

BIOLOGY 154 - FUNCTIONAL BIOLOGY

(16 credits: 3L, 3P)

MODULE FRAMEWORK AND STUDY GUIDE FOR 2022

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1. Welcome

Welcome to Biology 154 - Functional Biology. This module includes the functional biology of plants and animals, as well as an introduction to biotechnology. We will do our best to make this module a pleasant and informative learning experience.

1.1 Lectures

In 2022, this module will be offered on campus with no simultaneous live streaming.

We offer Face-face lectures (real-time) with the lecturers in the class venues (attendance is strongly recommended).

In this module we follow Option 1 of the Language Policy of the University of Stellenbosch. This means that you will be able to receive your lectures, practicals/tutorials in English or Afrikaans (separate classes).

1.2 Weekly work

Check each week's "What should I do this week?" on SUNLearn. These sections will explain what you are required to do each week, including assessments, tutorials, other due dates and important information. Please make sure that you understand what you need to do and if you are unsure of anything, email Mrs Nel at acnel@sun.ac.za. Please use your SU email address to simplify communication.

2. This Study Guide

This Study Guide contains important information about the course content, your tests, tutorials and practicals, administrative matters, and who you can contact if you experience problems or have queries. Please make sure that you know and understand the content.

The information in this document is complete and correct (as far as possible). However, we sometimes must make changes or add content. Any changes and any additional information will be announced on SUNLearn. **It is your responsibility to make sure that you regularly check the announcements and important dates on the Calendar in SUNLearn. You may not plead ignorance if announcements have been placed.** If you are in doubt about anything in this document, you are welcome to contact: Mrs Carrin Nel, Administrative Official, Room 1093, Natural Sciences Building, acnel@sun.ac.za.

3. The aim and scope of this module

This module serves as a basis for later programmes in Biological Sciences and therefore includes a variety of topics that are relevant to or essential for a present-day study in any biological discipline. The following topics are covered:

- Plant physiology will cover the integration of plant form (plant anatomy and morphology) and function, photosynthesis; water relations; transport in plants; plant mineral nutrition; growth and development).
- The organization and functioning of the animal body. This includes processes such as movement, digestion, circulation, and respiration.
- The general principles of Biotechnology.

4. The outcomes of this module

The structure and functioning of plant and animal bodies are covered in theory and practice as well as an introduction to biotechnology. See the module outline for more detail about the outcomes of each submodule. During online or f2f practicals or tutorials, several of these organisms will be studied. **Completion of ALL assessments / practicals / activities / tutorials is COMPULSORY to achieve the outcomes of this module.**

5. How we assess this module

This module will follow a flexible assessment model (Figure 1). 'Form and Function of Plants' and 'Form and Function of Animals' each carries a weight of 30% of the final mark, and the Biotechnology sub-module carries a weight of 20% of the final mark. The compulsory practical component in the form of assignments, online tutorials / activities / quizzes also carry a weighting of 20% (Plants 8%, Animals 8%, Biotechnology 4%). **You need to complete ALL assessments to pass this module! Take note of the following subminimum required:**

- You need to obtain a **40% subminimum** in at least two of the three theory tests to pass this module.
- AND a **40% subminimum** for the **practical component**.

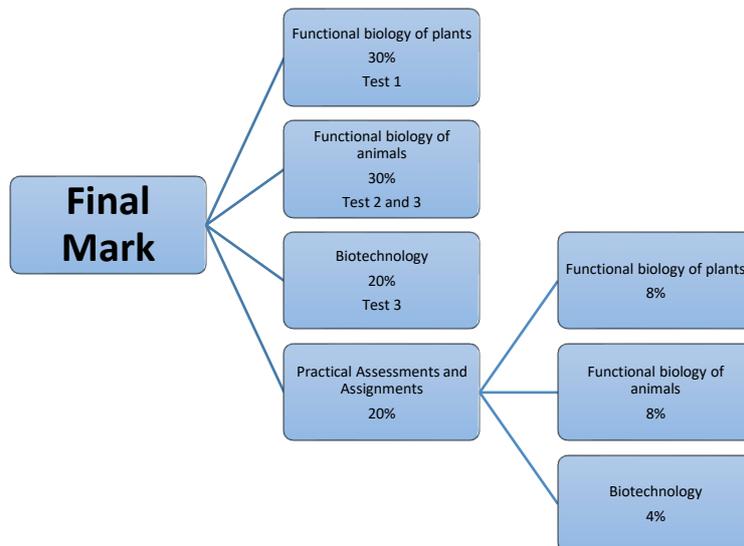


FIGURE 1: FINAL MARK CALCULATION

You pass the module if:

- Your final mark is 50% or more, AND
- You achieve a subminimum of 40% for at least two of your theory tests AND
- You achieve a 40% subminimum for the practical component.

