymes, hormones)
- protein synthesis; transcription and translation – revision and extension of form 6 to include role of DNA (triplets), mRNA (codons), tRNA (anticodons), ribosomes; use of codon dictionary to identify amino acids; redundant nature of the genetic code

SLO#	**Specific Learning Outcomes:** *Students are able to*	**Skill level**	**SLO code**
1	Define transcription/translation	1	Bio2.2.1.1
2	Define codons/anticodons	1	Bio2.2.1.2
3	State the function of mRNA/tRNA	1	Bio2.2.1.3
4	Identify transcription in a given representation of protein synthesis	1	Bio2.2.1.4
5	Identify translation in a given representation of protein synthesis	1	Bio2.2.1.9
6	Identify codons/anticodons in a given representation of protein synthesis	1	Bio2.2.1.5
7	Identify mRNA/tRNA in a given representation of protein synthesis	1	Bio2.2.1.6
8	Describe the structure of structural protein/regulatory protein	2	Bio2.2.2.1
9	Relate protein structure to its function (structural eg collagen, keratin, and regulatory e.g. enzymes, hormones)	3	Bio2.2.3.1
10	Discuss the importance of protein structure to different forms and functions in plants and/or animals	4	Bio2.2.4.1
11	Define protein synthesis	1	Bio2.2.1.7
12	Identify/State a feature of protein synthesis, within a given context	1	Bio2.2.1.8
13	Describe the process of protein synthesis	2	Bio2.2.2.2
14	Describe the use of codon dictionary to identify amino acids	2	Bio2.2.2.3
15	Describe the redundant nature of the genetic code	2	Bio2.2.2.4
16	Describe the role of enzymes in protein synthesis	2	Bio2.2.2.5
17	Explain the relationships within transcription and translation including role of DNA (triplets), mRNA (codons), tRNA (anticodons), ribosomes; use of codon dictionary to identify amino acids; redundant nature of the genetic code	3	Bio2.2.3.2

18	Discuss the interdependency of the different parts of the process of protein synthesis (transcription and translation including role of DNA (triplets), mRNA (codons), tRNA (anticodons), ribosomes; use of codon dictionary to identify amino acids; redundant nature of the genetic code) and the impact of a failure of one part to the whole process and to an organism.	4	Bio2.2.4.2

Sub-strand 2.3 Mutations

Key Learning Outcome: Students are able to demonstrate understanding of mutations and ways in which these influence DNA functioning

- mutations
- gene (point) mutations - substitution of bases producing missense (different amino acid) or nonsense codons (termination) ; addition or deletion of bases producing a frame shift (as all following amino acids changed leading to early termination).
- chromosome (block) mutations – deletion, inversion, duplication, translocation of genes in and between chromosomes
- aneuploidy – change in number of chromosomes within a set resulting from nondisjunction during meiosis eg Downs (trisomy 21), Turners, Kleinfelters syndromes
- polyploidy – change in numbers of (whole) sets of chromosomes resulting from complete non-disjunction during meiosis eg triploid (3n), tetraploid (4n); autopolyploidy, allopolyploidy

SLO#	Specific Learning Outcomes: *Students are able to*	Skill level	SLO code
1	Define mutation	1	Bio2.3.1.1
2	Define polyploidy	1	Bio2.3.1.6
3	Define triploid (3n)	1	Bio2.3.1.7
4	Define tetraploid (4n)	1	Bio2.3.1.8
5	Define auto polyploidy, allopolyploidy	1	Bio2.3.1.2
6	Define Down's syndrome/Turner's syndrome/Kleinfelter's syndrome	1	Bio2.3.1.3
7	Define deletion, inversion, duplication, translocation of genes	1	Bio2.3.1.4
8	Define missense or nonsense codons	1	Bio2.3.1.5
9	Describe the features of mutations and give examples	2	Bio2.3.2.1
10	Describe the chromosomal characteristics of aneuploidy and give examples (change in number of chromosomes within a set resulting from non-disjunction during meiosis e.g. Downs (trisomy 21), Turners, Kleinfelter's syndromes)	2	Bio2.3.2.2
11	Describe the common physical characteristics of Down's syndrome/Turner's syndrome/Kleinfelter's syndrome	2	Bio2.3.2.3
12	Compare the features of Down's syndrome, Turner's syndrome and Kleinfelter's syndrome	3	Bio2.3.3.1
13	Explain the effects of aneuploidy	3	Bio2.3.3.2
14	Discuss the impact of aneuploidy on an affected individual using examples	4	Bio2.3.4.1
15	Describe the characteristics of polyploidy (change in numbers of (whole) sets of chromosomes resulting from complete non-disjunction during meiosis eg triploid (3n), tetraploid (4n); autopolyploidy, allopolyploidy)	2	Bio2.3.2.4
16	Compare and contrast the features of triploid with tetraploid	3	Bio2.3.3.3
17	Compare and contrast autopolyploidy with allopolyploidy	3	Bio2.3.3.4
18	Explain the effects of any one form of polyploidy	3	Bio2.3.3.5
19	Discuss the impact of polyploidy on an affected individual using examples	4	Bio2.3.4.2

20	Differentiate between chromosome mutation and gene mutation	3	Bio2.3.3.6
21	Describe gene (point) mutations (substitution of bases producing missense or nonsense codons; addition or deletion of bases producing a frame shift).	2	Bio2.3.2.5
22	Explain the causes of gene (point) mutations	3	Bio2.3.3.7
23	Discuss the impact of gene (point) mutations on the functioning of an affected person using named examples	4	Bio2.3.4.3
24	Describe chromosome (block) mutations (deletion, inversion, duplication, translocation of genes in and between chromosomes)	2	Bio2.3.2.6
25	Explain the causes and effects of chromosome (block) mutations	3	Bio2.3.3.8
26	Discuss the impact of chromosome (block) mutations on an affected person using named examples	4	Bio2.3.4.4

Sub-strand 2.4 Metabolic Pathways, Linkages and Sex Linkages

Key Learning Outcome: Students are able to demonstrate understanding of metabolic pathways, linkages and sex linkages and ways in which these influence DNA functioning

- metabolic pathways eg PKU
- effects of mutation on enzyme control of metabolic pathways
- linkage and sex linkage
- inheritance of : red-green colour blindness in humans; haemophilia in humans; tortoiseshell colour in cats

