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Quality Council for General and Further Education and Training

International Benchmarking of the South African National Senior Certificate (NSC) Subject Findings Appendix: Life Sciences

20th Anniversary

Two Decades of Education Guardianship
2002 - 2022

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Introduction

Overview of NSC Life Sciences

Life Sciences is an optional subject in the NSC which is described as "the scientific study of living things from molecular level to their interactions with one another and their environments".[1] In many other national and international programmes (including those compared in this report), the same field of study is captured under the label "Biology". This NSC subject is structured using four "knowledge strands": Life at the Molecular, Cellular and Tissue Level; Life Processes in Plants and Animals; Environmental Studies; and Diversity, Change and Continuity.[2] Across the three years of the NSC, these knowledge strands are revisited with additional detail or new sub-topics in each year.

Structure of Appendix

This subject comparison appendix addresses the relationship between NSC Life Sciences and subjects which fulfil similar roles in 5 alternative programmes. This appendix is structured to first demonstrate points of comparability and contrasts between the subjects (under the subheading Comparison) and then to synthesise this into Key Findings with a particular focus on skill development. This analysis examines all comparison subjects against NSC Life Sciences simultaneously, to enable stakeholders to see the range of similarities and differences across the international contexts in a single place. The analysis is based on the review of the NSC Life Science curriculum and assessment documentation for grades 10 to 12, and more specifically on the 2011 Curriculum and Assessment Policy Statement for Life Sciences, the 2017 Examination Guidelines and the 2020 Marking Guidelines for Life Sciences.

[1] National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Life Sciences*, p. 8.

[2] Ibid. p.9.

Comparison

Subjects in Context

In each of the comparison programmes analysed here there is an optional subject named Biology. In the IB DP, the Biology curriculum is offered at Standard level and Higher level. Cambridge International offers a Biology International AS Level over one year, an International AS Level in year one leading to an International A Level in year two, or an International A Level split over two years.

Entry Requirements, Duration, Mode of Study, Progression Routes

The table below summarises any formal entry requirements for each subject, expected prior learning, the duration of study within the programme, the mode of study, and any notable facts about progression routes which study of each subject enables either nationally or internationally.

Table 1: Comparison of subject-specific entry requirements, expected prior learning, duration of study and recommended progression routes

	Subject-Specific Entry Requirements	Expected Prior Learning	Duration of Study	Recommended Progression Routes
NSC Life Sciences[3]	For Grade 10: • An official Grade 9 school report which indicates that a learner has met the requirements for promotion to Grade 10 or; • a General Education and Training Certificate (GETC) for Adult Basic Education and Training (ABET); or • a NQF Level 1 Certificate which requires two languages; or • a recognised equivalent qualification obtained at NQF Level 1 which requires two official languages. • an official document of approval from the relevant Head of Education confirming that a learner who has received home education prior to Grade 10 has reached the required level in Grade 9. • For Grades 11 and 12: • For Entrance into Grades 11 and 12, an appropriate statement of achievement at the appropriate levels is issued by an approved or recognised assessment body.	It is assumed that students will have followed the National Curriculum in earlier years.	Three years, over Grades 10, 11 and 12 at 4 hours per school week.	The aims refer to "providing access to higher education" and to "provide a sufficient background for further studies in one or more of the biological sub-disciplines". Additionally, Specific Aim 3 'The Value and Application of Life Sciences Knowledge in the Industry in Respect of Career Opportunities and in Everyday Life', focuses on raising learners' awareness on the different career choices in the field of Life Sciences, including career opportunities in the fields of socio-biology and animal behaviour, plant pathology, game management, environmental impact studies, preservation of biodiversity, palaeontology, palaeoanthropology, agriculture, horticulture, environmental law, science journalism, biotechnology, genetic engineering, and many others.

[3] National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Life Sciences*, pp. 4, 7, 17, 18; Department of Basic Education, Republic of South Africa (2021), *National Policy Pertaining to the Programme and Promotion Requirements of the National Curriculum Statement. Grades R-12*, pp. 29-30.

	Subject-Specific Entry Requirements	Expected Prior Learning	Duration of Study	Recommended Progression Routes
IB DP Biology HL/SL[4]	Schools will engage with students' educational backgrounds on an individual basis	The syllabus states that standard level can be taken with no prior science learning, but higher level requires "some previous exposure to formal science education", which could be IB middle years or an equivalent qualification.	Two years comprised of 150 hours (Standard Level) or 240 hours (Higher Level).	None stated, but reference is made to the subject being designed to prepare students for university entry.
Cambridge International AS/A Level Biology[5]	Schools will engage with students' educational backgrounds on an individual basis.	Cambridge International recommends that students have previously followed their IGCSE or "O" level or an equivalent in Biology or co-ordinated science.	360 guided learning hours for the full A Level, usually taken over two years. 180 guided learning hours for AS, usually taken over one year.	The syllabus makes reference to Cambridge International A Levels being accepted by universities in the US, Europe, Australia, Canada and New Zealand. The subject specifically states that "Cambridge International A Level Biology provides a suitable foundation for the study of Biology or related subjects in higher education. It is equally suitable for candidates intending to pursue careers or further study in biological sciences, or as part of a course of general education. Cambridge International AS Level Biology is the first half of Cambridge International A Level Biology. Depending on local university entrance requirements, the qualification may permit or assist progression directly to university courses in Biology or some other subjects."

4 International Baccalaureate Diploma Programme (2016), *Biology Guide,* pp.3,2,15.

5 Cambridge International Examinations (2016), *International AS and A Level Syllabus: Cambridge International AS and A Level Biology 9700*, pp. 5-6.

	Subject-Specific Entry Requirements	Expected Prior Learning	Duration of Study	Recommended Progression Routes
KCSE Biology[6]	None stated.	Candidates must be holders of the KCPE Certificate or its equivalent. Prospective candidates with foreign certificates must seek equation of the foreign certificates before being admitted into the Kenyan schools.	4 years	Students who scored an aggregate of C+ grade and above will be selected for the degree placement procedure, in both private and public universities, and their degree will be sponsored by the government.
ZIMSEC Forms 5-6 Biology[7]	"The syllabus assumes that learners: • have studied and passed Sciences and Mathematics at form 4 • can use appropriate apparatus to perform a given task • have developed an awareness and interest in the importance of conservation of the environment • can integrate concepts and skills learnt from other learning areas in the learning of Biology • have knowledge on use of ICT tools".	From the previous column, it is inferred that students will have studied Mathematics and Sciences up to and including form 4 of the Zimbabwean system.	A minimum of 12 teaching periods of at least 35 minutes each per week, over two school years.	Not stated.
NSW HSC Biology[8]	None, but expected to build on Stage 5 study.	None stated, but expected to build on Stage 5 study.	240 hours over 2 school years.	Awarding body documentation claims that: "The course provides the foundation knowledge and skills required to study Biology after completing school, and supports participation in a range of careers in biology and related interdisciplinary industries".

6 The Kenya National Examinations Council (2014), Kenya Certificate of Secondary Education (KCSE): *Examinations Regulations and Syllabuses.*

7 Zimbabwe Ministry of Primary and Secondary Education (2015), *Biology Syllabus Forms 5-6*, p. 1.

8 New South Wales Education Standards Authority (2017), *Biology Stage 6 syllabus*, p. 11. Available from: https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-science/biology-2017z

Although these programmes generally do not have subject-specific entry requirements for these Biology curricula, there is broadly an expectation that students will have at least passed a directly previous year of schooling and will have come across scientific approaches in some form. The NSC does not precisely list prior learning expectations in the way that the Zimbabwean qualification does, but the anticipation that students have followed the national curriculum up to Grade 10 and that they have acquired a Grade 9 school report which indicates that they have met the requirements for promotion to Grade 10 has implicit prior learning expectations built in.

Like the majority of other curricula analysed here, the NSC subject articulates the hope that students will be prepared to pursue a biology-related field of study in tertiary education as a result of completing this Life Sciences subject.

Regarding the duration of study, each of these programmes has slightly different structures; some are single-subject qualifications taken over two years, whereas other are diploma-style awards taken across two (IB and NSW HSC), three (NSC), or four (KCSE) years. The exact number of recommended learning hours does therefore vary, but are comparable in their expectation of full-time study being the typical mode.

