# Learning from Africa:
# Biology

## A report of Umalusi's research comparing Biology syllabuses and examinations in South Africa with those in Ghana, Kenya, and Zambia

An Umalusi Research Report
January 2008

PUBLISHED BY

UMALUSI COUNCIL FOR QUALITY ASSURANCE
IN GENERAL AND FURTHER EDUCATION AND TRAINING

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ISBN 978-0-9814176-1-5

Layout & Design
CJ Graphics

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# Acknowledgements

The report was written by Dr Stephanie Matseleng Allais, Dr Edith Dempster, and Dr Alice Barlow-Zambodla.

This research was designed by Stephanie Matseleng Allais. We are grateful to Professor Yael Shalem for her assistance in the research design, and to Professor Harold Noah for reading drafts of the report and assisting in thinking through our approach to the research as well as its implications.

Dr Heidi Bolton, Ms Liz Burroughs, and Dr Jeanne Gamble were critical readers.

The analysis was carried out by the following researchers: Dr Alice Barlow-Zambodla, Ms Heather Blanckensee, Ms Anna Crowe, Dr Edith Dempster, and Mr Michael Mavovana.

The research was managed by Ms Shireen Badat with assistance from Ms Ramadimetja Phaladi.

Umalusi's Research Forum provided guidance at various points. Members of the research forum over the period of the research included:

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# Introduction

This short subject report is an addendum to the main report emanating from an Umalusi study aimed at understanding how South Africa's senior secondary school certificate compares with those of three other African countries. The full research report is entitled *Learning from Africa: A Report of Umalusi's Research Comparing Syllabuses and Examinations in South Africa with those in Ghana, Kenya, and Zambia.* In comparing South Africa's Matric certificate with the senior secondary school certificates of Ghana, Kenya, and Zambia, the report explored various aspects of the curriculum and examinations systems, including the intended and examined curriculum in four subjects.

The aim of the research was to learn from English-speaking African countries in different regions, in order to contribute to improving the intended and examined curricula in the Further Education and Training (FET) phase in South Africa. Umalusi believes that it is valuable to consider systems in other countries, and hopes that this kind of comparative analysis will allow South Africans to stand back and achieve some distance from our internal debates. The research also cautions South Africa not to assume that our education system is superior to those found elsewhere in Africa.

The South African context of the research is a new curriculum which is in the process of being implemented in the FET phase (senior secondary school). The FET phase, which covers the final three years of secondary schooling (Grades 10 to 12), culminates in the National Senior Certificate, which will replace the current Senior Certificate. The implementation of the new curriculum began in Grade 10 in January 2006, and the first cohort of Grade 12 learners will write the new National Senior Certificate examinations in 2008.

The research aimed to understand how South Africa compares with the other countries in terms of both the old curriculum and examinations, which were still in use at the time of conducting the research, as well as the new curriculum. It sought to determine what we can learn from the other countries with regard to systemic issues, as well as lessons for our new curricula and examinations on the basis of the subject comparison. The study was conducted through meetings and open-ended interviews with officials in all four countries, supplemented by documentary information. Syllabus—and 2004 examination documentation was collected from each country and analyzed by groups of South African experts.

The main report provides a synthesis of what was learned from the comparative study. It deals mainly with three issues:

- An overview of aspects of the education systems in the four countries—i.e., years in school, examinations and certification;
- A brief overview of comparisons of the intended and examined curriculum in four subjects at school-exit level—i.e., Biology, Science, English, and Mathematics;
- Some reflections on the new curriculum in South Africa.

This short subject report, which provides a more detailed analysis of what evaluators found in their comparison of the Biology courses across the four countries, should ideally be read in conjunction with the main report.

The draft base report, which contains more detailed elaborations of the findings, is available on Umalusi's website as *Evaluating Syllabuses and Examinations: An Umalusi Technical Report comparing the Syllabuses and Examinations from Ghana, Kenya, South Africa, and Zambia*, and may be of interest to subject experts.

## Biology courses in the four countries

The courses examined were:

- Ghana Secondary Senior School Certificate: Biology
- Kenya Secondary School Certificate: Biology
- Zambia School Certificate: Biology
- Old South African Senior Certificate: Biology, Higher Grade
  Old South African Senior Certificate: Biology, Standard Grade
- New South African National Senior Certificate: Life Sciences (documents included *National Curriculum Statement*, Grades 10–12 Life Sciences (2003) and *Life Sciences: Learning Programme Guidelines* (2007)).