SLO#	**Specific Learning Outcomes:** ***Students are able to***	**Skill level**	**SLO code**
1	Define metabolic pathway	1	Bio2.4.1.1
2	Describe the characteristics of phenylketonuria (PKU)	2	Bio2.4.2.1
3	Explain the relation between metabolic pathways disorder and PKU	3	Bio2.4.3.1
4	Represent diagrammatically the metabolic pathway for PKU	3	Bio2.4.3.2
5	Explain the effects of untreated PKU	3	Bio2.4.3.3
6	Explain the effects of mutation on enzyme control of metabolic pathways	3	Bio2.4.3.4
7	Explain the effects of mutation on enzyme control of metabolic pathways	3	Bio2.4.3.5
8	Interpret effects of mutation on enzyme control of metabolic pathways based on given information	3	Bio2.4.3.6
9	Define linkage/sex linkage/homologous chromosomes	1	Bio2.4.1.2
10	Define sex linked conditions	1	Bio2.4.1.3
	Identify/State feature or example of sex linked conditions, in a given context	1	Bio2.4.1.4
11	Compare linkage and sex linkage	3	Bio2.4.3.7
12	Describe the process of linkage and sex linkage	2	Bio2.4.2.2
13	Discuss linkage and sex linkage as the biological basis of heredity	3	Bio2.4.3.8
14	Describe the process of inheritance of red-green colour blindness in humans	2	Bio2.4.2.3
15	Describe the process of inheritance of haemophilia in humans	2	Bio2.4.2.4
16	Describe the process of inheritance of tortoiseshell colour in cats	2	Bio2.4.2.5
17	Explain the complications of inheritance of red-green colour blindness in humans; haemophilia in humans; tortoiseshell colour in cats	3	Bio2.4.3.9
18	Represent the conditions using punnet squares	3	Bio2.4.3.10

Sub-strand 2.5 Gene – Gene Interactions and Mendelian Inheritance

Key Learning Outcome: Students are able to demonstrate understanding of gene-gene interactions and Mendelian inheritance and ways in which these influence DNA functioning

- gene – gene interactions : collaboration, epistasis (complementary; supplementary genes); polygenes (eg height and skin colour in humans); pleiotrophy (eg sickle cell disease)
- monohybrid and dihybrid crosses with : complete dominance, incomplete dominance, codominance, multiple alleles, test cross (genes, alleles, genotype, phenotype, homozygous, heterozygous) – revision of form 6

SLO#	Specific Learning Outcomes: *students are able to*	Skill level	SLO code
1	Define monohybrid cross / dihybrid crosses	1	Bio2.5.1.1
2	Define complete dominance/incomplete dominance/co-dominance,	1	Bio2.5.1.2
3	Define multiple alleles / test cross / homozygous / heterozygous	1	Bio2.5.1.3
4	Identify/State a feature or example of monohybrid cross / dihybrid crosses, in a given context	1	Bio2.5.1.4
5	Identify/State a feature or example of complete dominance/incomplete dominance/co-dominance, in a given context	1	Bio2.5.1.5
6	Identify/State a feature or example of multiple alleles / test cross / homozygous gene pairs, in a given context.	1	Bio2.5.1.6
7	Identify or state a feature of a heterozygous gene pair in a given context.	1	Bio2.5.1.9
8	Describe genotypes for monohybrid crosses with complete dominance, incomplete dominance, co-dominance, multiple alleles, test cross (genes, alleles, homozygous, heterozygous)	2	Bio2.5.2.1
9	Describe phenotypes from monohybrid crosses	2	Bio2.5.2.2
10	Make interpretations about monohybrid crosses using punnet squares	3	Bio2.5.3.1
11	Describe genotypes for dihybrid crosses with complete dominance, incomplete dominance, co-dominance, multiple alleles, test cross (genes, alleles, homozygous, heterozygous)	2	Bio2.5.2.3
12	Describe phenotypes from dihybrid crosses	2	Bio2.5.2.4
13	Make interpretations about dihybrid crosses using punnet squares	3	Bio2.5.3.2
14	Explain the expression of characteristics from monohybrid crosses monohybrid crosses complete dominance, incomplete dominance, co-dominance, multiple alleles, test cross (genes, alleles, genotype, phenotype, homozygous, heterozygous)	3	Bio2.5.3.3
15	Explain the expression of characteristics from dihybrid crosses monohybrid crosses complete dominance, incomplete dominance, co-dominance, multiple alleles, test cross (genes, alleles, genotype, phenotype, homozygous, heterozygous)	3	Bio2.5.3.4
16	Discuss the full picture of the inheritance of named characteristics through monohybrid and dihybrid crosses using named plants and or animals	4	Bio2.5.4.1
17	Define gene – gene interactions / collaboration / epistasis (complementary; supplementary genes) / polygenes (e.g. height and skin colour in humans); pleiotropy	1	Bio2.5.1.7
18	Identify/State a feature or example of gene interactions / collaboration / epistasis (complementary; supplementary genes) / polygenes (e.g. height and skin colour in humans); pleiotropy, in a given context	1	Bio2.5.1.8
19	Describe the process of gene – gene interactions with complementary genes	2	Bio2.5.2.5
20	Describe the process of gene – gene interactions with supplementary genes	2	Bio2.5.2.6
21	Describe the process of gene – gene interactions involving polygenes genes	2	Bio2.5.2.7
22	Describe the process of gene – gene interactions involving pleiotropy	2	Bio2.5.2.8

23	Explain height and skin colour in humans in terms of gene – gene interactions (e.g. sickle cell disease)	3	Bio2.5.3.5
24	Explain sickle cell disease in humans in terms of gene – gene interactions	3	Bio2.5.3.6
25	Discuss the interrelationship between gene – gene interactions in determining various characteristics in humans and the impact of these characteristics on survival.	4	Bio2.5.4.2

Sub-strand 2.6 Environmental effect on Phenotype

Key Learning Outcome: Students are able to demonstrate understanding of environmental effects on phenotypes

- the effects of the environment on the expression of the genotype eg diet on human height, exposure to sun on skin colour in humans, altitude on tree growth; soil temperature on sex of tuatara in eggs; Himalayan coat colouring eg Siamese cats

SLO#	**Specific Learning Outcomes:** *Students are able to*	Skill level	SLO code
1	Outline the ideas of the nature vs nurture debate	2	Bio2.6.2.1
2	Explain the effects of the environment on the expression of the genotype in terms of diet on human height	3	Bio2.6.3.1
3	Explain the effects of the environment on the expression of the genotype in terms of exposure to sun on skin colour in humans	3	Bio2.6.3.2
4	Explain the effects of the environment on the expression of the genotype in terms of altitude on tree growth	3	Bio2.6.3.3
5	Explain the effects of the environment on the expression of the genotype in terms of soil temperature on sex of tuatara in eggs	3	Bio2.6.3.4
6	Explain the effects of the environment on the expression of the genotype in terms of the Himalayan coat colouring e.g. Siamese cats	3	Bio2.6.3.5
7	Describe the types of gene interactions that causes certain phenotypes e.g. point coloration in Siamese cats	2	Bio2.6.2.2
8	Discuss the effects of the environment on the expression of the genotype eg diet on human height, exposure to sun on skin colour in humans, altitude on tree growth; soil temperature on sex of tuatara in eggs; Himalayan coat colouring eg Siamese cats	4	Bio2.6.4.1

Strand 3: Biotechnology Applications

Major Learning Outcome 3:
Students are able to describe, explain and discuss **biotechnology applications** and the **human needs and demands** for the applications.