Subject Aims

The following table lists the stated aims of each subject according to each programme's documentation. Where curriculum documentation does not explicitly articulate aims with, for example, a subheading titled "Aims", Ecctis have selected passages or extracts which most closely resemble a brief overview of the subject's purpose. This is intended to enable comparison between the different curricula as effectively as possible. Where something not labelled "aims" has been used to stand-in for curriculum aims, this is explained in the descriptive analysis underneath the table.

Table 2: Comparison of subject aims

	Subject Aims

NSC Life Sciences[9]	**The Purpose of Studying Life Sciences:**
	• The development of Scientific Knowledge and Understanding
	• The development of Science Process Skills (Scientific Investigations)
	• The development of an Understanding of Science's Roles in society
	Specific Aims:
	• **Specific Aim 1: Knowing Life Sciences (Life Sciences concepts, processes, phenomena, mechanisms, principles, theories, laws, models, etcetera).**
	  • **Acquire Knowledge** (access information form a variety of sources, select key ideas, recall facts, describe concepts, processes, phenomena, mechanisms, principles, theories etc. in Life Sciences)
	  • **Understand and Make Connections Between Ideas and Concepts to Make Meaning of Life Sciences** (build a conceptual framework of science ideas; organise or reorganise knowledge to derive new meaning; write summaries; develop flow charts, diagrams and mind maps; and recognise patterns and trends)
	  • **Apply Knowledge on Life Sciences in New and Unfamiliar Contexts** (use information in a new way; and apply knowledge to new and unfamiliar contexts)
	  • **Analyse, Evaluate and Synthesise Scientific Knowledge, Concepts and Ideas** (analyse information/data; recognise relationships between existing knowledge and new ideas; critically evaluate scientific information; identify assumptions; and categorise information).

[9] National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Life Sciences*, pp. 8,9,12-17.

	Subject Aims

	• **Specific Aim 2: Investigating Phenomena in Life Sciences**
	  • Follow Instructions
	  • Handle Equipment or Apparatus
	  • Make Observations
	  • Record Information or Data
	  • Measure
	  • Interpret
	  • Design/Plan Investigations or Experiments
	• **Specific Aim 3: Appreciating and Understanding the History, Importance and Applications of Life Sciences in Society**
	  • Understanding the History and Relevance of Some Scientific Discoveries
	  • The Relationship Between Indigenous knowledge and Life Sciences
	  • The Value and Application of Life Sciences Knowledge in the Industry in Respect of Career Opportunities and in Everyday Life.
	By studying and learning about Life Sciences, learners will develop:
	• their knowledge of key biological concepts, processes, systems and theories
	• an ability to critically evaluate and debate scientific issues and processes
	• greater awareness of the ways in which biotechnology and knowledge of Life Sciences have benefited humankind
	• an understanding of the ways in which humans have impacted negatively on the environment and organisms living in it
	• a deep appreciation of the unique diversity of past and present biomes in Southern Africa and the importance of conservation
	• an awareness of what it means to be a responsible citizen in terms of the environment and life-style choices that they make
	• an awareness of South African scientists' contributions
	• scientific skills and ways of thinking scientifically that enable them to see the flaws in pseudo-science in popular media
	• a level of academic and scientific literacy that enables them to read, talk about, write and think about biological processes, concepts and investigations.
	and:
	• to provide useful knowledge and skills that are needed in everyday life
	• to expose learners to the scope of biological studies to stimulate interest in and create awareness of possible specialisations
	• to provide a sufficient background for further studies in one or more of the biological sub-disciplines.

IB DP Biology[10]	• appreciate scientific study and creativity within a global context through stimulating and challenging opportunities • acquire a body of knowledge, methods and techniques that characterize science and technology • apply and use a body of knowledge, methods and techniques that characterize science and technology • develop an ability to analyse, evaluate and synthesize scientific information • develop a critical awareness of the need for, and the value of, effective collaboration and communication during scientific activities • develop experimental and investigative scientific skills including the use of current technologies

[10] International Baccalaureate Diploma Programme (2016), *Biology Guide*, pp. 18.

	Subject Aims
	• develop and apply 21st century communication skills in the study of science • become critically aware, as global citizens, of the ethical implications of using science and technology • develop an appreciation of the possibilities and limitations of science and technology • develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge.

Cambridge International AS/A Level Biology[11]	• provide, through well-designed studies of experimental and practical biological science, a worthwhile educational experience for all learners, whether or not they go on to study science beyond this level. In particular, it should enable them to:
	  • become confident citizens in a technological world, with an informed interest in scientific matters
	  • recognise the usefulness, and limitations, of scientific method and its application in other subjects and in everyday life
	  • be suitably prepared for studies in biological science beyond Cambridge International A Level, in further or higher education, and for professional courses.
	• develop abilities and skills that:
	  • are relevant to the study and practice of biological science
	  • are useful in everyday life
	  • encourage efficient and safe practice
	  • encourage effective communication using universal scientific conventions.
	• develop attitudes relevant to biological science such as:
	  • a concern for accuracy and precision
	  • objectivity
	  • integrity
	  • a spirit of enquiry
	  • initiative
	  • inventiveness.
	• stimulate interest in, and care for, the local and global environment and help learners to understand the need for conservation.
	• promote an awareness that:
	  • scientific theories and methods have developed, and continue to develop, as a result of groups and individuals working together, and that biological science overcomes national boundaries
	  • the study and practice of biology are affected and limited by social, economic, technological, ethical and cultural factors
	  • the applications of biological science may be both helpful and harmful to the individual, the community and the environment.
	  • The use of information technology is important for communication, as an aid to experiments and as a tool for interpreting experimental and theoretical results.
	• stimulate learners and create a sustained interest in biology so that the study of the subject is enjoyable and satisfying.

[11] Cambridge International Examinations (2016), *International AS and A Level Syllabus: Cambridge International AS and A Level Biology 9700*, p.11.

	Subject Aims
KCSE Biology[12]	• communicate biological information in a precise, clear and logical manner • develop an understanding of interrelationships between plants and animals and between humans and their environment • apply the knowledge gained to improve and maintain the health of the individual, family and the community • relate and apply relevant biological knowledge and understanding to social and economic situations in rural and urban settings • observe and identify features of familiar and unfamiliar organisms, record the observations and make deductions about the functions of parts of organisms • develop positive attitudes and interest towards biology and the relevant practical skills • demonstrate resourcefulness, relevant technical skills and scientific thinking necessary for economic development • design and carry out experiments and projects that will enable them to understand biological concepts • create awareness of the value of cooperation in solving problems • acquire a firm foundation of relevant knowledge, skills and attitudes for further education and for training in related scientific field.
ZIMSEC Forms 5-6 Biology[13]	• develop abilities and skills that enable learners solve day to day challenges and become self-reliant • provide the basis for further studies in Biological Sciences and other related professional and vocational courses • develop attitudes of concern for accuracy and precision, innovativeness, objectivity and integrity in the study of Biology • develop enterprising skills that lead to value addition of natural resources • develop an awareness of the diversity of life, global environmental issues and understand the need for conservation and its relevance to society • promote an awareness of the use of Information Technology (IT) for communication as an aid to biological research • develop an appreciation of health issues in a global context.
NSW HSC Biology[14]	To develop an appreciation and understanding of biological concepts that are used to explore the diversity of life, from a molecular to a biological systems level, and the interactions between living things and the environments in which they live. Through applying Working Scientifically skills processes and the use of biological technologies, the course aims to examine how biological practices are developed and used. The *Biology Stage 6 Syllabus* explores the diversity of life from a molecular to a biological systems level. The course examines the interactions between living things and the environments in which they live. It explores the application of biology and its significance in finding solutions to health and sustainability issues in a changing world. Biology uses Working Scientifically processes to develop scientific investigative skills. It focuses on developing problem-solving and critical thinking skills in order to understand and support the natural environment.

[12] The Kenya National Examinations Council (2014), *Kenya Certificate of Secondary Education (KCSE): Examinations Regulations and Syllabuses*, p. 106.

[13] Zimbabwe Ministry of Primary and Secondary Education (2015), *Biology Syllabus Forms 5-6*, p.1.