Test dates:

- Test 1: Submodule 1 – Form and Function of Plants: 25 August 2022 at 17:30
- Test 2: Submodule 2 - Form and Function of Animals: 30 September 2022 at 17:30
- Test 3: Submodule 2 & 3 – Biotechnology: 28 October 2022 at 14:00
- Sick test in form of an online oral: 21 November 2022

No previous test or exam papers are available to anyone. No part of any assessment or test may be copied in any form.

6. The organisation and administration of this module

6.1 Prescribed textbook

Russell, Hertz, McMillan. Biology: The Dynamic Science (5thedition). Brooks/Cole Publishers. International Edition.

6.2. Module Coordinator, Sub-module Conveners and Administrative Officials

- Send all your module related queries to Mrs C Nel, the Administrative Official, acnel@sun.ac.za. More serious matters may be brought to the attention of Dr M Mouton, the Module Coordinator (marnel@sun.ac.za).
- Your sub-module related queries or questions should be asked on the Discussion Forum on SUNLearn. The appropriate lecturer or sub-module convener will answer your question on that platform.

6.3. Biology 154 sub-modules

The Biology 154 module consists of 3 sub-modules indicated in Table 1.

Table 1: Biology 154 sub-modules

Sub-module		Lectures	Department	Conveners
1	Form and function of plants	13	Botany and Zoology ➤ Natural Science Building ➤ 021 808 3236	Prof Nox Makunga Room 1089 Natural Science Building ➤ 021 808 3061 ➤ makunga@sun.ac.za
2	Form and function of animals	15		Prof Theresa Wossler Room 2015 Natural Science Building ➤ 021 808 3160 ➤ wossler@sun.ac.za
3	Biotechnology	9	Genetics ➤ JC Smuts Building ➤ 021 808 5839	Dr Paul Hills Room 1057 Natural Sciences Building ➤ 021 808 3066 ➤ phills@sun.ac.za

Table 2: Biology 154 Group Divisions for Lectures

	Periods	Lecture Hall
Group 1.1 Afrikaans Lectures	Mon - 10:00 Tue - 08:00 Fri - 11:00	Merensky 3002
Group 1.2 English Lectures	Mon - 10:00 Tue - 08:00 Fri - 11:00	Schumann Annex 1027
Group 2.1 Afrikaans Lectures	Mon - 12:00 Wed - 08:00 Fri - 09:00	A203 JC Smuts Building
Group 2.2 English Lectures	Mon - 12:00 Wed - 08:00 Fri - 09:00	MathScience 1005 Arts & Social Science Building 230 Arts & Social Science Building 230

6.4 Availability of lecturers

Academic questions on learning content should be raised during the f2f classes or on the Discussion Forum on SUNLearn. Lecturers will check this forum regularly and answer your question. For other queries and problems, you can contact Mrs Nel (acnel@sun.ac.za). All communication on the administration of assessments and due dates should be addressed to Mrs Nel.

6.5 Implementation of SU's Language Policy in this Module

In this module, we follow Option 1 of the Language Policy of the University of Stellenbosch. This means that you will be able to receive lectures, practicals/tutorials in English or Afrikaans (separate classes).

7. Practicals / Tutorials

We will communicate the dates and format of all practicals on SUNLearn. **All practicals and tutorials (quizzes) are compulsory! You can therefore not pass the module without completing these assessments.** Failure to complete / hand in practical assignments will result in an incomplete mark and you will have to repeat the module in 2023. This is an important rule and applies to all three Biology-modules! If you are **absent due to unforeseen circumstances** (e.g. illness), you must send a scanned copy of a verifying document (e.g. a valid medical certificate) within seven calendar days of the date of absence to the administrative Official (Mrs Carrin Nel, acnel@sun.ac.za). The General Regulations of the University will apply. Doubtful cases will be referred to the Registrar's Office for a decision. (See SU Calendar: General 22, Part 1, p. 31).