Sub-strand 3.1 Gene cloning, Trans genesis and DNA Profiling

Key Learning Outcome: Students are able to demonstrate understanding of gene cloning, trans genesis and DNA profiling and ways in which these influence gene functioning

- the formation of recombinant DNA using techniques of restriction enzymes and ligation • the use of bacterial plasmids to produce multiple copies of the desired gene
- transgenesis using techniques of Agrobacterium tumefaciens; ballistic ('gene gun') method; pronuclear ('micro') injection; viral vectors
- formation of DNA profiles using the techniques of PCR and gel electrophoresis

SLO#	Specific Learning Outcomes: *Students are able to*	Skill level	SLO code
1	Define gene cloning/trans genesis/ bacterial plasmids	1	Bio3.1.1.1
2	Identify/State a feature or example of gene cloning/trans genesis/ bacterial plasmids, in a given context	1	Bio3.1.1.2
3	Describe the use of bacterial plasmids to produce multiple copies of the desired gene	2	Bio3.1.2.1
4	Discuss the formation of recombinant DNA using techniques of restriction enzymes and ligation and the possible impacts of these on bodily functions	4	Bio3.1.4.1
5	Define *Agrobacterium tumefaciens*	1	Bio3.1.1.3
6	Define gene gun / biolistic gene gun	1	Bio3.1.1.4
7	Describe trans genesis using techniques of Agrobacterium *tumefaciens*	1	Bio3.1.1.5
8	Describe trans genesis using techniques of ballistic ('gene gun') method	2	Bio3.1.2.2
9	Describe trans genesis using techniques of pronuclear ('micro') injection	2	Bio3.1.2.3
10	Describe trans genesis using techniques of viral vectors	2	Bio3.1.2.4
11	Explain the consequences of the use of trans genesis on the gene pool for a population	3	Bio3.1.3.1
12	Discuss the possible social consequences of the use of trans genesis on the human gene pool	4	Bio3.1.4.2
13	Define DNA profiling / DNA fingerprinting / DNA typing	1	Bio3.1.1.6
14	Identify/State a feature or example of DNA profiling / DNA fingerprinting / DNA typing, in a given context	1	Bio3.1.1.7
15	Describe the process of DNA profiling	2	Bio3.1.2.5
16	Discuss how the advent of DNA fingerprinting has 'revolutionised' criminal justice using examples	4	Bio3.1.4.3
17	Describe the uniqueness of DNA	2	Bio3.1.2.6
18	Define PCR / gel electrophoresis	1	Bio3.1.1.8
19	Identify/State a feature or example of PCR / gel electrophoresis, in a given context	1	Bio3.1.1.9
20	Describe formation of DNA profiles using the techniques of PCR	2	Bio3.1.2.7
21	Describe the applications of PCR	2	Bio3.1.2.8
22	Describe formation of DNA profiles using the techniques of gel electrophoresis	2	Bio3.1.2.9
23	Explain the impact of DNA profiling on medical health sciences	3	Bio3.1.3.2

24	Explain the interrelationships of processes in the formation of DNA profiles using the techniques of PCR and gel electrophoresis	3	Bio3.1.3.3
25	Discuss the impact of formation of DNA profiles using the techniques of PCR and gel electrophoresis on criminal justice, medicine and other areas	4	Bio3.1.4.4
26	Describe trans genesis using techniques of *Agrobacterium tumefaciens*	2	Bio3.1.2.10

Sub-strand 3.2 Contemporary biotechnology issue

[Internal Assessment (IA)]

Learning outcome 5:

Students are able to research and process information to write a report on a chosen contemporary issue regarding biotechnology.

Key Learning Outcome: Students are able to demonstrate understanding of contemporary biotechnology issues

- human needs or demands that have lead to the development of a biotechnological application which is an issue
- techniques needed to carry out the application
- any potential biological, social, ethical, economic impacts of the application
- the differing opinions of named people or groups, including their own justified opinion, on the issue

SLO#	**Specific Learning Outcomes:** *Students are able to research into contemporary biotechnological issues and process information to write a report that demonstrates ability to*	Skill level	SLO code
1	Name a biotechnology issue	1	Bio3.2.1.1
2	Locate area in which selected issue is commonly encountered	1	Bio3.2.1.2
3	List contemporary biotechnology issues as established through research	2	Bio3.2.2.1
4	Describe the human needs or demands that are giving rise to the use of the selected biotechnology application and the related issues	2	Bio3.2.2.2
5	Describe the procedures used in the selected biotechnology application	2	Bio3.2.2.3
6	Provide elaboration on at least two critical steps	3	Bio3.2.3.1
7	Discuss biological, social, ethical, economic impacts related to the selected biotechnology application	4	Bio3.2.4.1
8	Compare two differing opinions on the selected biotechnology application	3	Bio3.2.3.2
9	State a personal opinion on the use of the selected biotechnology application using supporting evidence	2	Bio3.2.2.4
10	Produce a structured report with logical flow of ideas	2	Bio3.2.2.5
11	Organise primary sources of information with correct referencing	2	Bio3.2.2.6

The assessment activity to be used by all schools and teachers, together with teacher guidelines and an assessment schedule or scoring rubric, is provided in Appendix 2. Using a common activity enables teachers to carry out consistent assessment.

Strand 4: Processes and Patterns of Evolution

Major Learning Outcome 4: Students are able to describe, explain and discuss **processes and patterns** of evolution

Sub-strand 4.1 Variation

Key Learning Outcome: Students are able to demonstrate understanding of variations in forms and functions and the contribution of genetics in these variations

- role of mutation as source of new alleles
- role of meiosis in producing variation and recombinant genotypes / gametes (independent assortment, segregation, crossing over) – revision and extension of form 6
- role of fertilization in sexual reproduction in producing variation
- importance of variation in evolution

SLO#	**Specific Learning Outcomes:** *Students are able to*	**Skill level**	**SLO code**
1	Define the terms independent assortment / segregation / crossing over / recombinant genotypes	1	Bio4.1.1.1
2	Identify/State a feature or example of independent assortment / segregation / crossing over / recombinant genotypes, in a given context	1	Bio4.1.1.2
3	Describe the process of mutation that leads to formation of new alleles	2	Bio4.1.2.1
4	Explain the contribution of mutation to the gene pool of the population	3	Bio4.1.3.1
5	Discuss the positive and negative impacts of mutation on a population	4	Bio4.1.4.1
6	Define meiosis / gametes / fertilisation / mitosis	1	Bio4.1.1.3
7	Identify/State a feature or example of meiosis / gametes / fertilisation / mitosis, in a given context	1	Bio4.1.1.4
8	Describe the features of the different stages in the process of meiosis	2	Bio4.1.2.2
9	Explain how meiosis contributes to variation through recombinant genotypes / gametes (independent assortment, segregation, crossing over)	3	Bio4.1.3.2
10	Describe the process of fertilisation in terms of combination of chromosomes from gametes	2	Bio4.1.2.3
11	Explain how fertilization in sexual reproduction produces variation	3	Bio4.1.3.3
12	Discuss role of fertilization in sexual reproduction in producing variation and enhancing biological success, using named examples.	4	Bio4.1.4.3
13	Define evolution	1	Bio4.1.1.5
14	Identify/State a feature or example of evolution, in a given context	1	Bio4.1.1.6
15	List the key features of the process of evolution	2	Bio4.1.2.4
16	Explain the importance of variation in evolution	3	Bio4.1.3.5
17	Discuss the impact of evolution on the survival of species and the critical role of variation in promoting evolution	4	Bio4.1.4.2

