CHAPTER 8

LIFE SCIENCES

The following report should be read in conjunction with the Life Sciences question papers of the November 2021 NSC examinations.

8.1 PERFORMANCE TRENDS (2017–2021)

The number of candidates who sat for the Life Sciences examination in 2021 increased significantly by 64 988 candidates compared to that in 2020, i.e. 20,4% of the cohort.

There was an improvement in the pass rate this year which halted the downward trend since 2018. The pass rates at 30% (Level 2) remained constant at approximately 71% of the cohorts for the past two years. However, there was an increase in the achievement level at 40% (Level 3) from 47,9% to 51,3% over this period.

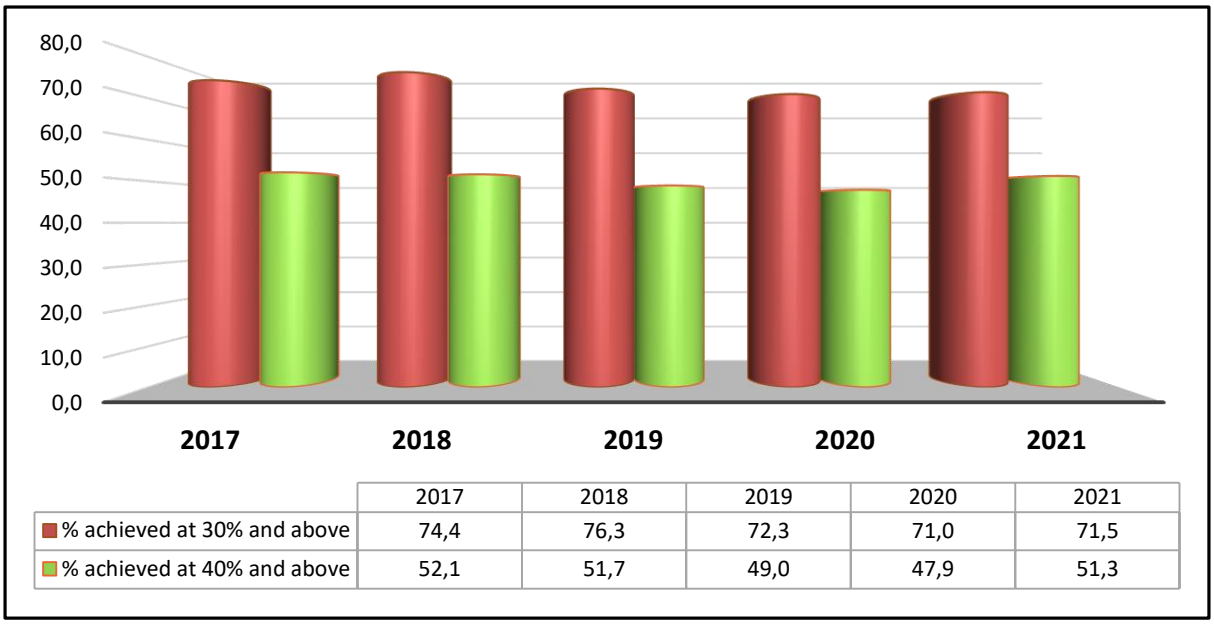
Given the increase in the size of the cohort, the number of passes achieved increased considerably at Level 2 by 47 884 and at Level 3 by 43 989. Furthermore, the percentage of distinctions (over 80%; Level 7) improved from 2,3% to 3,7% which converts into a pleasing increase in the total number of distinctions from 7 342 in 2020 to 14 216 in 2021.

The results reflected above were despite the challenging circumstances brought about by the Covid-19 pandemic over the past two years which affected the teaching and learning activities of the 2021 cohort. This appears to have been the result of creative intervention strategies by teachers and subject advisors as well as schools and provincial education departments. The resourcefulness and diligence of the above-average candidates also contributed to the overall performance in the subject.