[14] New South Wales Education Standards Authority (2017), *Biology Stage 6 syllabus*, pp. 10, 12. Available from:https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-science/biology-2017

The content of this table was drawn from:

- NSC curriculum aims were drawn from the "specific aims", "the purposes of studying Life Science" and "what is Life Science" subsections of the subject curriculum guide.
- IB DP curriculum aims were drawn from the "aims" subsection of the subject curriculum guide.
- Cambridge International AS/A Level curriculum aims were drawn from the "aims" subsection of the subject curriculum guide.
- KCSE aims were drawn from the "General Objectives" bullet point list in the curriculum guide, as there is no specific "aims" or "purpose" subsections.
- Zimbabwe Forms 5-6 aims were drawn from the "aims" subsection of the subject curriculum guide.
- NSW curriculum aims were drawn from the "Rationale" and "Aim" subsections of the subject curriculum guide.

There are broadly similar themes running through the aims of each of these six curricula. However, the NSC statement includes two aims that are unique. The first of these is to recognise the contributions to biology made by South African scientists. As a South African qualification, this focus should provide strong relevance for students. The second of these unique aims is to recognise the flaws in the pseudo-science of popular media. This aim is part of a broader critical thinking approach where students learn to question facts and figures and how they are presented. Critical thinking is included either explicitly or implicitly in the aims of other comparison points here, but the specific framing around recognising pseudo-science in popular media is unique to the NSC.

All of these statements of aims include the concept of understanding, rather than just knowledge, and also some references to higher order thinking skills. This is evidenced by the use of phrases like "critically evaluate", "thinking scientifically", and "critical and creative thinking" in the NSC aims.[15] Such higher order skills are emphasised in all these statements of aims, though to a lesser extent in the KCSE and ZIMSEC.

One of the purposes of the NSC Life Sciences focuses on the development of Science Process Skills (Scientific Investigations) and more specifically it is stated that "Learners develop the ability to think objectively and use different types of reasoning while they use process skills to investigate, reflect, synthesise and communicate".[16] Additionally, the Specific Aim 2 of the NSC Life Sciences focuses on developing learners' ability to plan and carry out investigations as well as solve problems that require some practical ability.[17] As a result, it is evident that NSC Life Sciences is making explicit references to investigation and practical work.

Additionally, it is evident from the review that the NSC Life Sciences curriculum makes mention of career opportunities under Specific Aim 3 "The Value and Application of Life Sciences Knowledge in the Industry in Respect of Career Opportunities and in Everyday Life", which focuses on raising learners' awareness on the different career choices in the field of Life Sciences, including career opportunities in the fields of socio-biology and animal behaviour, plant pathology, game management, environmental impact studies, preservation of biodiversity, palaeontology, palaeoanthropology, agriculture, horticulture, environmental law, science journalism, biotechnology, genetic engineering, and many others.[18]

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15 National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Life Sciences*, pp. 5, 8, 14.

16 Ibid., p.12.

17 Ibid., p.15.

18 National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Life Sciences*, pp. 17-18.

Learning Outcomes

The following table lists the learning outcomes named in each programme's subject documentation. Where curriculum documentation does not explicitly articulate learning outcomes with, for example, a subheading titled "Learning Outcomes", Ecctis have selected lists or extracts which most closely resemble the expected knowledge, skills and competencies that students should have on completion of a programme of study. This is intended to enable comparison between the different curricula as effectively as possible. Where something not labelled "Learning Outcomes" has been used to stand-in for learning outcomes, this is explained in the descriptive analysis underneath the table.

Table 3: Comparison of learning outcomes

	Learning Outcomes

NSC Life Sciences[19]	**The Purpose of Studying Life Sciences:**
	• The development of Scientific Knowledge and Understanding
	• The development of Science Process Skills (Scientific Investigations)
	• The development of an Understanding of Science's Roles in society
	Specific Aims:
	• **Specific Aim 1: Knowing Life Sciences (Life Sciences concepts, processes, phenomena, mechanisms, principles, theories, laws, models, etcetera).**
	  • **Acquire Knowledge** (access information form a variety of sources, select key ideas, recall facts, describe concepts, processes, phenomena, mechanisms, principles, theories etc. in Life Sciences)
	  • **Understand and Make Connections Between Ideas and Concepts to Make Meaning of Life Sciences** (build a conceptual framework of science ideas; organise or reorganise knowledge to derive new meaning; write summaries; develop flow charts, diagrams and mind maps; and recognise patterns and trends)
	  • **Apply Knowledge on Life Sciences in New and Unfamiliar Context**s (use information in a new way; and apply knowledge to new and unfamiliar contexts)
	  • **Analyse, Evaluate and Synthesise Scientific Knowledge, Concepts and Ideas** (analyse information/data; recognise relationships between existing knowledge and new ideas; critically evaluate scientific information; identify assumptions; and categorise information).
	• **Specific Aim 2: Investigating Phenomena in Life Sciences**
	  • Follow Instructions
	  • Handle Equipment or Apparatus
	  • Make Observations
	  • Record Information or Data
	  • Measure
	  • Interpret
	  • Design/Plan Investigations or Experiments
	• **Specific Aim 3: Appreciating and Understanding the History, Importance and and Applications of Life Sciences in Society**
	  • Understanding the History and Relevance of Some Scientific Discoveries
	  • The Relationship Between Indigenous knowledge and Life Sciences
	  • The Value and Application of Life Sciences Knowledge in the Industry in Respect of Career Opportunities and in Everyday Life.

[19] Ibid., pp.12-17.

	Learning Outcomes
	By studying and learning about Life Sciences, learners will develop: • their knowledge of key biological concepts, processes, systems and theories • an ability to critically evaluate and debate scientific issues and processes • greater awareness of the ways in which biotechnology and knowledge of Life Sciences have benefited humankind • an understanding of the ways in which humans have impacted negatively on the environment and organisms living in it • a deep appreciation of the unique diversity of past and present biomes in Southern Africa and the importance of conservation • an awareness of what it means to be a responsible citizen in terms of the environment and life-style choices that they make • an awareness of South African scientists' contributions • scientific skills and ways of thinking scientifically that enable them to see the flaws in pseudo-science in popular media • a level of academic and scientific literacy that enables them to read, talk about, write and think about biological processes, concepts and investigations. and: • to provide useful knowledge and skills that are needed in everyday life • to expose learners to the scope of biological studies to stimulate interest in and create awareness of possible specialisations • to provide a sufficient background for further studies in one or more of the biological sub-disciplines.

IB DP Biology[20]	• Demonstrate knowledge and understanding of:
	  • facts, concepts and terminology
	  • methodologies and techniques
	  • communicating scientific information.
	• Apply:
	  • facts, concepts and terminology
	  • methodologies and techniques
	  • methods of communicating scientific information.
	• Formulate, analyse and evaluate:
	  • hypotheses, research questions and predictions
	  • methodologies and techniques
	  • primary and secondary data
	  • scientific explanations.
	• Demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations.

Cambridge International AS/A Level Biology[21]	**AO1 Knowledge with understanding** Candidates should be able to demonstrate knowledge and understanding of: • scientific phenomena, facts, laws, definitions, concepts and theories • scientific vocabulary, terminology and conventions (including symbols, quantities and units) • scientific instruments and apparatus used in biology, including techniques of operation and aspects of safety • scientific quantities and their determination • scientific and technological applications, with their social, economic and environmental implications.

[20] International Baccalaureate Diploma Programme (2016), *Biology Guide*, p.19.

[21] Cambridge International Examinations (2016), *International AS and A Level 2016: Syllabus: Cambridge International AS and A Level Biology 9700*, pp.12-13.