Sub-strand 4.2 Natural Selection

Key Learning Outcome: Students are able to demonstrate understanding of natural selection and factors that influence this, and things that are impacted by natural selection

- theory of natural selection as proposed by Darwin; selecting agents / selection pressures (eg predators)
- sexual selection as a special case of natural selection – females act as the selecting agent for which males (strongest / biggest / most showy / healthiest) will breed

- artificial selection (selective breeding) – humans act as the selecting agent for which plants and animals (those with the desirable traits) will breed
- 'fitness' in terms of the organisms which breed successfully to produce the most offspring, so their alleles increase in frequency in the gene pool

SLO#	**Specific Learning Outcomes:** *Students are able to*	**Skill level**	**SLO code**
1	Define natural selection, selection pressure, sexual selection	1	Bio4.2.1.1
2	Identify/State a feature or example of natural selection / selection pressure / sexual selection, in a given context	1	Bio4.2.1.2
3	Outline the main points of the theory of natural selection as proposed by Darwin;	2	Bio4.2.2.1
4	List the selecting agents/selection pressures that contribute to natural selection	2	Bio4.2.2.2
5	Explain the related ideas in the theory of natural selection as proposed by Darwin	3	Bio4.2.3.1
6	Evaluate the theory of natural selection as proposed by Darwin; presenting your own opinion on the relative truth of the theory	4	Bio4.2.4.1
7	Outline the main features of sexual selection as a special case of natural selection (females act as the selecting agent for which males (strongest /biggest/ most showy/healthiest) will breed)	2	Bio4.2.2.3
8	Explain the interrelationships within sexual selection as a special case of natural selection	3	Bio4.2.3.2
9	Discuss the impact of sexual selection on populations using specific examples	4	Bio4.2.4.2
10	Define selective breeding	1	Bio4.2.1.3
11	Identify/State a feature or example of selective breeding, in a given context	1	Bio4.2.1.4
12	Describe the features of artificial selection or selective breeding	2	Bio4.2.2.4
13	Explain the role of humans in artificial selection (selective breeding)	3	Bio4.2.3.3
14	Discuss the impact of artificial selection (selective breeding) on variations in populations	3	Bio4.2.3.4
15	Compare the 'effectiveness' of methods of sexual selection and selective breeding in terms of their contribution to variations in populations	3	Bio4.2.3.5
16	Define 'fitness'	1	Bio4.2.1.5
17	Identify/State a feature or example of fitness, in a given context	1	Bio4.2.1.6
18	Explain how 'fitness' contributes to frequency of alleles in the gene pool	3	Bio4.2.3.6
19	Evaluate the contribution of natural selection, sexual selection and selective breeding on a population, providing an opinion on the preferred method	4	Bio4.2.4.3

Sub-strand 4.3 Gene pool and allele frequency

Key Learning Outcome: Students are able to demonstrate understanding of gene pools and allele frequencies within gene pools of a population and factors that affect allele frequency.

- gene pool as the sum total of genes within a population
- allele frequency as how often an allele occurs in a gene pool; factors affecting allele frequency - size of population; natural selection, sexual selection, migration (gene flow)
- genetic drift – the changes in allele frequency in a population by chance, related to population size
- founder effect and bottleneck effect as special cases of genetic drift

SLO#	**Specific Learning Outcomes:** *Students are able to*	Skill level	SLO code
1	Define gene pool / allele frequency	1	Bio4.3.1.1
2	Identify/State a feature or example of gene pool / allele frequency, in a given context	1	Bio4.3.1.2
3	Define founder effect / bottleneck effect	1	Bio4.3.1.3
4	Identify/State a feature or example of founder effect / bottleneck effect, in a given context	1	Bio4.3.1.4
5	List the factors that affect allele frequency within a population	2	Bio4.3.2.1
6	Explain how size of population affect allele frequency	3	Bio4.3.3.1
7	Explain how natural selection affect allele frequency	3	Bio4.3.3.2
8	Explain how migration (gene flow) affect allele frequency	3	Bio4.3.3.3
9	Define genetic drift	1	Bio4.3.1.5
10	Identify/State a feature or example of genetic drift, in a given context	1	Bio4.3.1.6
11	Explain how genetic drift affect changes in allele frequency in a population by chance	3	Bio4.3.3.4
12	Explain how genetic drift is related to or affected by population size	3	Bio4.3.3.5
13	Discuss the impact of genetic drift on populations and population size	4	Bio4.3.4.1
14	Describe the features of the founder effect as special cases of genetic drift	2	Bio4.3.2.2
15	Describe the features of the bottleneck effect as special cases of genetic drift	2	Bio4.3.2.3
16	Explain the relation between the founder effect and bottleneck effect as special cases of genetic drift	3	Bio4.3.3.6
17	Discuss the impacts of the founder effect and bottleneck effect as special cases of genetic drift	4	Bio4.3.4.2

Sub-strand 4.4 Speciation

Key Learning Outcome: Students are able to demonstrate understanding of the different types of speciation, the different reproductive isolating mechanisms and the impact of speciation on diversity

- allopatric, sympatric, instant (polyploidy) speciation
- reproductive isolating mechanisms :
  - pre-mating (pre-zygotic) – geographical, ecological, behavioural, structural, temporal
  - post-mating (post-zygotic) – hybrid inviable, hybrid sterile, hybrid breakdown.

SLO#	**Specific Learning Outcomes:** ***Students are able to***	Skill level	SLO code
1	Define allopatric / sympatric / instant (polyploidy) speciation	1	Bio4.4.1.1
2	Identify/State a feature or example of allopatric / sympatric / instant (polyploidy) speciation, in a given context	1	Bio4.4.1.2
3	Describe the features of allopatric, sympatric, instant (polyploidy) speciation	2	Bio4.4.2.1
4	List the pre-mating (pre-zygotic) reproductive isolating mechanisms	2	Bio4.4.2.2
5	Describe the features of each isolating mechanism	2	Bio4.4.2.3
6	Explain why geographical isolation leads to reproductive isolation	3	Bio4.4.3.1
7	Explain why ecological isolation leads to reproductive isolation	3	Bio4.4.3.2
8	Explain why behavioral isolation leads to reproductive isolation	3	Bio4.4.3.3
9	Explain why structural isolation leads to reproductive isolation	3	Bio4.4.3.4
10	Explain why temporal isolation leads to reproductive isolation	3	Bio4.4.3.5
11	Define hybrid inviable / hybrid sterile / hybrid breakdown	1	Bio4.4.1.3

12	Identify/State a feature or example of hybrid inviable / hybrid sterile / hybrid breakdown, in a given context	1	Bio4.4.1.4
13	List the post-mating (pre-zygotic) reproductive isolating mechanisms	2	Bio4.4.2.4
14	Explain why hybrid inviable mechanism leads to reproductive isolation	3	Bio4.4.3.6
15	Explain why hybrid sterile mechanism leads to reproductive isolation	3	Bio4.4.3.7
16	Explain why hybrid breakdown leads to reproductive isolation	3	Bio4.4.3.8
17	Discuss the combined impact of reproductive isolating mechanisms (pre-zygotic and post-zygotic) on speciation in populations using specific examples	4	Bio4.4.4.1