With regard to the old South African syllabuses, the syllabus of the Independent Examinations Board (IEB) is mentioned at times below, where it differs significantly from the old national syllabus.[1] The documents for the new South African *National Curriculum Statement* were dated 2003, and the *Learning Programme Guidelines* were dated 2007. New documents were released after this study was completed; thus, some of the criticisms and recommendations with regard to the new curriculum may already have been addressed in the new documents.

Of all the courses examined in this project, the Biology courses are the most similar, and thus lend themselves to the most careful comparison. The only significant difference is that South Africa has Higher Grade and Standard Grade courses, and the other three countries all have one Biology

[1] Syllabuses and examinations of the Beweeging vir Christelike Volkseie Onderways (BCVO) were not considered at all for this research, as the syllabuses are identical to the national curriculum, and the learner numbers writing the examinations are extremely small.

course. In terms of exit-level examinations, South Africa is the only country to examine only the final year of work; all other countries examine the entire final phase of schooling. South Africa is also the only country that does not have an authentic practical examination.

The number of learners who enrol for Biology in most countries is relatively high. In Zambia, it is compulsory for learners to enrol for a Science subject, and most choose Biology. Similarly in Kenya, where two Science subjects are compulsory, Biology is a popular choice (along with Physics). In South Africa, Biology is not compulsory, but still has very high learner enrolments. It is not clear why Biology should be such a popular subject, and this was not a matter which this research attempted to understand. It is interesting that the numbers in Ghana are relatively much lower—about 10% of the cohort. However, nothing specific from the subject comparison in this study sheds light on why this should be the case.

All six Biology courses studied here contain similar elements, but with some important differences.

# The intended curriculum

## Definition of Biology/Life Sciences

Ghana includes a definition of Biology in the rationale for teaching Biology. This describes biology as a branch of natural science, which deals with the study of life and living organisms. None of the remaining syllabus documents specifically define Biology.

The new South African *National Curriculum Statement* has renamed Biology as Life Sciences. Life Sciences is not a recognized discipline, and the way it is portrayed in the curriculum prioritizes human life science rather than the broad science of living organisms. The name change is appropriate if the focus is 'science for living'—that is, a strongly anthropocentric approach, which is in fact foregrounded in the *National Curriculum Statement* for Life Sciences. However, it misses the opportunity to provide an induction to broader biological theories, and the ways of thinking and investigating living systems appropriate to Biology.

As with the Ghanaian syllabus for Biology, the new *National Curriculum Statement* has an explicit definition for Life Sciences: '…. the systematic study of life in the changing natural and human-made environment. This systematic study involves critical inquiry, reflection, and the understanding of concepts and processes and their application in society' (*Life Sciences Curriculum Statement*, p. 9).

Unlike the textbooks used in this study and the other countries examined, the South African *National Curriculum Statement* does not include an introduction to Biology in the syllabus, though the old South African syllabus did so.

## Aims

While the old South African syllabus has no expressed rationale for including Biology in the school curriculum. Ghana has explicit, well-developed reasons why Biology is included in the school curriculum, in the sense of contributing to the wider good of individuals and human society in general. Zambia's rationale appears to be reactive, placing greater emphasis on skills and understanding, and also on the value of understanding and developing skills, which are perceived to be more beneficial than recalling large volumes of factual detail. The statement implies that the previous syllabus placed too little emphasis on skills and understanding, and too much emphasis on recalling factual information. Kenya's rationale emphasizes the importance of Biology in terms of environmental use and conservation. Humans are perceived to be part of the community of living organisms, although the rationale also sees Biology as useful in a variety of applied fields that are important to humans. These include health, agriculture, the environment and education. Technological advancement of society is mentioned by Ghana, Zambia, and Kenya as a reason for studying Biology.

Like the Ghanaian, Kenyan, and Zambian syllabuses, and unlike the old South African syllabus, the new South African *National Curriculum Statement* includes a rationale for having Life Sciences in the curriculum,. The new South African curriculum mentions technological advancement of society as a reason for studying Life Sciences. The curriculum statement includes diseases of the various systems, for example, cancer as a disorder of mitosis, allergies, parasites, fungal diseases of crops, malnutrition, and diseases of all the human organ systems. The theme, 'Environmental Studies', includes a number of issues such as human effects on the environment, pollution, sustaining the environment, and population management. The impression is created that the curriculum places much more emphasis on human biology and diseases than on general biological concepts and principles.

The new South African *National Curriculum Statement* does not discuss the aims of the syllabus explicitly, neither does it have any discussion about values that Biology aims to instil in learners. Evaluators felt that this

is an effect of the outcomes-led approach—outcomes are seen as aims. They pointed out that what needs to be thought through is whether anything is lost in this process, and whether it might still be useful to state broader syllabus aims. The curriculum statement does refer to the benefits of biological knowledge for healthy lifestyles and sustainable management of resources.