Table 3: Biology 154 Practical Schedule

WEEK	DATES	SUB-MODULE
1.	18/19/20/21 July	Form & Function of plants
2.	25/26/27/28 July	Form & Function of plants
3.	01/02/03/04 Aug	Form & Function of plants
4.	08/09/10/11 Aug	NO PRACTICALS
5.	15/16/17/18 Aug	Form & Function of plants
6.	22/23/24/25/Aug	Form & Function of animals
7.	29/30/31 Aug/01 Sept	Form & Function of animals
RECESS		
9.	12/13/14/15 Sept	How to write a scientific paper
3/	19/20/21/22 Sept	Writing of scientific paper in own time – no f2f practicals
11.	26/27/28/29 th Sept	Form & Function of animals online Quiz
12.	03/04/05/06 Oct	Biotechnology
13.	10/11/12/13 Oct	Biotechnology
14.	21/22/23/24 Oct	NO PRACTICALS

8. Lecture Content and Schedule

Table 4: Biology 154 Practical Schedule

WEEK	LECTURE	DATE AND TIME	MODULE
1	1	Mon 18 Jul (10:00 and 12:00)	Form/function of plants
	2	Tue 19 Jul (08:00) and Wed 20 Jul (08:00)	Form/function of plants
	3	Fri 22 Jul (09:00 and 11:00)	Form/function of plants
2	4	Mon 25 Jul (10:00 and 12:00)	Form/function of plants
	5	Tue 26 Jul (08:00) and Wed 27 Jul (08:00)	Form/function of plants
	6	Fri 29 Jul (09:00 and 11:00)	Form/function of plants
3	7	Mon 01 Aug (10:00 and 12:00)	Form/function of plants
	8	Tue 02 Aug (08:00) and Wed 03 Aug (08:00)	Form/function of plants
	9	Fri 05 Aug (09:00 and 11:00)	Form/function of plants
4	10	Mon 08 Aug (10:00 and 12:00)	Form/function of plants
		Tue 09 Aug (08:00) and Wed 10 Aug (08:00)	No lectures
	11	Fri 12 Aug (09:00 and 11:00)	Form/function of plants
5	12	Mon 15 Aug (10:00 and 12:00)	Form/function of plants
	13	Tue 16 Aug (08:00) and Wed 17 Aug (08:00)	Form/function of plants
	14	Fri 19 Aug (09:00 and 11:00)	Form/function of animals
6	15	Mon 22 Aug (10:00 and 12:00)	Form/function of animals
	16	Tue 23 Aug (08:00) and Wed 24 Aug (08:00)	Form/function of animals
	17	Fri 26 Aug (09:00 and 11:00)	Form/function of animals
7	18	Mon 29 Aug (10:00 and 12:00)	Form/function of animals
	19	Tue 30 Aug (08:00) and Wed 31 Aug (08:00)	Form/function of animals
	20	Fri 02 Sept (09:00 and 11:00)	Form/function of animals
RECESS			
8	21	Mon 12 Sept (10:00 and 12:00)	Form/function of animals
	22	Tue 13 Sept (08:00) and Wed 14 Sept (08:00)	Form/function of animals
	23	Fri 16 Sept (09:00 and 11:00)	Form/function of animals
09	24	Mon 19 Sept (10:00 and 12:00)	Form/function of animals
	25	Tue 20 Sept (08:00) and Wed 21 Sept (08:00)	Form/function of animals
	26	Fri 23 Sep (09:00 and 11:00)	Form/function of animals
10	27	Mon 26 Sep (10:00 and 12:00)	Form/function of animals
	28	Tue 27 Sept (08:00) & Wed 28 Sept (08:00)	Form/function of animals
	29	Fri 30 Sept (09:00 and 11:00)	No lectures
11	30	Mon 03 Oct (10:00 and 12:00)	Biotechnology
	31	Tue 04 Oct (08:00) and Wed 05 Oct (08:00)	Biotechnology
	32	Fri 07 Oct (09:00 and 11:00)	Biotechnology
12	33	Mon 10 Oct (10:00 and 12:00)	Biotechnology
	34	Tue 11 Oct (8:00) & Wed 12 Oct (08:00)	Biotechnology
	35	Fri 14 Oct (09:00 and 11:00)	Biotechnology
13	36	Mon 17 Oct (10:00 and 12:00)	Biotechnology
	37	Tue 18 Oct (08:00) & Wed 19 Oct (08:00)	Biotechnology
	38	Fri 21 Oct (09:00 and 11:00)	Biotechnology

9. Module Outline and Study Objectives for Biology 154 in 2022

9.1 Form and Function of Plants

Plant Physiology

The goal of this section of the module, is to gain an overview of how plants function, by integrating plant form and physiology for the following themes:

Plant anatomy and morphology; photosynthesis; water relations; transport in plants; plant mineral nutrition; responses to the environment.