Sub-strand 4.5 Patterns of Evolution

Key Learning Outcome: Students are able to demonstrate understanding of the different patterns of evolution

- divergent evolution from common ancestor; homologous structures
- divergent evolution; analogous structures
- co-evolution

SLO#	**Specific Learning Outcomes:** *Students are able to*	Skill level	SLO code
1	Define divergent evolution / convergent evolution / co-evolution	1	Bio4.5.1.1
2	Identify/State a feature or example of divergent evolution / co-evolution / convergent evolution, in a given context	1	Bio4.5.1.2
3	Define homologous structures / analogous structures	1	Bio4.5.1.3
4	Identify/State a feature or example of homologous structures / analogous structures, in a given context	1	Bio4.5.1.4
5	Outline the features of divergent evolution from common ancestor; homologous structures	2	Bio4.5.2.1
6	Explain how divergent evolution from common ancestor relates to homologous structures	3	Bio4.5.3.1
7	Discuss the impact of divergent evolution from common ancestor to the formation of new species using examples	4	Bio4.5.4.1
8	Describe the features of convergent evolution; analogous structures	2	Bio4.5.2.2
9	Explain how convergent evolution relates to analogous structures	3	Bio4.5.3.2
10	Compare and contrast divergent and convergent evolution	3	Bio4.5.3.3
11	Describe the features of co-evolution	2	Bio4.5.2.3
12	Discuss the interplay of divergent, convergent and co-evolution in the establishment of new organisms and new species	4	Bio4.5.4.2

8. Assessment

Assessment in this Biology course is in two parts - external assessment and internal assessment. The respective weightings are

1. **External Assessment (EA) : 70%**

2. **Internal Assessment (IA) : 30%**

The principal, or his/her nominee, will certify that the prescription requirements have been fulfilled.

Suggested Teaching Time and Weightings

Strands	Strands/Topics	External/ internal	Suggested Time	Overall Weighting (%)
1	Animal Behaviour	External	*4 weeks*	15.0
		Internal	*4 weeks*	15.0
2	Gene Expression	External	*6 weeks*	25.0
3	Biotechnology applications	External	*2 weeks*	10.0
		Internal	*4 weeks*	15.0
4	Process and Patterns of Evolution	External	*5 weeks*	20.0

External Assessment

This will be a three-hour written examination and will be out of 70%.

The external written examination will assess learning outcomes from all four strands in the following proportions:

Strand	Strand Title	Weighting
Strand 1:	Animal Behaviour	15%
Strand 2:	Gene Expression	25%
Strand 3:	Biotechnology Applications	10%
Strand 4:	Processes and Patterns of Evolution	20%

Questions will require students to demonstrate skills of different levels (Levels 1, 2, 3 and 4). The common skills being assessed include defining or stating or naming, describing, explaining, discussing and evaluating biological concepts and processes using sentences and paragraphs. They will be expected to interpret resource material supplied (including diagrams, table, and graphs) and to solve genetic problems. All questions in the written examination paper are COMPULSORY.

Internal Assessment

There are two internal assessment tasks and these include:

Task 1: Investigation into an Ecological Niche (15%)

Task 2: Research and report on a contemporary biotechnology issue (15%)

Teacher guidelines, assessment activities, assessment criteria and sample recording templates for the two internal assessment tasks are provided in appendices 1 to 4. These will be used by **all** schools and teachers *to ensure consistency in practice.* All student reports plus research material and log books will be retained on file by the schools after marking. This will assist with ensuring authenticity of work from year to year and the information contained in them may be referred to by teachers to assist both teachers and students in future assessment activities.

Assessment Blueprint

The blueprint below is to guide the internal and external assessment allocations for Biology.

The allocation of 20%, 30%, 30% and 20% for levels 1, 2 3 and 4 respectively is common across all subjects at the SPFSC level.

Strand	IA or EA	Level 1	Level 2	Level 3	Level 4	Total skill score allocation (%)
Strand 1: Animal Behavior and Ecological Niche	EA					15
	IA	1	2	2	1	15
Strand 2: Gene Expression	EA					25
Strand 3: Biotechnology Applications	EA					10
	IA	-	4	1	1	15
Strand 4: Process and Patterns of Evolution	EA					20
Number of items		**20**	**15**	**10**	**5**	**100**
TOTAL		**20**	**30**	**30**	**20**	

9. Appendices

Appendix 1: IA Task 1 Teacher and Student Guidelines

Task 1: Investigating an Ecological Niche

Teacher Guidelines:

The following guidelines are supplied to enable teachers to carry out a **valid** and **consistent assessment** using this internal assessment resource.

Context/setting:

This is an open ended activity to investigate *an aspect of the ecological niche* of a named species. The investigation will cover the complete process from planning to reporting, and will involve students in the collection of primary data related to the ecological niche of the species. The investigation may be **either**

- **FAIR TEST** - investigation involves manipulating a variable (the independent variable or IV) in controlled conditions (e.g. in a laboratory) to observe and record the effect on the organism **or**
- **PATTERN SEEKING -** investigation involves recording the distribution of an organism relative to an environmental factor(s) in the field.

Students are to investigate an aspect of the ecological niche of the organism they are studying. The organism may be either a plant or an animal. It is essential that they *develop an understanding* of the ecological niche of the organism being studied *before* the investigation is carried out. This will allow the student to select a *relevant* aspect of the ecological niche to investigate. Students who choose to investigate an aspect of a cultivated plant could investigate an aspect of the 'cultivated' niche. Student understanding can be developed through classroom teaching, research or practical investigation prior to, and during, the investigation. The teacher will need to guide the students in the selection of an appropriate aspect for investigation. Examples of possible investigations include:

Fair Test (minimum of three values across a range needed for the IV)

- Tolerance of fiddler crabs to salinity – need range of salinities, with mi the nest and / or distance at which sugar solution can be detected
- Substrate / soil preference of earthworms
- Germination rate / success of mangroves in differing salinities
- Tropic responses of dwarf bean seedlings – photo, hydro, thigmo, chemo.

Pattern Seeking

- Distribution (where found and how distributed eg clumped, spaced, random) and density of e.g. land crabs, fiddler crabs, mangroves (pneumatophores eg density in 1m radius around main trunk), frogs, toads (use mark / recapture) in relation to substrate type / named abiotic factor
- Territoriality in Picasso trigger fish – location and size of territories (include depth as varies with tidal movement) as indicated by response (observed / threat / attack) to human presence (e.g. snorkeler); what determines size / boundaries?
- Hierarchy in local dog packs – does a hierarchy exist as shown by aggressive interactions between identified dogs / fierceness of interactions / dominant and submissive behaviours; what determines hierarchy?