	Learning Outcomes
	The subject content defines the factual knowledge that candidates may be required to recall and explain. Questions testing these assessment objectives will often begin with one of the following words: define, state, name, describe, explain (using your knowledge and understanding) or outline. **AO2 Handling information and solving problems** Candidates should be able to handle information and solve problems using written, symbolic, graphical and numerical forms of presentation to: • locate, select, organise and present information from a variety of sources • translate information from one form to another • manipulate numerical and other data • use information to identify patterns, report trends and draw conclusions • give reasoned explanations for phenomena, patterns and relationships • make predictions and hypotheses • apply knowledge, including principles, to new situations • demonstrate an awareness of the limitations of biological theories and models • solve problems. **AO3 Experimental skills and investigations** Candidates should be able to: • plan experiments and investigations • collect, record and present observations, measurements and estimates • analyse and interpret data to reach conclusions • evaluate methods and quality of data and suggest possible improvements.
KCSE Biology[22]	• communicate biological information in a precise, clear and logical manner • develop an understanding of interrelationships between plants and animals and between humans and their environment • apply the knowledge gained to improve and maintain the health of the individual, family and the community • relate and apply relevant biological knowledge and understanding to social and economic situations in rural and urban settings • observe and identify features of familiar and unfamiliar organisms, record the observations and make deductions about the functions of parts of organisms • develop positive attitudes and interest towards biology and the relevant practical skills • demonstrate resourcefulness, relevant technical skills and scientific thinking necessary for economic development • design and carry out experiments and projects that will enable them to understand biological concepts • create awareness of the value of cooperation in solving problems • acquire a firm foundation of relevant knowledge, skills and attitudes for further education and for training in related scientific field.

[22] The Kenya National Examinations Council (2014), *Kenya Certificate of Secondary Education (KCSE): Examinations Regulations and Syllabuses*, p. 106.

	Learning Outcomes
ZIMSEC Forms 5-6 Biology[23]	• apply biological knowledge to solve day-to-day challenges • use scientific research methods and techniques for self-reliance • demonstrate an understanding of biological knowledge and concepts in novel situations • measure with accuracy and precision • manipulate numerical and other forms of data • design practical experiments and projects to solve problems • suggest ways of sustainable use of natural resources for socio economic development • explain the importance of conserving biodiversity and the environment • use appropriate ICT tools to solve scientific problems • demonstrate an understanding of global distribution of diseases.
NSW HSC Biology[24]	Students develop skills in applying the processes of Working Scientifically. Students develop knowledge and understanding of • the structure and function of organisms • the Earth's biodiversity and the effect of evolution. • heredity and genetic technologies • disease and disorders. Students develop values and attitudes to: • have positive and informed values and attitudes towards biology • recognise the importance and relevance of biology in their lives • recognise the influence of economic, political and societal impacts on the development of scientific knowledge • develop an appreciation of the influence of imagination and creativity in scientific research.

Where learning outcomes were drawn from:

- NSC curriculum learning outcomes were drawn from the "specific aims", "the purposes of studying Life Science" and "what is Life Science" subsections of the subject curriculum guide.
- IB DP curriculum learning outcomes were drawn from the "assessment objectives" subsection of the subject curriculum guide.
- Cambridge International AS/A Level curriculum learning outcomes were drawn from the "assessment objectives" subsection of the subject curriculum guide.
- KCSE learning outcomes were drawn from the "General Objectives" bullet point list in the curriculum guide, as there is no specific "learning outcomes" subsections.
- Zimbabwe Forms 5-6 learning outcomes were drawn from the "syllabus objectives" subsections of the subject curriculum guide.
- NSW HSC curriculum learning outcomes were drawn from "Objectives" subsections of the subject curriculum guide.

The NSC statements above are unique in drawing attention to their home country, not just with the role of South African scientists, but also in the study and conservation of the ecology of the home country. This will give the curriculum relevance to students, though may result in a lower emphasis on other types of ecosystems in other parts of the world and to the issues facing those.

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[23] Zimbabwe Ministry of Primary and Secondary Education (2015), *Biology Syllabus Forms 5-6*, p. 2.

[24] New South Wales Education Standards Authority (2017), *Biology Stage 6 syllabus*, p. 13. Available from: https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-science/biology-2017

In details extracted from this table it is evident that the IB, the NSC, Cambridge International, the KCSE and the ZIMSEC make explicit mention of designing or carrying out investigative scientific work. This is evident in the IB documentation which states that students should "demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations", and in the Cambridge International AO3 which outlines that "candidates should be able to plan experiments and investigations". Additionally, the focus on investigative scientific work is evident in the KCSE documentation which outlines that students should be able to "design and carry out experiments and projects that will enable them to understand biological concepts", as well as in the ZIMSEC which focuses on developing students' ability to "design practical experiments and projects to solve problems". The development of investigative scientific work is explicitly outlined in the Specific Aim 2 of the NSC Life Science curriculum documentation, focusing on supporting students to "investigate phenomena in Life Sciences".[25] Additionally, although these skills are not evident in the NSW HSC systems learning outcomes, the course structure and requirements, and the working scientifically and depth studies sections of the curriculum documentation for years 11 and 12 explicitly state the development of skills in planning and conducting both practical investigations which involve the collection of primary data as well as secondary-sourced investigations.[26]

Some of the sets of statements in the table above make explicit reference to the economic importance of biology. For example, the Cambridge International learning outcomes focus on the demonstration of students' "scientific and technological applications, with their social, economic and environmental implications" and the KCSE learning outcomes focus on the ability of students to "relate and apply relevant biological knowledge and understanding to social and economic situations in rural and urban settings". Additionally, this is evident in the ZIMSEC learning outcome focusing on students' ability to "suggest ways of sustainable use of natural resources for socio economic development" and in the NSW HSC systems learning outcome on developing students' values to "recognise the influence of economic, political and societal impacts on the development of scientific knowledge". Although the economic benefits of biology are not explicitly mentioned in the learning outcomes of NSC Life Sciences, in the 2011 CAPS Life Sciences learning outcomes the learner's ability to develop a "greater awareness of the ways in which biotechnology and knowledge of Life Sciences have benefited humankind" implicitly indicates a focus on the economic importance of biology.[27] In addition, although the economic benefits of Biology are not mentioned in the IB learning outcomes, the syllabus content includes some explicit references of the economic benefits of Biology such as in the topic Cell Biology and more specifically in the sub-topic area ultrastructure of cells, one aim is to develop students understanding on the "developments in science, such as electron microscopy, that can have economic benefits as they give commercial companies opportunities to make profits, but this can affect cooperation between scientists".[28]

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25 National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Life Sciences*, p.13.

26 New South Wales Education Standards Authority (2017), *Biology Stage 6 syllabus*, pp.21-26. Available from: https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-science/biology-2017.

27 National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Life Sciences*, p. 8.

28 International Baccalaureate Diploma Programme (2016), *Biology Guide*, p.31.

Content Areas

The following table summarises the different top-level content areas included within each of the comparison subjects. For ease of comparison, content areas have been grouped by Ecctis. The groups in the table below are labels assigned by Ecctis according to analysis of subject documentation and they do not necessarily reflect the groupings or labels used in the subject documentation for each programme. For the full details of subject content in each programme – listed in the order provided by each programme's documentation.

Table 4: Comparison of content areas

	Life at the molecular, cellular and tissue level	Life processes in plants and animals	Environmental studies	Diversity, change and continuity
NSC Life Sciences[29]	Chemistry of life - Inorganic compounds - Organic compounds Cell- unit of life Cell division (mitosis) Plant and animal tissues DNA code of Life RNA and protein synthesis Meiosis.	Support and transport in plants Support in animals Transport system in mammals Energy transformations to support life: photosynthesis Animal nutrition Energy transformations: respiration Gas exchange Excretion Reproduction in Vertebrates Human reproduction Nervous system Senses Endocrine system Homeostasis	Biosphere and ecosystems Population ecology Human impacts on environment (including current crises) Human impact on environment: current crises Grade 11	Biodiversity and classification History of life on Earth Biodiversity - classification of microorganisms Biodiversity - plants Reproduction - plants Biodiversity – animals Darwinism and Natural Selection Human evolution
IB DP Biology§[30]	Cell biology Molecular biology Biotechnology and bioinformatics* **Nucleic Acids** **Metabolism, cell respiration and photosynthesis**	Human and animal physiology Metabolism Respiration Photosynthesis **Plant biology** Neurology and behaviour* Human physiology* **Animal Physiology**	Ecology Ecology and conservation*	Genetics Evolution and biodiversity **Genetics and Evolution**

[29] National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Life Sciences*.