The lectures & practicals will cover the following themes:

1. Plant Form

The Plant Body

2. Plant Energy Metabolism

Photosynthesis

3. Water Relations & Transport

Transport in plants

4. Mineral Nutrition

Plant nutrition

PLANT FORM AND FUNCTION: STUDY OBJECTIVES

Following your study of this module you should be able to:

1. Understand of how plant structure from the cell to the organ scale relates to whole plant function.
2. Master the plant tissue systems, the shoot system, the root system, apical and lateral meristems, secondary growth.
3. Understand of how plants capture and use light energy and CO₂ during the light and dark phases of photosynthesis.
4. Understand of how plants use photosynthetic products during respiration.
5. Understand of how plants move water, sugar and other solutes throughout their bodies via xylem and phloem tissues.
6. Understand the mineral requirements of plants and how plants obtain and absorb mineral nutrients from soils.

9.2 Form and Function of Animals

Please note that many topics covered in class are NOT occurring in the textbook.

THEME 1: HOMEOSTATIC CONTROL AND BODY HEAT

Lecture 1. 'Homeostasis' and 'The Animal in its Environment'

- i. What is homeostasis?
- ii. Exchange with and responding to the environment
- iii. Feedback loops

Lecture 2. 'Feedback Control'

- i. Negative endocrine feedback control: Blood sugar levels
- ii. Positive feedback control: Parturition
- iii. Negative neural feedback control: Temperature regulation in humans

Lecture 3. Thermoregulation strategies

- i. Physiological effects of temperature
- ii. Heat exchange with the environment
- iii. Metabolic rate and Energy budgets

Lecture 4. Thermoregulation in cold environments

- i. Ectothermy, Endothermy and Mesothermy
- ii. Countercurrent heat exchange in marine vertebrates
- iii. How do honeybees thermoregulate as a group? And moths as solitary insects?

Lecture 5. Endothermia in hot, dry climates

- i. Small mammal adaptations
- ii. The Oryx - keeping a cool head: the *rete mirabile*
- iii. How camels survive water shortages via osmoregulatory, thermoregulatory and behavioural means

THEME 2: NEURAL CONTROL AND MUSCLE CONTRACTION

Lecture 6. Control of skeletal muscle contraction

- i. Organisation of the Nervous System
- ii. The Reflex Arch
- iii. Information flow along neurons

Lecture 7. The 'Neuron' and 'Membrane potentials'

- i. Structure of a neuron
- ii. Resting membrane potentials
- iii. Graded/receptor membrane potentials

Lecture 8. How neurons work

- i. Action potentials
- ii. Amplitude and frequency coded signals
- iii. Nerve impulse propagation

Lecture 9. Neural communication

- i. Synaptic clefts and neurotransmitters
- ii. Neuromuscular junctions
- iii. Postsynaptic potentials

Lecture 10. Muscle structure and contraction

- i. Striated muscle structure
- ii. Microfilaments
- iii. Sliding filament theory and cross bridge cycling

THEME 3: CONTROL OF MUSCLES AND RESPIRATION

Lecture 11. Energy and muscle contraction

- i. ATP performs work
- ii. 'Twitch to Tetanus'
- iii. Regulation of skeletal muscle contraction (motor units)

Lecture 12. Lungs and gas exchange

- i. Relationship between cellular and physiological respiration
- ii. Gas exchange and gas laws
- iii. Ventilation and perfusion

Lecture 13. Oxygen delivery and Carbon Dioxide removal

- i. Oxygen transport and cooperativity
- ii. Oxygen dissociation curves
 - a) the Bohr effect

b) effect of temperature, altitude, pregnancy, etc.

iii. Carbon dioxide transport

Lecture 14. Respiratory efficiency in non-mammalian vertebrates?

i. Fish gills

ii. Reptile and amphibian lungs

iii. Bird lungs

Lecture 15. Living at high altitudes

i. What happens to the partial pressure of oxygen at high altitudes?

ii. Oxygen dissociation curves:

a) During acclimatisation

b) Having evolved at high altitudes

iii. Defying Everest!