Guidance:
The teacher is to *guide* the students in the investigation. This means that the teacher interacts and discusses with the student throughout the investigation. The teacher sets the parameters (such as suitable species and suitable investigations for study; equipment available) and provides general information such as resource suggestions or possible new directions. Students will keep a **log book** of their progress and will submit this to their teacher at regular intervals (**milestones**) during the investigation for teacher feedback on their progress. All ideas such as rough notes, brainstorming, possible investigations, collection of data and observations, research and planning, failures, successes and tentative conclusions will be kept in the log book. The logbook is a *working document* - its function is to *record all findings* and shows the student's investigative skills. The students will write their formal report using information in the logbook. The use of milestones also provides opportunities for teachers to verify authenticity of the students' work and to record progress. The logbooks will be handed in with the final report.

Conditions:
Students are expected to carry out an **individual** investigation.

Specific conditions must be stated on the student instruction sheet for example, time in class, expected homework time, equipment and resources available, animal ethics guidelines and specific safety requirements, date(s) for writing the report.

Students need sufficient time for:

- examining / researching the ecological niche of the organism
- developing and trialling their method, carrying out their investigation, processing and interpreting their data
- writing the report.

The time needed will depend on the organism being studied. For example, plant investigations (e.g. mangrove germination) often require small amounts of time over a longer time period. It is important that students are able to **trial** their method to see if it will be **valid** i.e. the method is able measure what it intends to measure. The final method used will be developed from the trials.

The writing of the report will be done **in class under formal (open book) exam conditions using the student's logbook.** Students *may not* bring a *prepared* (draft) report into the exam room. A time period of 3 hours (maximum) will be allowed for this. If this time period goes over more than one day, then all the work (logbook and incomplete report) *must* be collected in between class sessions for authenticity purposes.

Resource requirements:

The resources required will depend on the investigations chosen by each student. It is suggested that students list the equipment / resources they require so that their availability can be checked. Simple resources e.g. a choice chamber may need to be made (and kept for use in future years).

Additional Information:

Whether this work is completed in a class laboratory or out of school, teachers will need to include strategies to ensure authenticity. For example: regular checking of logbooks; discussion with students about the recordings in their log books; digital photographs (students may be helped if the school is able to loan a digital camera so they can record aspects of their work, especially if in the field): signed authenticity statements.

The final marked reports and logbooks will **be kept by the teachers / school** after the students have checked their marks. The collected material will be kept on file in the school for future reference by teachers. The data that the students have collected may be made available to students in future years to be included in their investigations too so that eg changes in patterns of distribution from year to year may form part of the processed data and discussion.

Glossary

Ecological niche - functional place of an organism within ecosystem. The result of its structural adaptations, physiological responses and behaviour to its biotic and abiotic environment
Primary data - original data obtained by direct measurement or observations..
Hypothesis - a prediction (based on observations and / or research) which can be tested by experimentation.
Independent variable (**IV**) - variable that is altered over a range of values by the experimenter
Dependent variable (**DV**) - variable (with units) that is measured by the experimenter
Controlled variable – variable(s) that are kept constant (controlled) throughout the experiment to prevent any effect on the dependent variable (therefore the experiment is a 'fair test')
Valid - the design of the experiment (the method) means that the experiment *measures what is intended.*
Reliability - probability that the same result can be produced again if the experiment is repeated (by same or another experimenter).

Task 1: Student Instructions

Conditions

- *information about choice of organism and possible investigations*
- *conditions relating to time in class available, expected homework time involved, due dates for milestones, date for the writing of the report*
- *resources and equipment available*
- *investigation carried out independently*
- *animal ethics (if applicable)*
- *school's authenticity policy (if investigation carried out outside of the classroom)*

The scientific report will include:

- *description of the ecological niche of the species with respect to aspect being investigated*
- *an aim and hypothesis*
- *a step by step method which includes the dependent variable (DV); independent variable (IV) and other variables that need controlling*
- *recorded and processed data*
- *conclusion*
- *discussion*
- *evaluation*

Logbook

You are required to keep a logbook.

- All ideas, rough notes, brainstorming, possible investigations, collection of data and observations, research and planning, failures, successes, tentative conclusions, go into the logbook.
- Record all sources of information used eg **a reference list.**
- It is your 'rough' copy and a **working** document. Its neatness is not important, but it must be able to be read and understood by your teacher; its function is to record all findings and show your skills in

investigation. You will hand the logbook into your teacher at set dates (**milestones**). Your teacher will read it, give you feedback, and sign it. If possible, include relevant photographs of your investigation. Your logbook will also be used to establish authenticity.

- All entries must be **dated.**

It is from the information in this logbook that you will write your formal report

This investigation is divided into three activities.

Activity 1 Selecting an aspect of the ecological niche to investigate

In this task you will **gather and process information on the ecological niche of the species** from background reading and observations. The purpose of this task is to provide information that will enable you to develop *an investigation relating to an aspect of the ecological niche of the organism.*

Record the information in your logbook.

Activity 2 Carrying out the investigation

In this task you will **independently** investigate one particular aspect of the ecological niche of the species.

Activity 3 Reporting

This task requires the writing of a **scientific report**. The report will be written **in class** under formal exam conditions **using the material recorded in your logbook**. A 3 hour period will be allowed for this.

The report *must* contain the following:

1. **Introduction** – a *brief* description of the ecological niche of your species focussing on the *aspect* you investigated, explaining why it is important to the way of life of the members of the species.
2. **Aim** and **Hypothesis**.
3. **Method** – the final method used written as a *step by step set of instructions* sufficiently clear enough that another person could carry out then investigation.
4. **Results** – the processed data (eg tabulated, averaged, graphed *as appropriate*) showing the presence (or absence) of a relationship, trend, or pattern.
5. **Explanation of findings** – narrative about findings (e.g. patterns in the graph) are described and related ideas are linked so as to give the idea of totality of findings and their suitability for the purpose of the investigation..
6. **Discussion** and **Conclusion -** discuss the *biological significance* of the results and how they relate to the ecological niche of the organism.
7. **Evaluation** of your investigation in terms of:
    - **<u>either</u>** the **validity** of your method eg how sources of error were eliminated or how limitations were overcome or how the effects of bias were reduced
    - **<u>or</u>** the **reliability** of the data collected using statistical analysis eg Chi-squared test, t test

Your report, together with your logbook, must be handed in to your teacher for marking.

Task 1 Assessment Criteria

Item	Level 1	Level 2	Level 3	Level 4
1. Introduction - Ecological Niche (Level 2) Bio1.1.2.3	One correct idea is provided	Two or more descriptions are provided		
2. Aim / Hypothesis (Level 1) Bio1.1.1.2	States aim *or* hypothesis accurately			
3. Method / Procedure (Level 2) Bio1.1.2.4	Description of procedure is provided but partial only	Description of procedure is complete		
4. Results (Level 3) Bio1.1.3.4	Collected results tabulated or graphed with incomplete information	Collected results tabulated and graphed with most details correct	Collected results accurately tabulated and graphed and details are complete	
5. Explanation of findings (Level 3) Bio1.1.3.5	One relevant idea but far from complete	Findings are listed but related ideas are not linked	Description of findings is complete and related ideas are linked well	
6. Discussion and Conclusion (Level 4) Bio1.1.4.2	One relevant idea but far from complete	Two relevant ideas but still not complete	Related ideas are presented but not extended to aim/hypothesis and/or conclusion not drawn	Well discussed and valid conclusion drawn from data and linked to aim and / or hypothesis
7. Evaluation (Level 3**)** Bio1.1.3.6	One relevant idea but far from complete	Features (more than one) of validity or reliability are referred to	Validity and reliability are addressed and these are related back to data collection methods and data found	

Note: the progression from *define* → *describe* → *explain* → *discuss* indicates *higher levels of understanding* as follows:

- **Stating or defining** – statement of one idea or a definition
- **describe** – means to characterise, or give an account of, or outline features of or provide annotated diagrams.