Like Kenya and Zambia with respect to Biology, the new South African *National Curriculum Statement* highlights a variety of influences on Life Sciences, including ethics and biases, technology, and indigenous knowledge systems. This is the only syllabus document that specifically refers to indigenous knowledge systems.

## Coherence

The order in which biological concepts are taught is relatively constant across countries, but lacks cohesion in that there is no explicit organizing principle in the syllabuses of any of the countries. The new South African *National Curriculum Statement* organizes content around four themes: tissues, cells, and molecular studies; structure, control, and processes in basic life systems; environmental studies; and diversity, change, and continuity. The four themes are addressed in each year of study. They broadly coincide with the levels of organization of life, beginning at the molecular level and proceeding through cells, tissues, organ-systems, whole organisms, populations, communities, ecosystems, and biomes, and ending with the biosphere. Each level of organization responds to selection pressures that result in its present form and function. Evolution over time and in space has resulted in biodiversity, as seen in the fossil record, and also in the diversity of living species.

Like the new South African *National Curriculum Statement*, all syllabi studied here teach across several levels of the hierarchy of living systems in each year of the secondary school curriculum. There is agreement among the syllabuses that cell structure and function should be taught early in the sequence, and genetics, heredity, and evolution should be taught towards the end of the course of study, with the exception of the old South African syllabus, where genetics is taught in Grade 11. Diversity

of life occupies the middle years, and does not extend into the final years. Form and function in living organisms extends across all the years of study, and the order in which life processes are studied generally ends with co-ordination, but varies in the previous years. Ecology, which in most foundational textbooks appears towards the end of the book, is taught early in the secondary school curriculum in most countries.

None of the syllabuses prescribe an evolutionary theme within which to frame the diversity of life. Evolution is not included in the old South African syllabus and the Zambian syllabus, but appears in the final year of study in Kenya, Ghana, and the new South African *National Curriculum Statement* for Life Sciences. One can assume, therefore, that evolution is regarded as an advanced topic, along with genetics and DNA structure and functioning.

## Content

The syllabuses reviewed here contain a traditional assemblage of topics that constitute foundational concepts in the study of life. In each country, local examples and issues are included where possible. There is a strong resemblance among the syllabuses in the scope covered, but there is variations in the depth to which subjects are taught. For example, photosynthesis and respiration are taught at a relatively superficial level in Kenya, but in greater depth in Ghana and Zambia. Biologically important molecules are left out in some syllabuses, and treated superficially in others (Kenya).

Ghana, Kenya, and the IEB in South Africa begin with a definition of the scope and practice of Biology. All countries teach cell structure and function in the first year of senior secondary school, and some countries progress to photosynthesis and cellular respiration in higher years. The exceptions are Kenya, where photosynthesis is covered at a rudimentary level in year 0 and not re-visited thereafter, and the new South African curriculum for Life Sciences, where food production and energy release are included in Year 1. The *Learning Programme Guidelines* for Life Sciences (2007) indicate that cellular respiration (aerobic and anaerobic) is taught in Year 1, as is photosynthesis.

There are some differences in content:

- Some countries reflect the different levels of organization from cell to tissue, to organ and organ-system, while others do not do so.
- Evaluators were surprised that, unlike all syllabuses except that of Ghana, the new *National Curriculum Statement* for Life Sciences in South Africa fails to mention biologically important molecules specifically.
- The study of tissues in plants and animals is detailed in Year 1 in the old South African syllabus, but in other countries, it forms part of the study of the morphology and anatomy of plants and animals, if it appears at all.

Some content is common to all of the Biology curricula in the study. This discussed below.

All countries include an introduction to basic concepts in ecology as part of the syllabus. These concepts appear at Year 1 in South Africa (in both the old syllabus and new *National Curriculum Statement* for Life Sciences), Year 2 in Ghana, and Year 2 in Kenya. In each case, human impact on natural environments is included, as is the value of biodiversity for humans. South Africa teaches population dynamics as a separate topic in Year 3, but other countries do not continue the study of ecology in subsequent years. Population dynamics in the new *National Curriculum Statement* for Life Sciences is included in the theme 'Diversity, Change and Continuity' and not in 'Environmental Studies', where it would flow from introductory ecology. The *Learning Programme Guidelines* for Life Sciences (2007) indicate considerable overlap between the Environmental Studies knowledge area and the Diversity, Change and Continuity knowledge area. For example, biomes are studied in both knowledge areas.

Ecology usually occupies one of the final chapters in most foundation Biology texts, but appears early in the syllabus of all the countries studied here. In some cases, ecology is taught before photosynthesis, which accounts for the entry of energy into an ecosystem. An understanding of ecology and the niche concept also relies on an understanding of nutrition and the variety of foods and feeding strategies displayed by living organisms.