Table 8.1.1 Overall achievement rates in Life Sciences

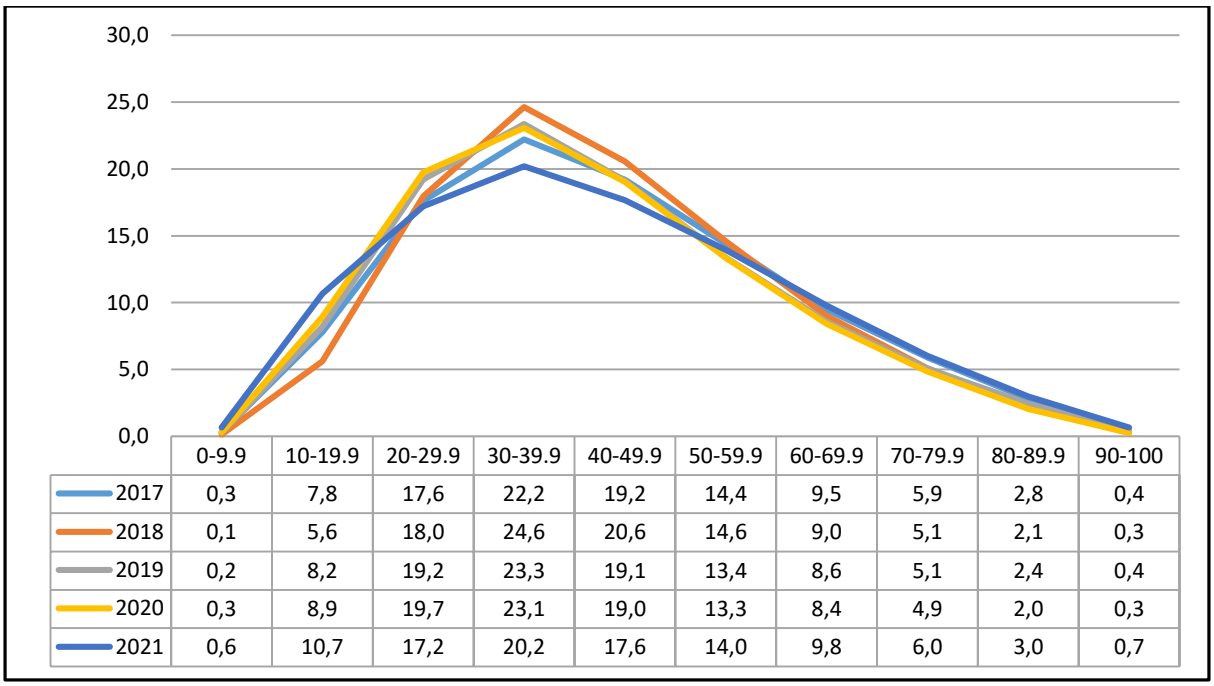
Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above	No. achieved at 40% and above	% achieved at 40% and above
2017	318 474	236 809	74,4	166 071	52,1
2018	310 041	236 584	76,3	160 208	51,7
2019	301 037	217 729	72,3	147 436	49,0
2020	319 228	226 700	71,0	153 028	47,9
2021	384 216	274 584	71,5	197 017	51,3

Graph 8.1.1 Overall achievement rates in Life Sciences (percentage)



	2017	2018	2019	2020	2021
% achieved at 30% and above	74,4	76,3	72,3	71,0	71,5
% achieved at 40% and above	52,1	51,7	49,0	47,9	51,3

Graph 8.1.2 Performance distribution curves in Life Sciences (percentage)



	0-9.9	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	70-79.9	80-89.9	90-100
2017	0,3	7,8	17,6	22,2	19,2	14,4	9,5	5,9	2,8	0,4
2018	0,1	5,6	18,0	24,6	20,6	14,6	9,0	5,1	2,1	0,3
2019	0,2	8,2	19,2	23,3	19,1	13,4	8,6	5,1	2,4	0,4
2020	0,3	8,9	19,7	23,1	19,0	13,3	8,4	4,9	2,0	0,3
2021	0,6	10,7	17,2	20,2	17,6	14,0	9,8	6,0	3,0	0,7

Life Sciences: background information

The NSC examination in Life Sciences specifically sets out to assess the acquisition of scientific skills as outlined in the *CAPS*. It is therefore encouraging to note that the majority of candidates have developed the necessary skills in data analysis, data presentation (drawing of graphs) and calculations. The application of knowledge to practical situations is an area that appears to require strengthening, as does the evaluation and design of scientific investigations. This form of assessment is found in Papers 1 and 2 and it would serve the learners well if they could master it. Scientific investigations are introduced in Grade 10 and

should be thoroughly reinforced before Grade 12. Training and teacher support on these concepts must be given from Grade 10.

With the implementation of the amended section 4 of the *CAPS* (NSC November 2021), topics on Reproduction and Responding to the Environment in Paper 1 have a greater weighting than before. In Paper 2, there is a higher mark allocation (21 marks) toward the topic of meiosis. This section is assessed more rigorously than before. Teaching and support strategies should, therefore, devote more time and resources on these sections.

There is no longer an essay in Life Sciences examination papers, but the ability of candidates to successfully articulate their responses is still assessed in questions that require extended writing. The very nature of Life Sciences research is based on the ability to read and extract relevant information. Any valid assessment will involve lengthy texts. Learners need to be trained not to be intimidated by these questions and should practise active reading and comprehension skills.

8.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN PAPER 1

General comments

(a) Teachers must make sure that candidates understand instruction verbs such as *state*, *describe*, *explain*, *tabulate* and *calculate,* and how to approach the requirements of the question. Misinterpretation of the instruction verbs reflects in low learner performance.

(b) Many candidates have serious problems with spelling. Sometimes if a spelling error shows ambiguity, candidates may lose marks. For example correct spelling is necessary when writing terms such as *ureter* and *urethra*, *epididymis* and *epidermis*.

(c) Some candidates gave more responses than those required by a question. If only two answers were required, only the first two answers will be marked according to Marking Principle 2 of Life Sciences.

(d) Poor performance is still evident in questions based on scientific investigations despite the support provided in the diagnostic reports of previous years.

(e) There was also poor performance in questions on the Endocrine System, Homeostasis and Reproductive strategies.

(f) Teachers need to identify the links between content in Grades 10, 11 and 12. Emphasis must be placed on content that requires deep understanding and that supports content in Grade 12. The negative feedback mechanisms must be dealt with properly in Grade 11 when teaching nutrition, gaseous exchange and excretion.