[30] International Baccalaureate Diploma Programme (2016), *Biology Guide*.

	Life at the molecular, cellular and tissue level	Life processes in plants and animals	Environmental studies	Diversity, change and continuity
Cambridge International AS/A Level Biology§[31]	Cells and microscopy Biological molecules Enzymes Transport across membranes Mitosis, DNA RNA and protein synthesis.	Transport in plants Transport in mammals Gas exchange Respiration Photosynthesis Homeostasis in plants and animals, Control and coordination in plants and in animals	Conservation	Inheritance Genes Alleles Operons Variation Natural and artificial selection Evolution Biodiversity Classification Genetic technology in medicine and agriculture
KCSE Biology[32]	Cell structure Microscopy Transport across membranes	Animal and plant nutrition Digestion and photosynthesis Transport and animals and plants Gas exchange Excretion and homeostasis The endocrine and nervous systems Support and movement in animals and plants Reproduction in plants and animals Sexual and asexual reproduction Growth and development	Ecology Sampling Energy and nutrient flow	Observation of organisms and classification Evolution Lamarck Natural selection antibiotic resistance Mendelian inheritance and sex-linkage

31 Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Biology 9700.*

32 The Kenya National Examinations Council (2014), *Kenya Certificate of Secondary Education (KCSE): Examinations Regulations and Syllabuses.*

	Life at the molecular, cellular and tissue level	Life processes in plants and animals	Environmental studies	Diversity, change and continuity
ZIMSEC Forms 5-6 Biology[33]	Cell structure and function Biological molecules and water Cell and nuclear division.	Energetics Transport systems Nervous control Sexual reproduction	Ecology	Genetic control Gene technology Inherited change and evolution Biodiversity
NSW HSC Biology[34]	Cell ultrastructure Transport across membranes Mode of action of enzymes Cell organisation: tissues and organs Microscopy Roles of DNA and RNA in protein synthesis.	Photosynthesis Digestion Nutrition and excretion Gas exchange Mass transport in plants and animals Homeostasis and disorders of this Sexual and asexual reproduction Pregnancy and birth control	Biodiversity and the effect of environment on organisms Ecosystem dynamics Past and future ecosystems	Heredity Genetic variation Meiosis and genetic crosses Mutations and new alleles Biotechnology

The differences at sub-topic level are not represented in the table, only top-level topics are shown.

* These four content areas are options within the IB curriculum, from which students choose one.

§ Cambridge International: topics in bold are included in the full A Level only. AS includes only those topics not bold.

§ IB DP: topics in bold are included in the Higher Level (HL) award only. SL includes only those topics not bold.

[33] Zimbabwe Ministry of Primary and Secondary Education. (2015), *Biology Syllabus Forms 5-6*.

[34] New South Wales Education Standards Authority (2017), *Biology Stage 6 syllabus*. Available from: https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-science/biology-2017

All the basic topic areas of modern biology are covered in all six curricula. The differences occur in the detail of the content of these topics between the programmes and in the level of detail and expected duration of each topic. For example, the NSC curriculum (like NSW HSC and KCSE) covers cellular respiration in overview form only, not going into biochemical detail. However, the Cambridge International, the IB and ZIMSEC systems each specify that respiration is covered in considerable biochemical detail. On the other hand, the NSC system covers many more aspects of ecology and evolution than the Cambridge International award. With respect to duration, the NSC syllabus recommends 20 hours contact time devoted to the history of life on Earth, whereas this topic does not appear in Cambridge International or IB DP. Such variations are generally of emphasis and methods of grouping content; there are not significant differences in the content taught across all six curricula.

The aims and learning outcomes of NSC Life Sciences focus on equipping learners with the necessary knowledge about the contributions of South African scientists. However, in terms of the content areas, the NSC Life Sciences document includes content not only in relation to South African scientists, South African ecosystems and indigenous medicines and healing, but also the work of scientists in other parts of the world.[35] As a result, it is evident that although the NSC Life Sciences curriculum documentation focuses and prioritises content areas on the contributions of South African scientists, the subject content also includes references to the work of scientists in other parts of the world e.g. Carl Linnaeus.3[6]

Additionally, the top-level topic of "reproduction" does not appear in the Cambridge international AS/A Level Biology and the IB DP Biology, but it appears in the NSC Life Sciences (Reproduction in Vertebrates; Human reproduction; Reproduction – plants) but also in the KCSE Biology, ZIMSEC Forms 5-6 Biology and NSW HSC Biology. However, at the sub-topic level, it is evident that the IB DP Biology includes sub-topic areas focusing on reproduction, including the sub-topic areas of "Hormones, homeostasis and reproduction", "Reproduction in plants", and "Sexual Reproduction". Similarly, at the sub-topic level, it is evident that the Cambridge international AS/A Level Biology, the sub-topic areas focus on the element of reproduction, including reproduction in plants and sexual reproduction.[37]

It is evident that the NSC Life Science content areas explicitly outline the development of practical, investigation and experimentation skills through the different content areas. For example, in Grade 10 (Term 2; Strand 2: Life Processes in Plants and Animals) in the topic area "Support and Transport Systems in Plants" where students are required to "design an investigation to discover the effect of temperature, light intensity or humidity on transpiration rate (using a simple potometer). Identify variables and control variables".[38] Another example of explicit reference to the development of students' practical, investigation and experimentation skills is evident in Grade 11 (Term 2; Strand 2: Life Processes in Plants and Animals) in the topic area "Energy Transformation to Sustain Life" where students are required to "design and investigation or demonstration to show that: oxygen is used by living organisms during respiration, carbon dioxide is produced by living organisms during respiration or provide relevant data that can be interpreted by learners. Identify variables, suggest controls

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35 National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Life Sciences*, p.63.

36 Ibid., p.35.

37 International Baccalaureate Diploma Programme (2016), *Biology Guide*.

38 National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Life Sciences,* p. 29.

for variables and record observations".[39] In addition, another example of explicit reference to the development of students' practical, investigation and experimentation skills is evident in Grade 12 (Term 3; Strand 2: Life Processes in Plants and Animals) in the content area of "Responding to the Environment: Plants" where students are required to "design investigations to show geotropism and phototropism. Identify the variables and recommend ways to control the variables and record and interpret the results".[40]

Assessment Objectives

The table below provides a list of the subject-specific assessment objectives for each subject.

Where curriculum documentation does not explicitly articulate assessment objectives with, for example, a subheading titled "Assessment Objectives", Ecctis have selected lists or extracts which most closely resemble the knowledge, skills and competencies that students are assessed on. This is intended to enable comparison between the different curricula as effectively as possible. Where something not labelled "Assessment Objectives" has been used to stand-in for assessment objectives, this is explained in the descriptive analysis underneath the table.

Table 5: Comparison of assessment objectives

	Assessment Objectives
NSC Life Sciences[41]	**Knowing** (weighted at 40%) and assessed by: • state, name, label, list, define, describe etc. **Understanding science** (25%) and assessed by: • explain, compare, rearrange, give an example of, illustrate, calculate, make a generalisation etc. **Applying scientific knowledge** (20%) and assessed by: • predict, apply, use knowledge, demonstrate, solve, implement, judge etc. **Evaluating, analysing and synthesising scientific knowledge** (15%) and assessed by: • select, differentiate, analyse, infer, suggest a reason, discuss, categorise etc.

IB DP Biology[42]	• Demonstrate knowledge and understanding of:
	  • facts, concepts and terminology
	  • methodologies and techniques
	  • communicating scientific information.
	• Apply:
	  • facts, concepts and terminology
	  • methodologies and techniques
	  • methods of communicating scientific information.
	• Formulate, analyse and evaluate:
	  • hypotheses, research questions and predictions
	  • methodologies and techniques
	  • primary and secondary data
	  • scientific explanations.
	• Demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations.

[39] National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Life Sciences*, p. 45.

[40] Ibid., p. 61.

[41] Ibid.

[42] International Baccalaureate Diploma Programme (2016), *Biology Guide*, p.19.