Diversity, heredity, and evolution receive different treatments in the different countries. The Linnaean system of classification of life receives specific attention in all syllabuses except the old South African syllabus. This syllabus does not prescribe a particular classification system, but is written in a way that supports a two-kingdom system. The *Learning Programme Guidelines* for the new Life Sciences curriculum in South Africa prescribes a five-kingdom classification system, to be introduced in Year 1, but no phyla are studied. All other syllabuses refer to a five-kingdom system. The order in which the different taxonomic levels are studied are kingdom first, then phyla, then certain classes and some orders of insects in the Ghanaian syllabus. This takes place in Years 1 and 2 in Ghana and in Years 0 and 2 in Kenya. All countries except South Africa cover genetics in the final year of study; in South Africa, genetics is included in Year 2, which means it is not examined in the final examinations. Variation, mutations, natural selection, and evolution are covered in the final year of study in Kenya, Ghana, and the new *National Curriculum Statement* for Life Sciences in South Africa. Evolution is not mentioned in old South African syllabus, although it is mentioned in the additional syllabus documentation of the IEB. It is also not mentioned in the Zambian syllabus, but is included in all other syllabuses.

The treatment of form and function in whole organisms differs from country to country. The old South African syllabus and Ghana treat the taxa separately, although in South Africa, provision is made for teachers to teach thematically if they wish to do so. Kenya and Zambia adopt a thematic approach by investigating life processes with reference to a range of examples that exhibit different ways of carrying out the life process. The *Learning Programme Guidelines* for the new South African Life Sciences curriculum do not mention form and function in organisms other than plants and humans.

The order in which life processes of mammals are taught varies in the different syllabuses.

The old South African syllabus includes a survey of examples from a range of major phyla and divisions, and classes of flowering plants, vertebrates, and arthropods. The new South African *National Curriculum*

*Statement* for Life Sciences as well as the associated *Learning Programme Guidelines* focus strongly on human form and function, featuring disorders and diseases of all systems. The new curriculum covers life processes across the three years of study, but makes little mention specifically of plant form and function, which is added in the *Learning Programme Guidelines*.

Zambia has adopted a sophisticated approach to life processes, by using each life process as a unifying theme, within which a variety of ways of accomplishing the life process are examined. Kenya does likewise, while the old syllabus in South Africa does not structure the syllabus in this way, but allows flexibility for teachers to choose a thematic approach. Ghana teaches life process by taxonomic groups, beginning with the Protista, Fungi, non-flowering plants and insects, followed by vertebrates and flowering plants, and finally mammals and the remaining life processes of flowering plants. This would appear to be the reverse order of what one would expect in a syllabus that progresses from the familiar to the unfamiliar.

With regard to social and economic applications of Biology, the evaluators argued that while they may question the inclusion of the large section on community health in the Ghanaian syllabus, the curriculum serves a dual role of inducting students into the ways of thinking and doing within a subject, while also contributing to the development of communities and societies.

The evaluators argued that the old South African syllabus was wanting with regard to explication of the social and economic applications of Biology. The new curriculum includes diseases of the various systems—for example, cancer as a disorder of mitosis, allergies, parasites, fungal diseases of crops, malnutrition, and diseases of all the human organ-systems. The theme on Environmental Studies includes a number of issues such as human effects on the environment, pollution, sustaining the environment, and population management.

The curricula studied here have adopted a traditional selection of content for Biology, with limited applied sections that reflect the societies within which the curriculum was developed. This may be a reflection of a British influence on the curriculum of African countries. Evaluators

recommended that these African curricula should have a stronger emphasis on the unique African environment and its assets in terms of its biodiversity and range of biomes. Ghana and Zambia have attempted to contextualize the syllabus by including the study of some insects that have great economic and/or social importance in their countries. However, the selected species generally have negative impacts on humanity, and they do not lead to general principles of biology. The evaluators emphasized that there is a very real danger that unless our young people learn about and value the living natural resources (in the broadest sense) of Africa, we may lose many species through extinction.

A suggested topic might be the following:

> Origins of Africa's flora and fauna, unique features of African species, distribution patterns, and modes of life (including social structure and behavioural ecology) of a range of species inhabiting the country. Impact of humans on Africa's natural environment; conservation of ecosystems and biomes.

The core biological principles and processes need to be understood, but should ideally be localized within the African context. This is the last continent that still retains a relatively broad range of biodiversity, including an impressive array of large mammals, which attract tourists to areas unsuitable for farming. Thus there is an economic reason for educating our children about African natural environments, with the spin-off that the biodiversity may survive the great extinction currently under way, caused directly by human activities.