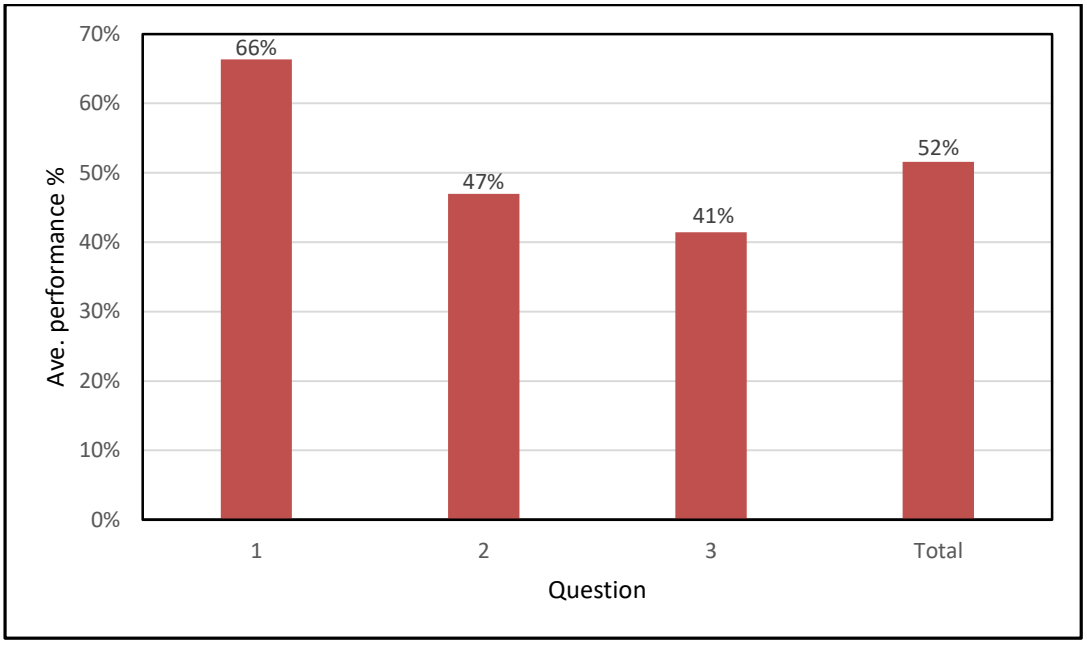
(g) When using past papers for revision, teachers must ensure that learners do not regard the marking guidelines as definitive or complete information on a particular topic. Scenarios might well be different depending on the demands of a question. Learners need to identify the requirements of a question to answer it appropriately.

8.3 DIAGNOSTIC QUESTION ANALYSIS FOR PAPER 1

The weakest performance by candidates was recorded in the subquestions on the Eye, Negative Feedback Mechanisms of Female Hormones (endometriosis), Thyroxin and TSH and Reproductive Strategies.

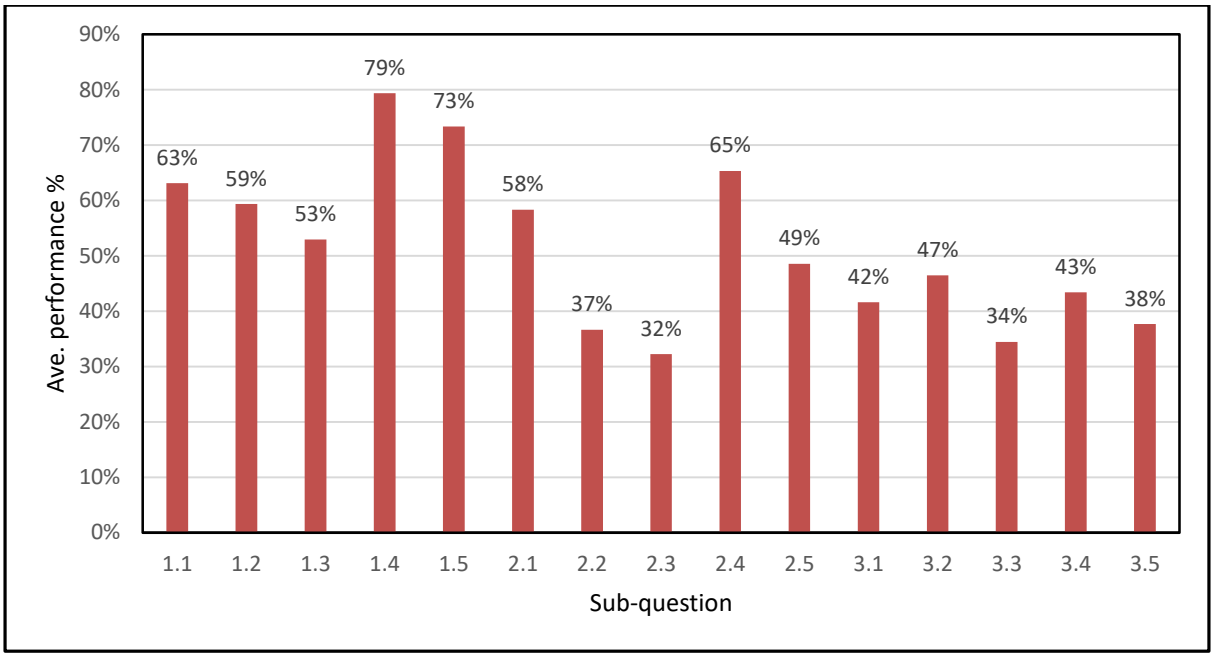
The following graph is based on data from a random sample of candidates. While this graph might not accurately reflect national averages, it is useful in assessing the relative degrees of challenge of each question as experienced by candidates.