	Assessment Objectives
Cambridge International AS/A Level Biology[43]	**AO1 Knowledge with understanding** Candidates should be able to demonstrate knowledge and understanding of: • scientific phenomena, facts, laws, definitions, concepts and theories • scientific vocabulary, terminology and conventions (including symbols, quantities and units) • scientific instruments and apparatus used in biology, including techniques of operation and aspects of safety • scientific quantities and their determination • scientific and technological applications, with their social, economic and environmental implications. The subject content defines the factual knowledge that candidates may be required to recall and explain. Questions testing these assessment objectives will often begin with one of the following words: define, state, name, describe, explain (using your knowledge and understanding) or outline. **AO2 Handling information and solving problems** Candidates should be able to handle information and solve problems using written, symbolic, graphical and numerical forms of presentation to: • locate, select, organise and present information from a variety of sources • translate information from one form to another • manipulate numerical and other data • use information to identify patterns, report trends and draw conclusions • give reasoned explanations for phenomena, patterns and relationships • make predictions and hypotheses • apply knowledge, including principles, to new situations • demonstrate an awareness of the limitations of biological theories and models • solve problems. **AO3 Experimental skills and investigations** Candidates should be able to: • plan experiments and investigations • collect, record and present observations, measurements and estimates • analyse and interpret data to reach conclusions • evaluate methods and quality of data and suggest possible improvements.[44]
KCSE Biology[45]	• communicate biological information in a precise, clear and logical manner • develop an understanding of interrelationships between plants and animals and between humans and their environment • apply the knowledge gained to improve and maintain the health of the individual, family and the community • relate and apply relevant biological knowledge and understanding to social and economic situations in rural and urban settings • observe and identify features of familiar and unfamiliar organisms, record the observations and make deductions about the functions of parts of organisms

43 Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Biology 9700*.

44 Ibid. pp. 12 - 13

45 The Kenya National Examinations Council (2014), *Kenya Certificate of Secondary Education (KCSE): Examinations Regulations and Syllabuses*, p. 106.

	Assessment Objectives
	• develop positive attitudes and interest towards biology and the relevant practical skills • demonstrate resourcefulness, relevant technical skills and scientific thinking necessary for economic development • design and carry out experiments and projects that will enable them to understand biological concepts • create awareness of the value of cooperation in solving problems • acquire a firm foundation of relevant knowledge, skills and attitudes for further education and for training in related scientific field.
ZIMSEC Forms 5-6 Biology[46]	**Skill A: Knowledge with understanding** Candidates should be able to demonstrate knowledge and understanding in relation to: • biological phenomena, facts, laws, definitions, concepts, theories • biological vocabulary, terminology, conventions (including symbols, quantities and units) • scientific instruments and apparatus used in biology, including techniques of operation and aspects of safety • scientific quantities and their determination • biological and technological applications with their social. economic and environmental implications. The syllabus content defines the factual materials that candidates need to recall and explain. Questions testing the objectives above will often begin with one of the words: define, state, name, describe, explain, outline or suggest. **Skill B: Handling information and solving problems** Candidates should be able to use oral, written, symbolic, graphical and numerical material to: • locate, select, organise and present information from a variety of sources • translate information from one form to another • manipulate numerical and other data • use information to identify patterns, report trends and draw inferences • present reasoned explanation for phenomena, patterns and relationships • make predictions and propose hypotheses • apply knowledge, including principles, to novel situations • solve problems. **Skill C: Experimental skills and investigations** candidates should be able to: • follow a sequence of instruction • use techniques, apparatus and materials • make and record observations, measurements and estimates.

[46] Zimbabwe Ministry of Primary and Secondary Education (2015), *Biology Syllabus Forms 5 and 6*, p. 30.

	Assessment Objectives
NSW HSC Biology[47]	**AO1: Skills in working scientifically (60%)** **AO2: Knowledge and understanding of course content (40%)** Overall objectives are given as: • working scientifically • developing positive, informed values and attitudes towards biology • recognising the importance and relevance of biology in their lives • recognising the influence of economic, political and societal impacts on the development of scientific knowledge • developing an appreciation of the influence of imagination and creativity in scientific research. Outcomes are given as: • Questioning and predicting • Planning investigations • Conducting investigations • Processing data and information • Analysing data and information • Problem solving • Communicating scientific ideas

* The Cognitive Demand weightings explain how key skills are assessed to different ratios in the assessment, which is what we are seeking to compare and contrast. We are not directly comparing the assessment objectives of the other programmes with the cognitive demand weightings of the NSC Life Science. Assessment objectives are statements that refer to the knowledge, skills, and competencies that individuals are expected to be able to demonstrate when they are assessed for a course. As a result, the cognitive demand weightings in the NSC Life Science were considered the most appropriate indicators for comparison to the Assessment Objectives of the other programmes.

Some programmes do not specifically name "assessment objectives". The content of this table was drawn from:

- NSC curriculum assessment objectives were drawn from the "cognitive demand" information in the subject curriculum guide.
- IB DP curriculum assessment objectives were drawn from the assessment objectives subsections of the subject curriculum guide.
- Cambridge International AS/A Level curriculum assessment objectives were drawn from the assessment objectives subsection of the subject curriculum guide.
- KCSE assessment objectives were drawn from the "General Objectives" bullet point list in the curriculum guide, as there is no specific "assessment objectives" subsection.
- Zimbabwe Forms 5-6 assessment objectives were drawn from the assessment objectives subsections of the subject curriculum guide.
- NSW curricula assessment objectives were drawn from "Objectives" and "Outcomes" subsections of the subject curriculum guide.

There is a similarity between the structure of the assessment objectives between Cambridge International and ZIMSEC. While these two systems class their objectives into three groups, NSC and IB group theirs into four. It is useful that NSC gives the percentage weightings of each assessment objective in the final exams (like

[47] New South Wales Education Standards Authority (2017), *Biology Stage 6 syllabus*, p.14. Available from: https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-science/biology-2017

IB, Cambridge International and ZIMSEC) and, in addition, examples of command words to be used in exam questions. This way, students and teachers can gain familiarity with what the question wording means in terms of the type of answer that is expected.

Across those four systems (NSC, IB, Cambridge International and ZIMSEC) that specify their assessment objectives in a similar format, there is an overall similarity in the intentions of the statements. Although the assessment of practical, experimental and investigation skills are not outlined in the cognitive demand statements of the NSC Life Sciences, different sections of the curriculum documentation provide explicit evidence that these skills are being assessed across grades 10-12. More specifically, the NSC Life Sciences Specific Aim 2 focuses on supporting learners in "investigating phenomena in Life Sciences" through the development of seven skills related to practical work, experimentation, and investigation (follow instructions; handle equipment or apparatus; make observations; record information or data; measure; interpret; and design/plan investigations or experiments). In the NSC Life Sciences curriculum documentation it is also outlined that teachers must select those skills that apply to and can be assessed in the context of specific activities. More specifically, the NSC Life Sciences documentation states that by the end of the Grade 10 year, all the above seven skills should be assessed at a grade-appropriate level. In addition, in the NSC Life Sciences curriculum documentation it is noted that these skills can apply to the variety of practical work that is appropriate for a particular grade in Life Sciences, including simple investigations or experiments. This makes it easier for teachers to assess learners in a range of different circumstances and it enables them to judge a learner's ability to do science.

Additionally, formal assessment in NSC Life Science provides teachers with a systematic way of evaluating how well learners are progressing in a grade and in a particular subject. Examples of formal assessments include tests, examinations, practical tasks, projects, oral presentations, demonstrations and performances.[48] More specifically, part of the formal, recorded and school-based assessment is the assessment of content but also practical knowledge and skills. The assessment of practical knowledge and skills is being conducted through a selection of three representative practical tasks, which cover the range of skills, that must be marked and recorded (the marks allocated for a practical task should range from 20 to 40. The number of marks allocated for a practical task is the same across Grades 10 to 12). The range of skills that are being assessed through practical assessment are included in Specific Aim 2 as mentioned above. In addition, several investigation skills may be assessed in a project or assignment in either Grade 10 or Grade 11 as well as well as knowledge of these investigation skills are assessed in the (theoretical) tests and examinations.[49]

Assessment Methods

The table below demonstrates some key features of the methods used to assess each subject.

[48] National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Life Sciences*, p. 67.

[49] Ibid., pp. 68-70.