ANIMAL FORM AND FUNCTION: STUDY OBJECTIVES

Following your study of this module you should be able to:

1. Understand the role of homeostasis in biological systems.
2. Compare positive and negative homeostatic feedback loops.
3. Understanding how organisms respond to their environments
4. Know what a hormone is and how it acts on cells
5. Explain the various strategies of thermoregulation.
6. Compare ectothermic and endothermic animals.
7. Understand energy budgets and metabolic rates.
8. Describe how counter current heat exchange operates in marine mammals.
9. Describe the structure of a neuron and neuron organisation.
10. Understand membrane properties of neurons.
11. Describe how an action potential is generated and how the nervous system conveys information.
12. Distinguish between amplitude and frequency coded signals.
13. Explain how an impulse travels from one neuron to another.
14. Understand the theory of "sliding filaments" and cross bridge cycling.
15. Describe the control of muscle contraction.
16. Understand energy metabolism during muscle contraction.
17. Compare isometric and isotonic contractions.
18. Compare how different respiratory organs function.
19. Understand the gas laws and the partial pressure of gases.

20. Describe how gaseous exchange takes place in the lungs and capillaries.
21. Compare the transport of oxygen and carbon dioxide.
22. Explain the role of haemoglobin in gas transport.
23. Interpret oxygen dissociation curves (of both myoglobin and haemoglobin).
24. Discuss the control of respiration.
25. Describe acclimatisation to high altitudes and how this differs to having evolved at high altitudes.
26. Discuss and understand the physiological, anatomical and behavioural adaptations to living in extreme habitats.
27. Conduct simple experiments, interpret and present the results.
28. Dissect and identify the structures within a vertebrate, the frog.

9.3 Biotechnology

BACKGROUND

Subjects in the 1st year biology courses should be (1) relevant to the course, the program structure and national/international priorities/trends and (2) offer students the opportunity to make a well informed choice in terms of the direction/program in which they would like to specialize. The relevance of biotechnology is obvious in all three areas as identified above. Although some of the basic aspects of biotechnology are addressed in BIOL 124 (Introductory cell biology) this is the only 1st year module where students are exposed to biotechnology by name and where aspects specific to biotechnology are touched on.

GENERAL

- 9 lectures / 2 practicals
- Principles
- Broad objectives include a better insight into and exposure to biotechnology.
- “Theme” and not “discipline” based.
- Ensure exposure to a single lecturer, but with inputs from and reference to other role players on campus, to ensure continuity.

MODULE OUTLINE

I. Lectures

1. Background

What is biotechnology? History, relevance / role in our world (modern agriculture, medicine etc.), different generations (including different rainbow colours which correlates to industries) of biotechnology and the current status of biotechnology.

2. Recombinant DNA technology 1

Central dogma, restriction enzymes and ligase, PCR, plasmid vectors, libraries

3. Recombinant DNA technology 2

DNA synthesis, artificial chromosomes, artificial life, antisense, RNAi, transgenesis, cisgenesis, CRISPR/Cas9

4. Microbial biotechnology

Exponential growth, pandemic, vaccine, herd immunity, gene shuffling, virus assembly, recombinant protein, synthetic biology

5. Plant Biotechnology 1

Plant industrial products, bioethanol and biodiesel, drugs

6. Plant biotechnology 2

GMO, callus, selectable markers, transgenic selection, GMO regulation

7. Animal Biotechnology 1

Clinical and pre-clinical trials, stage 1, 2 and 3 of drug discovery, declaration of Helsinki, vaccine development

8. Animal Biotechnology 2

Gene therapy, totipotency, pluripotency, multipotency, animal transgenics, cloning, pharming

9. Genomics

DNA sequencing, transcriptomics (microarrays, RNAseq), proteomics, metabolomics, pharmacogenomics

II. Practical/tutorial

1. Online metabolic modelling

2. Online DNA analysis

COURSE OBJECTIVES

After completing this module you should ...

1. Understand what biotechnology is, better understand the role that it plays in our society and appreciate its potential.
 2. Distinguish between 1st, 2nd and 3rd generation biotechnology and be aware of the present status of biotechnology.
 3. Realize how many products are obtained from plants/animals/microorganisms and how they can be improved.
 4. Understand how DNA/genes can be manipulated.
 5. Understand what is necessary to genetically manipulate organisms and know how it is done.
 6. Hopefully realise how EXCITING it is to PRACTICE biology!
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