Graph 8.3.1 Average performance per question in Paper 1



Q	Topics
1	Multiple Choice, Terminology, Matching Items, Male Reproduction & Human Reproduction
2	Neurons, Sense Organs and Human Reproduction
3	Brain, Endocrine System and Homeostasis, Plant hormones and Reproduction Strategies

Graph 8.3.2 Average performance per subquestion in Paper 1



Sub-Q	Topic	Sub-Q	Topic
1.1	Multiple-choice Question	2.4	Hearing
1.2	Terminology	2.5	Reproduction (Developing Foetus)
1.3	Matching Items Question	3.1	Brain and Kidney
1.4	Reproduction (Male Reproductive System)	3.2	Temperature on blood flow
1.5	Reproduction (Sperm and Ovum)	3.3	Thyroxin (Negative Feedback)
2.1	The Neuron	3.4	Investigation (Bean Seeds)
2.2	The Eye	3.5	Reproduction (Vertebrates)
2.3	Endometriosis		

8.4 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN PAPER 1

QUESTION 1: MULTIPLE-CHOICE, TERMINOLOGY, MATCHING ITEMS, HUMAN REPRODUCTION AND NEURONS

Common errors and misconceptions

(a) In Q1.1 candidates performed well except for Q1.1.7 where they could not interpret the graphs correctly and Q1.1.9 where they had to determine the reason for a smaller volume of urine in a person.

(b) In Q1.2 performance in biological terms has improved but the following remains problematic for many candidates. In this regard, candidates:

- Provided the term *pregnancy* in Q1.2.3 instead of *gestation.* Gestation is the specific time period of development of the foetus while pregnancy includes all the changes that take place during this period. In Afrikaans the term *'draagtydperk'* was not accepted as it refers to pregnancy rather than gestation.
- Provided the terms *phototropism and geotropism* in Q1.2.4 when the required term was *tropism*.

- Wrote *chorion* or *amnion* instead of *allantois* and *seminal tubules* instead of *seminiferous tubules*. In Afrikaans the term '*spermbuisies'* was not accepted.
- Used the abbreviation ABA in Q1.2.8 instead of giving the correct term *Abscisic acid*. Some also just wrote *Abscisic* and left out *acid*.

(c) In Q1.3.1 many candidates did not know the difference between an *exocrine* and an *endocrine gland*. In Q1.3.2 most candidates did not consider the pancreas as an exocrine gland and that the *peripheral nervous system* is made up of both *cranial* and *spinal nerves*.

(d) Candidates lost marks in Q1.4 since they confused *urethra* with *ureter* and when asked to give both the letter and the name of a part, they wrote only the letter or the name.

(e) Marks were lost in Q1.5 due to candidates' inability to distinguish between an *ovum* and the *amniotic egg*; *mitochondria* and *mitochondrial DNA*; *oogenesis* and *ovulation*. They also wrote *jelly membrane/wall* instead of *jelly layer*.

Suggestions for improvement

(a) It is important to teach learners to write only one letter in multiple-choice questions. If a candidate gave more than one letter for a response, they were not awarded any marks.

(b) The abbreviation *ABA* for *Abscisic acid* was only marked as a concession for 2021 and will not be accepted in future. Spelling is also very important for terminology. Incorrect spelling often changes the meaning of the word and marks were consequently lost in this regard. Teachers should emphasize the difference between *pregnancy* and *gestation* as highlighted earlier. Teachers should use various strategies to improve the teaching of terminology. This has been outlined in the Diagnostic Reports of the previous years.

(c) Learners should be encouraged to read questions with proper understanding. Teachers must emphasise that learners must follow instructions correctly when answering questions.

(d) Certain sections of work, especially those that involve structure and function (such as the reproductive system in Q1.5 the ovum and the sperm) are best taught using diagrams. Teachers should give learners multiple opportunities to label drawings and write in the functions next to the labels.

(e) Teachers should use the information provided by the *Examination Guidelines* and not teach unnecessary content which might be provided in some textbooks.

QUESTION 2: NEURONS, SENSE ORGANS, ENDOMETRIOSIS AND HUMAN REPRODUCTION

Common errors and misconceptions

(a) In Q2.1.3 some candidates were not able to compare neurons. They did not always pick up that neuron 1 had a myelin sheath and neuron 2 did not, and therefore could not explain the transmission speed of the impulse. Both neurons were *motor neurons* as stipulated in the *Examination Guidelines,* but *multipolar neurons* were also accepted as a concession for 2021 only.

(b) In Q2.1.4 candidates understood the reason why a person could not respond if a motor neuron is damaged, but they did not explain the complete pathway. They described the *reflex arc* instead of explaining the *reflex action*. Also, they mentioned spinal cord only without mentioning the brain. They needed to mention the entire central nervous system.

(c) The following common errors were observed in Q2.2:
- In Q2.2.1 some candidates confused the *Choroid* in the eye with the *Chorion* in the developing foetus, and in Q2.2.5 *Circular muscles* with *Ciliary muscles*.
- In Q2.2.3 candidates needed to state why the yellow spot had the clearest image. It must be noted that the yellow spot consists of cones only and therefore has the highest concentration of cones. There are no rods in the yellow spot. If the candidates answered *rods and cones are in the highest concentration* they were not awarded a mark. Photoreceptors were also not accepted as an alternative for cones as it implies both rods and cones.
- In Q2.2.4 some candidates wrote a comparison of the functions of parts B (sclera) and F (lens), rather than a comparison of the structure. Candidates also lost marks as their comparisons did not refer to the same structural feature. If a candidate stated that *B is inelastic* then they should state that *F is elastic*. If they wrote *B is elastic* and *F is transparent* the two statements did not compare the same feature.
- Q2.2.6 was a higher-order question which, as expected, was poorly answered. Candidates understood that light focussed in front of the retina but failed to explain why this was so. They needed to state that both the spectacles and the lens were refracting the light inwards/converging. No marks were credited for refracting light outwards/diverging.