- **explain** – means to provide a reason as to *how* or *why* something occurs, to link event and impact, cause and effect, event and a reason etc..
- **discuss** – this means *linking biological ideas* (descriptions, explanations) to show understanding.

NOTE: The student's report must be handed in together with the logbook to the teacher for marking. Reports that are handed in without a logbook receive a zero score.

Task 1 IA Score Capture Sheet

The electronic version of the IA Score Capture Sheet will be provided by EQAP to all schools. Teachers are to enter student scores into the score sheet using instructions provided by EQAP.

Appendix 2: IA Task 2 Guidelines for Teachers and Students

Teacher Guidelines:

The following guidelines are supplied to enable teachers to carry out a **valid and consistent assessment** using this internal assessment resource.

Context/setting:

This activity is based on **Sub-strand 3.2: Contemporary Biotechnology Application**. The application to be researched must be considered an **issue**; this means that there is some controversy about the topic with people holding differing opinions. The students select a topic from those listed and then collect **a range of material** covering

- the biological **application**
- potential **impacts** (positive and negative) of the application
- **different opinions** relating to the issue

It may assist teachers and students in their research and assessment to think of:

- **B** for the **B**iotechnological application
- **I** for the **I**mpacts
- **O** for the **O**pinions

The activity is to be carried out with teacher supervision.

Students could collect primary and secondary data, information and opinions.

Students work through the researched material and **process** the information to identify aspects that will be suitable for use in their report. They bring to class their researched material and any notes they have made and **write a report** on their chosen topic. Their notes and research material are organised and handed in as part of the authenticity process. The report is written in the student's **own words** with paragraphs flowing in a logical manner rather than jumping from one topic to another. **A traceable reference system** should be used in the report so that the sources of information can be accessed. For example, by using *footnotes* or *endnotes* – this will need to be demonstrated to the students.

Conditions:

The research is to be carried out **individually**. The writing of the report will be done **in class under formal (open book) exam conditions using the student's own research material and notes.** Students *may not* bring a *prepared* (draft) report into the exam room. A time period of 3 hours (maximum) will be allowed for this. If this time period goes over more than one day, then all the work (research data and incomplete report) *must* be collected in between class sessions for authenticity purposes.

Two weeks of class time and homework time is allowed for the collection and processing of data. **The teacher is to indicate the start and end time of these two weeks in the IA Program proposal that is submitted to EQAP**.

Three hours of class time in formal exam conditions is allowed for the writing of the report using the researched data. Again, **the teacher will have to indicate the dates for this in the IA Program proposal.**

Failure to indicate these dates may result in the proposed IA program not being approved.

Milestones:

Students need to hand in their researched material to their teachers regularly (once every week) during the four week time frame to allow teachers to check and provide feedback on:

- relevance of the material collected
- range of material collected
- compilation of a reference list
- appropriate and relevant processing

Resource requirements:

Students will require access to a range of sources of information on their issue including internet access. All sources used must be *relevant* and *up to date.*

Additional information:

The final marked reports and research material will **be kept by the teachers / school** after the students have checked their marks. The collected material will be kept on file in the school for future reference by teachers. This will also minimise potential copying of the material by students in future year.

Glossary

Primary data - original data obtained by direct measurement or observation of the event e.g. data collected field data, interview, lecture

Secondary data - data from another source eg website, newspaper, DVD

Reference List – a list of the sources collected with titles / author or organisation / date published (eg book) or produced (eg DVD) or accessed (eg website)

Traceable Reference System – a report has all its material / information / data referenced in such a way that a reader *can find the source of that information.*

Footnotes – the information in the body of the report has a number superscript, then that number is repeated *at the bottom of the page* under the text with the source alongside it eg '200 people were killed in traffic accidents in 2009' [1] (body of text) and at the bottom of the same page eg '[1] ABC Herald page 3 January 18, 2010'. A second reference on the same page would be numbered '2' and so on.

Endnotes - the information in the body of the report has a number superscript (in numerical order eg 1, 2, 3…through the report), then that number is repeated at the *end of the report* with the source alongside resulting in a list being compiled.

Task 2 Student Instructions

Introduction

This task is about researching, processing information, and writing a report on a contemporary biotechnological issue.

Conditions

Two weeks of class time and homework time is allowed for the collection and processing of data. **The teacher will indicate to students the start and end time of these two weeks.**

Three hours of class time in formal exam conditions is allowed for the writing of the report using the researched data. Again, **the teacher will indicate to students the date(s) for this.**

Failure to adhere to these conditions may result in the proposed IA program not being approved.

Activity 1 – Selecting a topic

Select a topic from the following list of biological issues:

- cloning of animals
- xenotransplantation
- transgenic plant crops
- genome analysis
- gene therapy
- stem cell technology in medicine

Activity 2 – Research

1. Use a wide range of relevant and up to date of (e.g. websites, books, newspaper/journal articles, DVDs, interviews) to collect information on the:
   - **human need(s) or demand(s)** that has led to the development of the biotechnology application
   - **technique(s)** used in the application
   - any potential biological, social, ethical, economic **impacts** of the application. Impacts may be positive or negative.
   - **differing opinions** relating to the topic.

   Keep a record of the **sources** of all the researched information so that it can be used to produce a reference list.

2. **Organise** your research notes and copies of research material into a folder or ring binder or clear pockets or similar

3. **Process** your researched material by highlighting or tagging the key ideas (e.g. colour highlighting, notepad stickies, annotations etc). This will help you to quickly access **key ideas** from your researched material when you are writing your report.

4. Produce a **reference list** of all the relevant sources of information – this will be needed for referencing your report.

Activity 3 – Report

You will have **5 hours of supervised class time** in which to **write a report** using your processed research material. Your research material, including annotations and notes, will be available for you to use when writing the report. If the five hours is spread over the week, you will be required to hand in all research material and the incomplete report at the end of each period. You may *not* bring a prepared draft report into the room.