In summary, Biology is an extremely broad and diverse science, which means that choices about what constitutes school Biology must be made within the context of the interests and priorities of each educational system. The curricula examined here display homogeneity in that all take a fairly traditional approach by including cell biology, genetics and heredity, classification, form and function in a variety of taxa but particularly flowering plants and mammals, and ecology. All countries also include some social applications of biology. Kenya includes a classical treatment of evolution, including a reference to human evolution, which is particularly apt in a country that has contributed so much to our understanding of human evolution.

Evaluators recommended that the new South African *National Curriculum Statement* for Life Sciences should more explicitly enable Biology teachers to capitalize on the available fossil history of life in Southern Africa, including such notable contributions as the mammal-like reptiles of the Karoo and the hominid fossils of our many hominid fossil sites. This, they argued, has been introduced at the General Education and Training level, in the Natural Sciences Learning Area, but not continued into the Further Education and Training level.

Over and above its rich fossil history, Africa has a wonderful diversity of ecosystems and biomes that illustrate many ecological principles in authentic environments. The *Learning Programme Guidelines* for the new South African Life Sciences curriculum indicate that this knowledge area has been strengthened, with emphasis on biomes and local ecosystems. Evaluators strongly recommended that African curriculum developers emphasize the ecology strand, and include behavioural ecology, which would enable students to develop a greater understanding and appreciation of African wildlife. They also recommended a strengthening of the evolution strand, since it is the most powerful explanatory principle in Biology. Africa has contributed very significantly to international understanding of the evolution of many groups, including the oldest fossil bacteria in the world, and humankind.

## Views of science

The curricula of the other three countries as well as the old South African syllabus support a traditional view of science, which regards scientific knowledge as universally applicable and objective. This is most clearly stated in the aims and objectives of the Zambian syllabus that aims to lead learners to an understanding that biological principles and the language of science are universal, although local examples may be used to exemplify those principles. Ghana emphasizes knowledge and skills, Kenya emphasizes skills and social applications, Zambia emphasizes attitudes, and the old South African syllabus emphasizes knowledge, skills and values.

A more contemporary view of science portrays scientific knowledge as tentative and influenced by social factors. The Zambian syllabus, despite its clearly articulated traditional view, also appears to embrace a more

contemporary view. It states in Aim 7.1 of the Biology syllabus that 'the study and practice of Biological Sciences is subject to social, economic, technological, ethical, and cultural influences and limitations' (Republic of Zambia Biology High School Syllabus, p. v).

The new South African *National Curriculum Statement* for Life Sciences more explicitly supports a contemporary view of science.

## Recommended pedagogies

All the syllabus documents make some mention of the importance of active learner participation by incorporating hands-on practical investigations and activities in the teaching and learning situation.

Kenya highlights the discovery method of learning. Ghana recommends participatory teaching. Zambia advocates a variety of teaching experiences as opposed to chalk and talk; its syllabus emphasizes practical work and recommends using an investigative approach. The old South African syllabus proposes that students should make their own observations and be actively involved in practical work; teachers are advised to emphasize understanding and application of facts rather than memorization.

The South African curriculum for Life Sciences differs from all the other syllabuses in being strongly outcomes-based and learner-centred to the point of rarely mentioning the role of the teacher. In this curriculum, content is viewed as the vehicle for achieving three major outcomes: constructing knowledge, reflecting on and exploring phenomena, and designing investigations. These learning outcomes must be achieved by the end of Grade 12. Each learning outcome is assessed by means of three or four assessment standards that are specific to each grade, and that indicate progression across grades. The other syllabuses in the current study tend to prescribe particular investigations and investigative procedures.

## Structure and organization of syllabuses

It is notable that Zambia does not prescribe a sequencing of topics. The syllabus is not divided into years of study, and includes thirteen units of study in total. It covers 33 pages.

The Ghanaian syllabus is organized by year of study, then by Section (headed by a set of general objectives), followed by Unit of Work. For each Unit of Work, objectives are specified and are phrased in the form, 'The student will be able to'. Specific objectives are linked to a description of content relevant to the Unit and to the specific and general objectives. Teaching and learning activities are suggested for each content area, and evaluation is suggested to meet the objectives. As an example, in Year 1, Section 1 (Introducing Biology), Unit 1 is entitled 'Biology as a Science of Life'. Specific objective 1.1.2 states that the student will be able to mention some fields of biology. The associated content states, 'Fields of biology: anatomy, botany, biochemistry … zoology'. Under teaching and learning activities, the document suggests, 'List various fields of biology,' and the evaluation proposes, 'Mention four fields of biology'. This is the structure of the document throughout the three years of study. The full document is 94 pages long.