(d) Q2.3 was poorly answered. Questions 2.3.2 and 2.3.3 were higher-order questions and most candidates could not apply their knowledge in answering these questions.

Poor performance is Q2.3 can be attributed to the following factors:
- Candidates wrote *uterine wall* instead of *uterus* in Q2.3.1. The question asked for the structure where the endometrium develops. They were not credited for *baarmoeder* as it refers to the womb which was also not accepted in English.
- In Q2.3.3 the progesterone inhibits the pituitary gland from producing FSH. Most candidates were not aware of this negative feedback mechanism. The lack of FSH would then prevent a follicle from developing and because there is no developing follicle it would not produce oestrogen. This would then cause endometriosis. Candidates only wrote *progesterone inhibits FSH production* whereas in any negative feedback mechanism an endocrine gland must be inhibited or stimulated. Therefore, candidates that wrote the answer without mentioning that the *pituitary was inhibited from producing FSH* were not credited.
- In Q2.4 they had to describe the process of hearing. The performance of candidates was more encouraging in this question. Some candidates did not describe the process using full statements. They only used keywords and flow charts, and marks were consequently not awarded.

(e) Candidates generally performed well in Q2.5.1 and Q2.5.2. Some did not properly read Q2.5.3 to describe what happens after the zygote is formed. They inappropriately included the whole process leading up to fertilisation. Some did not mention that the zygote divides by mitosis or they incorrectly wrote meiosis. They also gave the term *blastocyte* (a type of blood cell) for *blastocyst/blastula*.

(f) In Q2.5.4 some candidates wrote all the functions of the placenta when the question required them to only write those functions that are involved in the protection of the

foetus. They also did not read this question clearly. Protective functions prevent harm from being done to the foetus. In Q2.5.5 some stated that the oviparous organism received nutrition from the egg rather than the egg yolk and albumen.

Suggestions for improvement

(a) Questions such as Q2.2.1, Q2.2.2, Q2.5.1, Q2.5.2 (labelling of diagrams and functions of parts), Q2.2.5 (the pupillary mechanism) and Q2.4 (hearing) are recall questions. This type of question should be practised regularly in class through daily testing to ensure that learners do not lose marks from level 1 questions.

(b) Learners must be guided and supported in the skill of *reading with comprehension.*

(c) Learners must follow instructions correctly when answering questions according to the verb of instruction, e.g. *name*, *state*, *describe*, *explain*, *calculate*.

(d) Teachers must expose learners to more questions that require comparison and differentiation in their teaching and assessment (both informal and formal).

(e) Teachers should continue to expose learners to higher-order questions that require the application of knowledge. They must use past papers for questions and focus on explaining answers in a step-by-step method so that learners can obtain full marks.

(f) Teachers must expose learners to extracts like the one on endometriosis. This question had a high cognitive demand requiring an application of knowledge. Learners must be exposed to such questions and teachers must assist learners with reading with understanding.

(g) When covering the process of hearing, teachers must emphasize or stress the point that sound is in the form of waves (in the outer ear); vibrations (middle ear) and pressure waves (inner ear), which are then converted into impulses.

(h) Teachers should emphasise the effects of too much or too little of a hormone on the body and allow learners to explain the effects.

(i) When explaining negative feedback mechanisms, emphasis must be on the stimulus (high/low), the endocrine gland involved and the effect (more/less).

A better understanding of negative feedback mechanisms can be achieved using the 7-step process which is also elaborated in the *Mind the Gap* study guide under the section on homeostasis. This study guide presents a useful format for recording, understanding, and recalling the different negative feedback mechanisms using a generic format. It consists of the following steps:

Step 1: An imbalance occurs
Step 2: A control centre is stimulated
Step 3: Control centre responds
Step 4: Message sent to target organ(s)
Step 5: The target organ responds
Step 6: It opposes/reverses the imbalance
Step 7: Balance is restored

An application for this process is:

GENERAL	SPECIFIC
IMBALANCE	Progesterone levels **increase** (above normal)
CONTROL CENTER STIMULATED	The pituitary gland is stimulated
CONTROL CENTER RESPONSE	The Pituitary gland produce **less** FSH
MESSAGE TO TARGET ORGAN	**Low** levels of FSH inhibits the follicle
TARGET ORGAN RESPONSE	The follicle on the ovary **do not develop**
IMBALANCE CORRECTED	Therefore, oestrogen will not be secreted

In the case of pregnancy this will continue for 9 months. In the case of endometriosis this will reduce oestrogen levels to prevent the formation of the endometrium in the wrong place.

(j) Subject advisors should organise workshops for Life Sciences teachers on the topics in which learners did not perform well, e.g. the nervous system including the eye and ear, the endocrine system and homeostasis, negative feedback mechanism of thyroxin and TSH, plant hormones and scientific investigations.