Table 6: Comparison of assessment method

	Assessment Method (External) and Weighting	Assessment Method (Internal) and Weighting	Use of Question Types
NSC Life Sciences[50]	Two 2.5 hour Theory papers, 150 marks each	Tests, exams, fieldwork and practical tasks that are teacher-marked and externally moderated make up 25% of the total mark.	Paper 1: • Multiple choice • short answer • data interpretation • calculation Paper 2: • Multiple choice • short answer • data interpretation • calculations • extended answer
IB DP Biology[51]	One 1 hour Theory multiple choice paper, 40 marks and 20% weighting. One 2.25 hour Theory paper, 72 marks and 36% weighting. One 1.25 hour Theory paper, 45 marks and 24% weighting.[2]	Internal assessment covers all 4 assessment objectives and makes up 20% of the total mark. It is to be holistic rather than given specific times and dates. This is teacher-marked and externally moderated.	Paper 1: • multiple choice testing assessment objectives 1, 2 and 3 Paper 2: • data interpretation • calculations • short answer • extended answer (with choice) testing assessment objectives 1, 2 and 3 Paper 3: • short answer on experimental procedure • extended answer (with choice) testing assessment objectives 1, 2 and 3
Cambridge International AS/A Level Biology[52]	One 1 hour Theory multiple choice paper, 40 marks and 15.5% weighting One 1.25 hour Theory paper, 60 marks and 23% weighting. One 2 hour practical paper, 40 marks and 11.5% weighting	None	Paper 1: • multiple choice testing assessment objectives 1 and 2 Paper 2: • short answer • extended answer • data interpretation • calculation testing assessment objectives 1 and 2

50 Department of Basic Education Republic of South Africa (2017), *Life Sciences: Examination Guidelines Grade 12; Data from past NSC papers, 2020*.

51 International Baccalaureate Diploma Programme (2016), *Biology Guide*. p. 147.

52 Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Biology 9700*, p. 9.

	Assessment Method (External) and Weighting	Assessment Method (Internal) and Weighting	Use of Question Types
	One 2 hour Theory paper, 100 marks and 38.5% weighting. One 1.25 hour Written paper on practical skills, 30 marks and 11.5% weighting.[3]		Paper 3: • observing • measuring • recording results testing assessment objectives 1, 2 and mostly 3 Paper 4: • short answer • extended answer • data interpretation • calculations • essay (with choice) testing assessment objectives 1 and 2. Paper 5: • short answer • extended answer • data interpretation • calculations • graph plotting testing assessment objectives 2 and mostly 3.
KCSE Biology[53]	Two 2 hour Theory papers, 80 marks each One 1.75 hour Practical paper, 40 marks[4]	None	Paper 1: • Short answer • data interpretation Paper 2: • Short answer • data interpretation • graph plotting • essay Paper 3: • Making observations and recording results
ZIMSEC Forms 5-6 Biology[54]	One 1 hour multiple choice paper, 40 marks and 11% weighting. One 1.5 hour Theory paper, 60 marks and 17% weighting. One 2 hour Theory paper, 100 marks and 28% weighting. One 2.5 hour Practical paper, 50 marks and 14% weighting.[5]	A project, tests and practical work (10% each) make up 30% of the total mark. These are teacher-marked but do not appear to be externally moderated.	Paper 1: • multiple choice testing assessment objectives A and B. Paper 2: • "structured questions": short answer and extended answer. • Tests assessment objectives A and B. Paper 3: • extended answer / essay (with choice) testing assessment objectives A and B. Paper 4: • observing, measuring, and recording results, • testing assessment objective C.

53 The Kenya National Examinations Council (2014), *Kenya Certificate of Secondary Education (KCSE): Examinations Regulations and Syllabuses*, p. 18.

54 Zimbabwe Ministry of Primary and Secondary Education (2015), *Biology Syllabus Forms 5 and 6*, p. 32.

	Assessment Method (External) and Weighting	Assessment Method (Internal) and Weighting	Use of Question Types
NSW HSC Biology[57]	One 3 hour paper, 100 marks[6]	The Year 12 formal school-based assessment program is to reflect the following requirements: a maximum of four assessment tasks (the minimum weighting for an individual task is 10%; the maximum weighting for an individual task is 40%) • only one task may be a formal written examination with a maximum weighting of 30% • one task must focus on a depth study or an aspect of a depth study with a weighting of 20–40% the depth study task must assess: • the Working Scientifically skills outcomes: (Questioning and Predicting; Communicating) • a minimum of two additional Working Scientifically skills outcomes • at least one Knowledge and Understanding outcome.	External examination paper: • Multiple choice (4 option) • short answer • graph plotting • data interpretation • extended answer.

* These three papers can be taken alone for the AS award. If this is the case, the weightings are double those shown here.

55 Data from New South Wales HSC past papers, 2019.

The most notable difference in the assessment methods here are those that include some form of internal assessment (NSC, IB DP, ZIMSEC, and NSW HSC) and those where the assessment is 100% external examination (Cambridge International and KCSE).

Within the exam papers, there are several distinctions. In no particular order these are: whether multiple choice questions are used, whether any choice is given on what to answer, whether there is a practical paper, and the proportion of marks made up by mathematical skills.

Some of the NSC multiple choice questions were seen with ambiguities and considerable variations in style, while the Cambridge International and IB DP multiple choice questions were of higher quality overall.

IB DP, Cambridge International and ZIMSEC all give some element of choice in their extended answer or essay questions. This can be helpful to those candidates who feel greater confidence in a certain syllabus area.

Mathematical skills are an essential part of Biology and are likely to include features such as: calculations, measurements, data interpretation, graph plotting, and some statistical analyses. In curriculum documentation, there is more explicit evidence of focus on mathematical skills in Cambridge International AS/A level and the IB DP. Both these programmes set out a list of "Mathematical Requirements" that students are expected to know and demonstrate in their studies and assessment. Cambridge International's list is extensive and split into AS Level and A level, whereas IB sets out a list for all Biology students taking either SL or HL. The NSC does not set out such a list, though does make some references to mathematical skills in the content descriptions (especially under "Investigations"). Notably, however, statistical analysis is lacking in NSC documentation, but is present in Cambridge International, IB, and ZIMSEC. Indeed, Biology curricula tend to touch on at least one from: standard deviation, types of distribution (normal, skewed, bi-modal etc.), correlation, chi-squared or t-test. Correlation, for example, is an essential concept in science as it underpins any analysis of cause-and-effect relationships.

Looking at the external assessment of mathematical skills in all programmes, Cambridge International had the highest percentage of questions and marks allocated to these skills in their exam papers. Approximately, 20% of marks in external assessment were for mathematical-based skills, as opposed to approximately 8% in NSC. Generally, Cambridge International had considerably more questions requiring interpretation and analysis of graphs and tables, as well as some questions about statistical tests. All Cambridge papers had a substantial amount of mathematical content, though papers which had an especially high focus on mathematical skills were Paper 3 – Advanced Practical Skills and Paper 5 – Planning, Analysis, and Evaluation. However, unlike Cambridge International, the NSC includes investigative internal assessments, which may involve mathematical skills like those observed in Paper 3. Similarly, mathematical skills in IB DP external assessments account for approximately 13% of marks in exam papers, but IB also has internal assessments and projects which will utilise mathematical skills.

Overall, Cambridge International, IB DP, and ZIMSEC include a wider range of mathematical skills in their curricula than the NSC. Cambridge International and the IB highlight mathematical requirements more explicitly in curriculum documentation. In exam papers, Cambridge International has a greater emphasis on mathematical skills than NSC, as does the IB DP. However, the NSC syllabus stipulates that the internally assessed component will cover mathematical skills also.

Key Findings

Learning Outcomes and Assessment Objectives

Scope

In terms of assessment objectives, there is broad similarity between the six systems compared here. NSC, IB DP, Cambridge International and ZIMSEC list their assessment objectives in order of increasing cognitive demand, starting from recall of knowledge and progressing to synthesis and evaluation. NSC assessment objectives (i.e., cognitive demand levels with weighting) make implicit mention of practical or experimental skills. However, there are explicit references to practical or experimental skills elsewhere throughout the NSC Life Science curriculum documentation and more specifically in the Specific Aim 2 "Investigating Phenomena in Life Sciences", focusing on the development of the following skills: following instructions, handling equipment or apparatus, making observations, recording information or data, measuring, interpreting information and designing/planning investigations or experiments the learning outcomes and the assessment requirements. According to the NSC Life Sciences documentation, these skills should be developed and assessed over the course of study.[56] Most other programmes mention these skills explicitly in their assessment objectives.