The Kenyan Biology teaching syllabus begins with a one-page Introduction, which sets out the rationale, recommended pedagogy, inclusion of socially relevant issues, and pacing of the syllabus. The introduction is followed by a list of subject objectives, which are analyzed separately. The syllabus is organized by year of study (1 – 4) and theme. Each theme has a list of specific objectives, which are phrased in the format, 'By the end of the topic, the learner should be able to….' The specific objectives are followed by a list of content topics and a list of practical activities. Thus, for example, the theme 'Introduction to Biology' is allocated five lessons, and one of the specific objectives is that learners should be able to 'state the main differences between plants and animals'. The content lists 'comparison between plants and animals' as a topic; practical activities include 'collecting, observing and recording external features of plants and animals'. The document is 28 pages long. A separate assessment syllabus contains specification for assessment.

The old South African syllabus is very specific as to the content to be covered, and provides a detailed list of the scope and depth of the content. The Standard Grade syllabus covers the same content as Higher Grade, with the omission of some details. In 2001, a document entitled

*Clarification of the Common Understanding of the Core Syllabus for the National Examination* was issued, in preparation for a common national examination. This document clarifies the scope and depth of the detail required in some sections, and prescribes practical work to be covered. The document is 55 pages long.

The IEB in South Africa has a modified Biology syllabus based on the National Core Curriculum. It is organized by theme for each year of study. The theme for the first year is 'Looking at Living Things', the second year 'Continuity of Life' and the third year 'Homeostasis: Maintaining Life'. Skills are highlighted by means of a concept map at the beginning of the syllabus, and include thinking skills, practical skills, social skills, communication skills, and data collection and manipulation skills. The syllabus document is organized around a suggested problem, issue or story which sets the scene for a section of work. This is followed by linking questions arising from the scene-setting introduction. Suggested activities follow, and skills appropriate to the topic are listed. The content occupies two columns, one labelled 'Exam' and the other 'Review'. The distinction between the two columns is not clear. For example, a suggested problem in the theme 'Classification of Living Organisms' is, 'How does a biologist make sense of the living world?' The related linking question is, 'How does one classify an organism?' Suggested activities include grouping metal objects, making a key, making a spider key, making a dichotomous key, and making a table. Appropriate skills are grouping on similarities, separating on differences, recognising distinguishing characteristics, understanding appropriate features for classifying, and constructing biological keys. Under Content (Exam) is 'features by which organisms are classified', while the Content (Review) column is blank. The document covers 44 pages, and is supplemented by extensive support materials for teachers.

The new *National Curriculum Statement* for Life Sciences in South Africa provides very broad topics with very little detail of depth, scope, and pacing; these details are provided in the separate *Learning Programme Guidelines*. The curriculum statement consists of four chapters, the first of which describes the general principles and design features of the *National*

*Curriculum Statement*, Grades 10–12 (General). The second chapter provides definition, purpose, scope, career links, and learning outcomes of the subject Life Sciences. The learning outcomes and assessment standards are expanded in Chapter 3, and illustrated by means of exemplars. The curriculum is an outcomes-based curriculum, in which the content is perceived to be the vehicle for attaining the assessment standards. The content and contexts for achieving the learning outcomes are listed in brief in four pages of this chapter. The final chapter outlines the generic approach to assessment in the new curriculum.

The curriculum statement is supplemented by *Learning Programme Guidelines* and an assessment guideline, which provide considerable detail about the recommended pedagogy and the format of the assessment throughout the phase.

The *National Curriculum Statement* for Life Sciences is arranged around three learning outcomes, each of which is assessed by means of assessment standards, which show progression across the grades. The Curriculum Statement states clearly that the content is the vehicle for achieving the assessment standards, and thereby the learning outcomes. Thus, content is described very briefly in the policy document. It is difficult to deduce how choices were made, and what the organizing principle was. 'Diseases' are mentioned many times in the policy document, creating the impression that the syllabus is intended to develop an understanding of human diseases of the various systems studied.

The content appears discontinuous and without organizing principles in relation to Biology, although it touches on many social and environmental issues that affect the people of South Africa. The practical skills listed under Learning Outcome 1 contain many innovative suggestions for investigations that are not traditionally practised in Biology, but have more to do with social science research. The topics listed under Learning Outcome 3 reveal that the view of science that is portrayed in this syllabus is versatile, incorporating indigenous knowledge systems, and emphasizing the tentative nature of science. Students are expected to debate complex and sophisticated issues such as creationism versus evolution, land ownership issues, and the impact of ethics and beliefs on scientific

understanding. These topics require a deep knowledge of the subject before meaningful debate can take place, and unfortunately the prescribed content does not provide this knowledge.