QUESTION 3: BRAIN AND KIDNEY, TEMPERATURE ON BLOOD FLOW, THYROXIN (NEGATIVE FEEDBACK) INVESTIGATION (BEAN SEEDS) AND REPRODUCTION STRATEGIES

Common errors and misconceptions

(a) In Q3.1.2 some candidates could not give the correct function of the *corpus callosum*. They wrote the corpus callosum *separates* or *divides* the two hemispheres of the cerebrum. Candidates had to state that it connects the hemispheres of the *cerebrum* since the cerebellum also has two hemispheres.

(b) Q 3.1.4 (b) was poorly answered. Candidates had to read and interpret text before answering this higher-order question and not just quote directly from the text for answers. They failed to write how high breathing rate and heart rate contribute to increased energy production. They neglected to explain that an increase in breathing rate will lead to inhalation of oxygen. An increase in the heart rate will cause blood to be pumped to the skeletal muscles faster to provide more glucose and oxygen to cells quicker, thereby increasing the rate of cellular respiration. Many candidates wrote that more blood will be pumped, which is scientifically incorrect. There is not more blood. The blood volume stays almost the same, except when there is bleeding or a blood transfusion is done.

(c) Q3.1.4 (c) candidates did not explain how the *medulla oblongata* is involved in carbon dioxide homeostasis. Some candidates wrote only that the CO_2 level decreased instead of writing the CO_2 decreased to its normal level.

(d) The following common errors were observed in Q3.2:

- In Q3.2.2 some candidates wrote that the high environmental temperature is directly proportional to the high average blood flow to the skin. The information in the table did not show such a relationship between the two.
- In Q3.2.3 candidates had difficulty with calculating the percentage increase in blood flow to the skin between 5 ℃ and 35 ℃ correctly.
- Many candidates could recall only the results and were unable to interpret and explain it in Q3.2.4. Some did not understand the meaning of *vasodilation* and referred to *bigger* or *larger* blood vessels.

- In Q3.2.5 many candidates could not explain in a cause-effect way why the tissue in the skin would die when frostbite occurs at exposure to very low temperatures. They did not link less blood flow to the skin with less supply of oxygen/nutrients to cells which leads to the tissue dying.

(e) In Q3.3.2 candidates could not explain that the lower concentration of thyroxin in the blood leads to the lower rate of metabolism; and also that a lower rate of metabolism contributes to the storage of more fat in the body.

(f) In Q3.4.1 some candidates were unable to identify the dependent variable for this investigation. The dependent variable is extracted from the aim of the investigation stated in the question. Candidates did not recognise the tip of the stem as the site of auxin production in Q3.4.2

(g) Q3.5.2 was poorly answered by many of the candidates as they were unable to explain the two reproductive strategies adopted by great white sharks to increase their reproductive success. Although some of the candidates identified the strategies correctly, they failed to explain the reason for adopting those strategies.

(h) In Q3.5.3 candidates were not familiar with recognising the production of a large of number of gametes as a strategy to increase the chances of fertilisation despite the threat of predation and other undesirable environmental factors during external fertilisation.

Suggestions for improvement

(a) Teaching of the different parts, functions and location of the brain should be taught with the use of diagrams. It must be emphasized that the corpus callosum connects the two hemispheres of the brain and not divide it.

(b) Teachers must give learners more activities with text extracts as a form of practice and on how to respond on the questions thereof.

(c) Teachers should use a diagram to illustrate the structure of the skin with emphasis on the parts involved in thermoregulation.

(d) Negative feedback mechanism of hormones also requires more in-depth teaching. Learners should not only know how to describe the negative feedback mechanism but should also be exposed to how these feedback mechanisms work in real situations.

(e) Teachers should pay more attention to the teaching of the effect of auxins in phototropism, geotropism and apical dominance. They must teach learners the role of auxins with reference to relevant diagrams.

(f) Teachers must place more emphasis on scientific investigations such as those assessed in Q3.4. Learners should be taught on how to identify variables using the aim of the investigation and not the results. Every formal assessment should assess Specific Aim 2, to familiarise learners with the scientific skills.

(g) Teachers must integrate scientific investigations into the teaching and learning process. Prescribed practical work in plant responses must be done. Previous examination papers are useful in exposing learners to the different types of investigations of this topic. Teachers must emphasise cause-effect relationships and teach learners the skill of formulating answers in a logical way.

(h) A greater emphasis on practical work and practical tasks of good quality in Grades 10 and 11 will also assist with preparing learners more adequately for questions based on scientific investigations. This is especially important since knowledge of scientific investigations is assessed in both Paper 1 and Paper 2.

(i) Teachers must expose learners to answering paragraph-type questions. Although the essay has been removed from the paper, learners are still required to answer questions of 7 to 8 marks.

8.5 OVERVIEW OF CANDIDATES' PERFORMANCE IN PAPER 2

General comments

(a) In general, candidates did not perform as well as expected in recall-type questions. Basic terminology was confused and where a description of processes was required, the sequence and accurate description of the steps were often confused. This is an indication that the candidates are not learning basic terms, laws, principles and definitions.

(b) Candidates performed well in questions requiring short answers and where responses were quoted directly from an extract. Performance was poor in questions requiring extended responses in the form of paragraphs or in questions where answers had to be substantiated.

(c) Candidates may learn and understand specific concepts, but perform poorly when they have to apply this knowledge and understanding to a new scenario.

(d) Many candidates had difficulties with the interpretation of tables, graphs, case studies and diagrams. They also found it challenging to phrase their responses correctly.

(e) Certain problem areas were mentioned in previous reports. For example, investigations which form part of the work throughout the year remain a challenge to some candidates.