Skills Coverage

The skills generally described as outcomes of school-leaving Biology curricula include: the ability to recall information, the ability to understand and apply this information in novel situations, the ability to plan and carry out investigative work, the ability to record and analyse results, and the ability to evaluate both results and procedures. Each of the six systems compared here aim to develop those skills to varying levels.

The IB DP and Cambridge International more explicitly state the mathematical outcomes that students are expected to demonstrate during their studies of Biology, as both are the only programmes to set out a list of "Mathematical Requirements". Cambridge International's list is extensive and split into AS Level and A level, whereas IB sets out a list for all Biology students taking either SL or HL.

The IB DP, Cambridge International, and ZIMSEC curricula have greater emphasis on the chemical, biochemical, and mathematical aspects of biology. On the other hand, the NSC, KCSE and NSW HSC place more emphasis on aspects of biology such as ecology and populations. These differences of emphases are reflected in some of the skills and competences articulated at the level out outcomes and objectives.

Content and Structure

Scope

The main biology topics are covered in all six systems but with varying depth and breadth. All six of the systems compared here cover the core biology content of cells and cell division, molecules of life, transport systems, genetics and some physiology. The biggest variations come in the levels of detail and extent of coverage of biotechnology, ecology, evolution and mathematical methods. NSC, for example, includes a history of life on Earth, which is unique among these six. Statistical methods are covered by IB DP, Cambridge International and ZIMSEC but not by the other three programmes analysed here. It is interesting to note that these

[56] National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Life Sciences*, pp.15-17.

same three are the only ones to cover respiration and photosynthesis at the molecular level.

Sequencing

The NSC curriculum suggests the time allocation for each topic. This is useful, because it places all of the information regarding learning content and time allocation into one document without teachers having to cross-reference between the curriculum and a scheme of work. The IB DP Biology curriculum documentation is the only other programme here to do this to a similar level of detail.

Most of these curricula have the biology of the cell and biological molecules listed first. This is logical, because these topics underpin all others. For example, transport in plants requires understanding of the properties of water molecules; respiration requires understanding of cell compartmentalisation and some properties of glucose. However, after these two fundamental topics have been covered, the sequence that follows can be in almost any order. It would not matter whether the mammalian circulatory system was covered before or after energy flow in ecosystems, for example. Moreover, it does not matter in what order the two fundamental topics are taught. NSC puts biological molecules before cells, but Cambridge International and IB DP both do this the other way around. Neither of these is more effective than the other. Indeed, if co-teaching was occurring then one teacher may facilitate learning of cells while the other covered biological molecules.

In terms of time allocations, NSC can only be directly compared with IB here because only those two specify timings in their curriculum / syllabus documents. Comparing the timings in these subjects shows differences in the actual numbers of hours allocated to a topic, but the percentage of times can be quite similar. For example, the topic of biological molecules is allocated 2% time in NSC and a similar percentage in IB. Topics that are covered in less depth on the NSC curriculum are allocated commensurately less time. Cellular respiration is an example of this because NSC omits the biochemistry of the process. The shortfalls in percentage time allocations are then compensated by those topics that NSC covers exclusively, such as the history of life on Earth and the studies of ecosystems.

Skills Coverage

There is clear division in curriculum documentation between those programmes whose subject content focus on a wide range of mathematical skills, and those that do not. Cambridge International, IB DP, and ZIMSEC fall into the former category and NSC, KCSE and NSW HSC fall into the latter. The NSC has a narrower range of mathematical skills than Cambridge International, IB DP and ZIMSEC curricula – these programmes also contain statistical analysis (such as chi-squared tests). KCSE and NSW HSC are also light on mathematical skills. The traditional view is that biology is a lot less dependent on numeracy than physics or chemistry. However, the study of genetics requires understanding of ratio and possibly the Hardy-Weinberg equations. Population studies require the understanding of sampling techniques, possibly including direct proportion, capture-mark-recapture methods and ideas about types of distribution curves. Practical skills involve the understanding of measurement and uncertainty, types of graphs, detection of outliers, ideas about correlation and statistical methods: chi-squared, standard deviation, variance, t-test etc.

Lower order skills such as recall of fact form a significant proportion of the curricula compared here. This is not surprising, because biology (like the other sciences) is more heavily content-knowledge-based than other subjects such as mathematics or languages. All curricula here expect students to be able to apply this knowledge and its understanding to novel situations and this is evident from the assessments that have been seen. Skills of evaluation and synthesis are mentioned in the specifications of NSC, IB DP, and Cambridge International.

Assessment

Structure

Four of the subjects compared here (NSC, IB DP, NSW HSC, and ZIMSEC) use an internally assessed component in addition to externally marked papers. These are worth 25% (NSC), 20% (IB DP), 50% (NSW HSC), and 30% (ZIMSEC). NSC, IB DP, and NSW HSC stipulate that their internal assessments are teacher-marked and externally moderated. ZIMSEC makes no mention of moderation.

All of the assessments that have been seen include short and extended answer question styles. Some use multiple choice (NSC, IB DP, Cambridge International, ZIMSEC and NSW HSC) and some have essays (Cambridge International, KCSE, and ZIMSEC). Some incorporate choice of questions (IB, Cambridge International, and ZIMSEC) whereas the others do not.

Besides validity, reliability and practicability, one of the key points for assessments is accessibility. By this we mean the clarity of the wording used to give the command, set the context, and any additional instructions need to inform the candidate what they are expected to do. Language should not be a barrier to science or to the questions. Accessibility involves the use of commands rather than questions and is always impersonal. For example, "Explain how …" rather than "Why do you think …?". NSC papers adhere to these rules of accessibility and along with IB and Cambridge International it is one of the more rigorous in doing so.

Question papers vary in length from 3 hours (NSW HSC) to 1 hour for dedicated multiple-choice papers. Mark allocations on papers vary from 40 on some multiple choice and practical papers up to 150 on the NSC external papers.

Total mark allocations of the externally marked parts of the assessments are, in order from greatest to smallest: NSC, 300; Cambridge International, 270; ZIMSEC, 250; KCSE, 200; IB, 157; NSW HSC, 100.

Marking

In terms of both working and published mark schemes, the short answers are mark-point based and the longer answers, usually including essays are criterion-based. The latter is sometimes referred to as "level of response" marking that is common to essay writing in non-science subjects. Here, the examiner reads the response, judges the level, and then on re-reading, decides on the mark within that level. NSC uses almost exclusively a mark-point based system, even for the extended answers where only 3 of the available marks are based on levels.

Skills Coverage

Assessment of skills varies in the six curricula compared here according to whether externally marked examinations are used to assess all skills or whether some skills are assessed through internal teacher-marked components, as in NSC, IB, NSW HSC, and ZIMSEC. In the externally marked papers, the skills of recall and application are assessed to roughly equal extents in each of the systems compared here. Other, higher-level skills such as data interpretation and mathematical skills are more variable. Skills such as evaluation and synthesis are assessed on the external papers to the greatest extent by IB and Cambridge International and to the least extent by KCSE.

Furthermore, in examination papers, the NSC has less emphasis on mathematical skills than Cambridge International and the IB DP. Furthermore, mathematics-based questions in the NSC are usually simplistic, whereas those on the Cambridge International papers are significantly more challenging, especially on Paper 5. Continuing this comparison, the NSC mathematical skills are more comparable to those on Cambridge International paper 2, which is one of the International AS Level

papers. Indeed, the differences regarding mathematical skills are less strong when comparing NSC with Cambridge International AS Level than Cambridge International A Level. Furthermore, unlike Cambridge International, NSC includes investigative internal assessments, which may involve mathematical skills like those observed in Paper 3.

Documentation

For details of the subject guides, assessment materials, and mark schemes used throughout this appendix (including years of publication), see **7. Bibliography** in the body of the report.

Notes

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