The curriculum documentation includes 116 pages in total.

## The examined curriculum

It should be noted that with regard to South Africa, only the old syllabus has been examined, and the discussion below therefore excludes the new curriculum.

Examinations in all countries included multiple-choice and/or one-word answer questions in their summative assessment. Examinations differed in the weighting given to multiple-choice questions. The questions were worth two marks each in the South African papers, and one mark each in papers in each of the other countries, despite the high levels of reasoning sometimes required. The average number of marks per question varied between two and just over four, with South African IEB papers having the highest ratio at 4.1 marks per question.

Examinations also included free-response questions that require longer answers, although the form of these questions differed considerably. In the Ghanaian paper, for example, the section labelled 'essay' contained seven questions worth twenty marks each, from which students had to answer four. Each question was divided into subsections, so that the highest mark allocation for a single question was seventeen marks. The only paper that contained a question that made it possible for students to construct a substantial essay was the South African IEB Higher Grade paper. The essay required here was worth 60 marks, and had to consist of about 600 words. One may question whether essay-writing is a necessary skill for Biology students, but certainly only the IEB paper provided this opportunity for students to demonstrate in-depth knowledge of a topic.

The South African papers contained far more questions than those of any other country. They also required a higher level of visual literacy. South Africa is the only country that assesses only the final year of schooling

in the final examination.

The length of the papers, number of individual questions, and requirements in terms of visual literacy all have implications for the demands they place on predominantly English second-language speakers in terms of reading and constructing their answers in English. Evaluators criticized the South African papers for being too long, and requiring a higher level of reading and visual literacy than papers from other countries. They also singled out the Zambian Paper 1, which contained some questions that they found difficult to comprehend.

The practical examination in Ghana, Kenya, and Zambia required learners to examine specimens and/or carry out experiments in the laboratory. South Africa does not have a separate practical examination, but several questions in the theory papers were built around standard demonstrations of biological processes such as the factors required for photosynthesis, measurements of transpiration rate, root pressure, and respiration. Some of the experiments illustrated in the examination papers are beyond the scope of school laboratory work, and even the simplest experiments are probably not carried out in most South African schools. The intention of including these experiments and results is to highlight the importance of practical work in Biology, and to change the perception of Biology from a subject that can be rote-learned to one that foregrounds experimental and analytical skills.

Some of the data response questions were also inappropriate. For example, in a South African Higher Grade paper, one such question referred to an athlete exercising on a running machine—a scenario which is likely to be unfamiliar to the large majority of South African learners. Evaluators were also puzzled that the mechanics of kidney machines appeared in some recent South African examination papers, and in the Zambian paper of 2004. They questioned how many children in African would have had experience of these machines, and why it would be important to know about them.

However, incorporating questions relating to experiments that the majority of learners may never have carried out, using equipment that they have never seen (as is likely the case in most South African schools) is

no substitute for assessing learners' ability to handle real apparatus, set up authentic investigations, collect and interpret results, or to observe and draw real specimens. Incorporating a practical examination is commendable, but may not be possible to manage in South Africa because of the large enrolment in Matric.

## Summary of analysis of cognitive operations

All the countries shared the following features: Procedural knowledge was accorded the lowest percentage of marks of the knowledge dimension, and very few marks were awarded in cognitive categories above 'apply'. Kenya and South African Higher Grade were remarkably similar in the percentage of marks allocated to each knowledge dimension, with about half of the marks allocated to conceptual knowledge, approximately one-third to factual knowledge, and the remainder to procedural knowledge. Zambia had approximately equal percentages of the marks allocated to factual and conceptual knowledge, followed by about 16% of the marks allocated to procedural knowledge. The South African IEB Higher Grade paper had almost 60% of the marks allocated to conceptual knowledge, with fewer marks allocated to factual knowledge than other examining bodies. South African Standard Grade and Ghana were closely similar in terms of their weightings in the knowledge dimension, with factual knowledge far ahead of conceptual and then procedural knowledge.

In the cognitive dimension, Zambia and South African Higher Grade had very similar weightings in 'remember' and 'understand', and both had smaller weightings on 'apply', 'analyze', 'evaluate' and 'create'. IEB Higher Grade had a similar pattern, with higher weighting on understanding than the other countries. Kenya had a lower weighting on 'understand', but higher weighting on 'apply' than all other countries. Kenya had very few marks allocated to higher-order cognitive skills.

South African Standard Grade and Ghana had closely similar weightings in 'remember' and 'understand', but South African Standard Grade extended into higher-order cognitive skills, with the exception of 'create'. The Ghanaian paper had negligible weighting on skills above 'apply'.