(f) Candidates' performance indicates that they are still having trouble with certain aspects of meiosis, genetics and evolution.

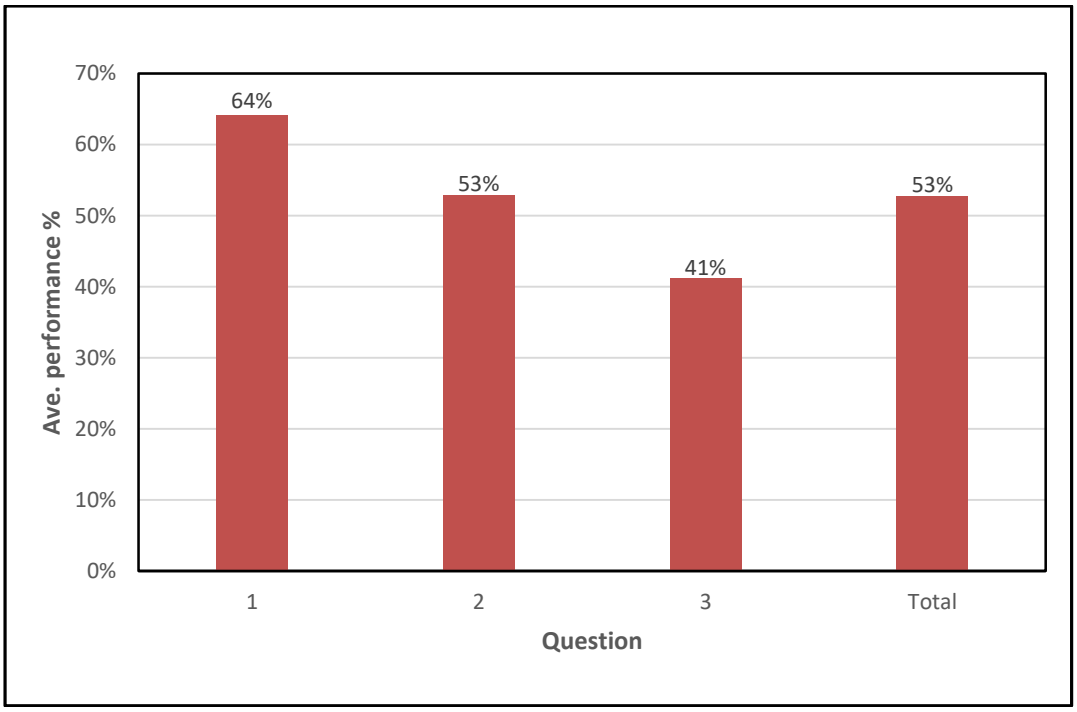
(g) Teachers should always be guided by the *CAPS* and the *Examination Guideline* documents for Life Sciences for elaboration on content and the correct phrasing of concepts.

8.6 DIAGNOSTIC QUESTION ANALYSIS FOR PAPER 2

Candidates performed well in Q1, less so in Q2, with the weakest performance in Q3 which was largely based on the sections of Genetics and Evolution.

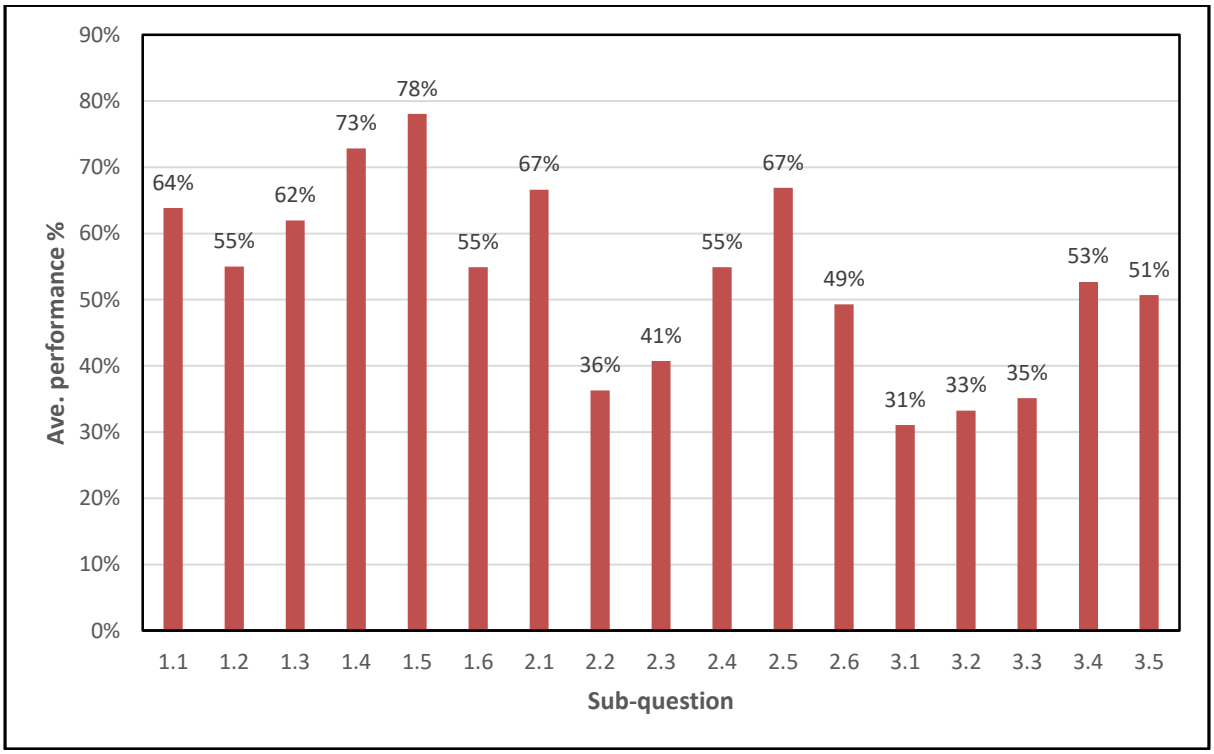
The following graph is based on data from a random sample of candidates. While this graph might not accurately reflect national averages, it is useful in assessing the relative degrees of challenge of each question as experienced by candidates.