It is expected that the written report will take about three to four sides of A4 paper

Task:

Write a report, **in your own words**, in which you **integrate** information from your researched material to:

1. describe the **human need(s) or demand(s)** that have lead to the development of the biotechnological application
2. describe the **technique(s)** used to carry out the application
3. discuss potential **biological, social, ethical, economic impacts** relating to the use of the application.
4. give the **differing opinions** named people, groups or organisations hold and the **reasons** for each opinion.
5. include **your own opinion** on the issue and use supporting evidence from your report
6. include a **traceable reference system** in your report by using **footnotes** or **endnotes.**

Hand in

- **your report**
- **your research material** and **reference list.**

Task 2 IA Score Capture Sheet

The electronic version of the IA Score Capture Sheet will be provided by EQAP to all schools. Teachers are to enter student scores into the score capture sheet using instructions provided by EQAP.

Task 2 Assessment Criteria

Item	Skill Level	Level 1	Level 2	Level 3	Level 4
1. List contemporary biotechnology issue from research Bio3.2.2.1	2	One relevant biotechnology issue is stated	More than one relevant biotechnology issue listed		
2. Describe the Human need / demand) Bio3.2.2.2	2	One relevant point only is provided	A number of relevant ideas are provided		
3. Describe the techniques in application Bio3.2.2.3	2	One relevant point only is provided	A number of relevant ideas are provided		
4. Discuss possible impacts of application Bio3.2.4.1	4	Mentions one impact with minimal description	Mentions two or more impacts with descriptions	Relates the impact to the need for the application	Relates the 4 impact areas appropriately with clear examples of each
5. Differing opinions Bio3.2.3.2	3	Mentions one differing opinion with minimal description	Mentions two or more differing opinions with details	Compares the *two* differing opinions highlighting the difference/s	
6. Own opinion Bio3.2.2.4	2	One opinion matter only is stated	More than one aspect of personal opinion described		
7. Logical flow of ideas Bio3.2.2.5	2	Ideas in the write-up seem disparate at a number of points	Ideas in the write-up link up well		
8. Sources and referencing Bio3.2.2.6	2	One relevant source in reference list	Two or more relevant sources are found in the reference list		

Note: the progression from *define* → *describe* → *explain* → *discuss* indicates *higher levels of understanding* as follows:

- **Stating or defining** – statement of one idea or a definition
- **describe** – means to characterise, or give an account of, or outline features of or provide annotated diagrams.
- **explain** – means to provide a reason as to *how* or *why* something occurs, to link event and impact, cause and effect, event and a reason etc..
- **discuss** – this means *linking biological ideas* (descriptions, explanations) to show understanding.

NOTE: The student's report must be handed in together with the research materials and reference list to the teacher for marking. Reports that are handed in without a research materials receive a zero score.

Appendix 3: IA Summary Form

South Pacific Form Seven Certificate

Internal Assessment Summary Form

BIOLOGY

Country: _____ ***School:*** _____

Task	Brief Description	Start Date	End Date	Weighting
1. Investigation into an Ecological Niche				15%
2. Research and report on a contemporary biotechnological issue				15%
TOTAL				**30%**

Note: 1. Be specific about dates, not just Week 3 Term 1, etc.

2. Assessment schedules for the tasks will be provided. Teachers must use these.

Teacher's Name and Signature: ……..

Principal's Name and Signature: ……

****Note that IA Score Capture Sheets will be sent to each school from EQAP.**

A full IA program is to be submitted together with this IA Summary Form.

10. Advisory Section

Sample Biology Programme Timeline

TERM	WEEKS	TOPIC	ASSESSMENT
ONE	4 weeks	Animal Behaviour	Test
	4 weeks	Practical Investigation	Internal Assessment activity
	4 weeks	Genetics : Molecular Genetics	Test
TWO	4 weeks	Genetics : Gene – gene interactions	Test
	2 weeks	MID YEAR EXAM	EXAMINATION
	2 weeks	Biotechnology applications	Test
	2 weeks	Contemporary biotechnological issue	Internal Assessment activity
THREE	5 weeks	Processes and Patterns of Evolution	Test
	2 weeks	FINAL EXAM	EXAMINATION

Note that this is a suggested timeline. Teachers may modify the timeline to suit the needs of their school year and students.

Teacher Resources

Note: The content of SPFSC Biology for both Form 6 and 7 will be found in current (and new) texts designed for NZ years 12 and 13 e.g. ESA publications. No one NZ text will cover either Form 6 PSSC or Form 7 SPFSC courses.

Note – be aware of **copyright** regulations when using any of this material.

BOOKS – many publications / publishers offer DVD ROMs; on-line material as well as / together with hard copy texts

- Campbell Biology 9th edition Reece, Jane B et al (ISBN 9780321558237)
  This is probably the most comprehensive text for teacher (and student) reference; one book for staff reference for each school is highly recommended for senior biology at all levels.
- ESA publications (www.esa.co.nz) produce both Study Guides (SG) and Learning workbooks (LWB) for all subjects and updates regularly. Currently all books are being updated for the introduction of the new curriculum. The year 12 and 13 LWB and SG are good references for both teachers and students (eg class sets). The new line of LWB are in the write-on format and designed for daily use in class

- Biozone course Manuals (www.biozone.co.nz) are available for year 12 and 13 biology and updated annually; new editions will be in production for the new curriculum in 2012 and 2013. Excellent graphics; degree of difficulty of content in current editions varies greatly, hence suitability to students
- Meg Bayley: Designs of Life (year 13) and Patterns of Life (year 12) www.pearsoned.co.nz . These two have been standard texts for many years and are still valuable resources. They will need to be updated / replaced for the new NZ curriculum.
- Pathfinder Series: Biology Year 13 (Jarvis and Schofield); Year 12 (Relph) www.nelsonsecondary.co.nz . The books in this series have a set format of 2 pages of key notes for a topic accompanied by 2 pages of questions; can be a very useful resource and class set is recommended.

SCIENTIFIC PERIODICALS / MAGAZINES / JOURNALS

Excellent, relevant material may be found in any / all of the following publications, especially New Scientist. A school subscription recommended for these publications in following priority:

- New Scientist
- National Geographic
- Biological Science Review
- Scientific American
- Time

Newspapers – many of these can still be accessed free on the web, and many regularly have good articles on aspects of biology that can make good resource material in fields such as biotechnology, ecology, genetics, medicine e.g. www.nzherald.co.nz. Internationals such as New York Times, Guardian are worth browsing.

INTERNET RESOURCES

The easiest and quickest way to find information on any topic is simple to '**google it'.** Teachers need access to computers and internet as part of their education requirements at this level in order to research information for class work and assignment work. **Wikipedia** is often the main source provided in a google search (www.wikipedia.org). Youtube (www.youtube.com) can be an excellent source of **video clips** eg animations for DNA replication; transcription and translation. www.istockphoto.com is an excellent source of photos.

Video / DVD material can be accessed and bought from www.vea.com.au (Video Education Australasia)

Resource material provided for NZ teachers and students by the government will have relevance for teachers and students for form 6 PSSC and 7 SPSFC biology –

- www.nzqa. govt.nz (then follow links to **NCEA**) - provides external (exam) AND internal assessment material for all levels of biology; the exam papers and schedules for various topics may provide stimulus material for teaching and learning
- www.tki.govt.nz - provides resource material for internal assessment for all levels; the tasks and schedules for various topics may provide stimulus material for teaching and learning. It can be reached too by link from NCEA webpage.