## Summary of examination-related information, and ranking South Africa against other countries

Compared with the examination papers from other countries, the South African papers test a wider range of cognitive skills and knowledge dimensions, but assess only one year of study. Ghana, Kenya, and Zambia assess the work covered in all the years of senior secondary school in their final papers. This could make the South African papers narrower and easier to prepare for, as learners have a smaller volume of work to prepare, but on the other hand it could have the opposite effect, as examinations testing three or four years' work could tend to lack depth. It is not clear from this research which practice is better.

South Africa has no practical examination, whereas the other three countries have practical exams that require learners to demonstrate skills in handling laboratory equipment, as well as observing, drawing, and identifying specimens. Evaluators very clearly argued for the value of practical examinations in testing skills that cannot be tested through written examinations, but questioned whether it is realistic to expect South Africa, with its large learner cohorts, to go this route.

The smaller scope of content in the South African final examinations was specified in terms of weighting given to different topics in official documentation. This practice may be discontinued when the new curriculum for Life Sciences is first examined in 2008. Weighting of various topics was not given in the documents provided by the other countries, and may change from year to year, thus increasing the level of unpredictability of the examinations.

The level of difficulty of South African Higher Grade papers from the national Department of Education was rated below that of the IEB paper, but this was mostly due to the fact that one-third of the marks on the IEB paper were allocated to an essay question, which was rated as the most difficult type of question. The Department of Education paper had two mini-essays, each worth 18 marks. In relation to other countries, South African Higher Grade papers, set by the national Department of Education, had fewer marks allocated to difficult questions than IEB, Ghana, and Kenya papers, while the Zambian papers contained fewer

difficult questions than the South African Standard Grade papers.

In comparison with other countries, South African exit-level examinations contained more questions, requiring more reading, and relied on visual literacy more than in other countries. Many questions were based on experimental set-ups, which may or may not have been familiar to learners.

Ghana exhibited the most marked distinction between theory and practical examinations, while other countries included experimental investigations and data analysis in the theory paper. A common feature of all papers was that most of the marks were allocated to factual and conceptual categories of the knowledge dimension, and fewer marks allocated to procedural knowledge. No marks were allocated to metacognitive knowledge. In the cognitive dimension, very few marks were allocated to analyze, evaluate, and create cognitive skills, with the highest number of marks in remember and understand-type questions, and fewer in apply. The South African Higher Grade paper had the greatest spread of marks across all cognitive levels.

Regarding overall level of difficulty, the South African paper was found to be on a similar level to those of the Kenyan and Zambian papers. The Ghanaian paper was rated as about the same level of difficulty as the South African Standard Grade paper, and the two papers covered a similar range of cognitive operations and levels. However, the examined syllabus of Ghana covered three years of study, whereas that of South Africa covered only one year. The IEB paper was rated as the most difficult paper, with a high concentration of questions in the understand conceptual cell in the Revised Bloom's Taxonomy, and the highest proportion of marks in difficulty level 3. Zambia had few marks allocated to difficult questions, and exhibited the biggest disparity between the levels of difficulty of its examination papers. Some of the multiple-choice questions (Paper 1) required several steps of reasoning, and seemed to the evaluators to be very difficult, given the time allowed for the paper, and the fact that each question was worth only one mark. By contrast, Paper 2 was rated as a very easy paper.

An important constraint on this analysis is that previous exposure to the questions would have altered the analysis very considerably, and this

information was not available, nor could evaluators have analysed it in the time available. Likewise, making judgements about the appropriateness of examination papers for the subject was difficult, because it depends on the priorities of the country. On the whole, most of the examination papers tested the intended curriculum of the country. Questions were, in general, appropriate for the subject.

The examination papers were of equivalent standard in terms of reproduction, clarity, and layout. Evaluators queried the wording of a few questions, and, in particular, the wording of some questions in the South African Higher Grade paper. Where space for writing, drawing, or answering questions was required, it was provided. Marking memoranda were sufficiently detailed to facilitate equivalence in marking across markers. It is notable that the South African examined curriculum omits the following topics, which are central to Biology and which are assessed to greater or lesser degrees in other countries:

- Classification
- Genetics and heredity
- Ecology (apart from population dynamics)
- Cell structure and function
- Reproduction
- Movement
- Life processes in organisms other than flowering plants and mammals
- Social applications of Biology
- Growth and development.

In summary, then, the South African exit-level examinations for Higher Grade in 2004 compared favourably in terms of levels of knowledge, difficulty levels, and types of cognitive operations tested, although the scope of material tested in South Africa was smaller than in other countries, and the absence of a practical examination meant that some aspects tested in other countries were not tested in South Africa.