Graph 8.6.1 Average performance per question in Paper 2



Q	Topic
1	Multiple choice, terminology, matching items, DNA, Meiosis, Dihybrid cross
2	Protein synthesis, Meiosis, Genetics
3	Genetics, Evolution

Graph 8.6.2 Average performance per subquestion in Paper 2



Sub-Q	Topics	Sub-Q	Topics
1.1	Multiple-choice Questions	2.4	Genetics - Pedigree diagram
1.2	Terminology	2.5	Genetics - Genetic cross
1.3	AB matching	2.6	Genetics - Mutations
1.4	DNA	3.1	Genetics - Cloning
1.5	Meiosis	3.2	Evolution - Speciation
1.6	Genetics - Dihybrid cross	3.3	Evolution - Natural selection
2.1	DNA - Protein synthesis	3.4	Evolution - Scientific investigation
2.2	Meiosis - Non-disjunction	3.5	Evolution - Human evolution
2.3	Genetics - Karyotype		

8.7 ANALYSIS OF CANDIDATE PERFORMANCE IN EACH QUESTION IN PAPER 2

QUESTION 1: MULTIPLE-CHOICE, TERMINOLOGY, MATCHING ITEMS, DNA, MEIOSIS, AND A DIHYBRID CROSS

Common errors and misconceptions

(a) The two multiple-choice questions in which candidates performed poorly were Q1.1.5 and Q1.1.7. A *DNA profile* was to be analysed in Q1.1.5 and this proved problematic for many candidates, as they may be familiar with DNA profiling for forensics, but not for paternity testing. Poor interpretation of the stem of the question in Q1.1.7 resulted in many candidates responding incorrectly. Candidates were supposed to select the option that represented all the missing stages, in the correct order, between the phases shown. This meant that the phases shown were not to be included in the response.

(b) Providing the correct biological terms in Q1.2 was problematic for many candidates. In this regard candidates:

- Provided partial responses, e.g. *phylogenetic*, instead of *phylogenetic tree* in Q1.2.1; *punctuated* rather than *punctuated equilibrium* in Q1.2.3 and *artificial* rather than *artificial selection* in Q1.2.5.
- Lost marks due to poor spelling. Although credit was given in general for phonetic spelling, some responses were a big departure from this.
- Confused similar sounding terms, e.g. *homologous* and *homozygous in* Q1.2.4 as well as *co-dominance* and *complete dominance in Q*1.2.6.

(c) Candidates fared poorly in Q1.3.2 where they were asked to identify the fossils found in South Africa. This performance was unexpected, since these fossil names are clearly listed in the *Examination Guidelines* (2021).

(d) Performance in Q1.4 was encouraging, with infrequent misconceptions being presented. Some candidates confused *hydrogen* bonds and *peptide* bonds in Q1.2.2 and Q1.4.1 (c). Candidates used colloquial language to describe the shape of the DNA molecule in Q1.4.3 instead of using the scientific terminology.

(e) Many candidates lost marks due to misinterpretation of the question. This occurred in the following questions:

- Q1.2.4 where candidates responded to the *type of evidence presented* rather than the *structures* that serve as evidence
- Q1.4.5 where the response was *type of DNA* rather than the *location of DNA*

- Q1.5.1 (b) and Q1.5.2 (a) where the *process of crossing over* and the *point of crossing over* were confused.
- Q1.6 where the *genotypes* were given when *phenotypes* were required, and vice versa.
- In Q1.6.2 (c) where a *genotype* was given when an *allele* was required

(f) In Q5.2 (b) and Q1.5.2 (c) candidates lost credit as they still confused similar terms that occur in this section. These are *chromatid, chromatin, centriole, centromere, centrosome* and c*hromosome.* Refer to page 156 of the *Diagnostic Report of November 2020* for elaboration https://www.education.gov.za/2021NSCExamReports.aspx

(g) Candidates gave the incorrect format of a *dihybrid genotype (e.g*. FHfh) in Q1.6. The two alleles of a gene must be written together, e.g. FfHh.

(h) When asked for a *phenotype* in genetics questions, too many candidates lost marks because they did not use the specific descriptions given in the question, e.g. Q1.6.2(d) and Q2.4.2.

Suggestions for improvement

(a) Curriculum advisors must provide all teachers in their charge with the links to the diagnostic reports. Where possible, hard copies of these must be distributed, more especially to novice teachers.

(b) Curriculum advisors must also ensure that all teachers have copies of the most recent *Examination Guidelines (2021)*. Learners must also have access to the *Examination Guidelines* and use it as a 'tick list' as they study and master each topic.

(c) Teachers must use the *CAPS* document and the *Examination Guidelines* to establish what content is examinable.

(d) The mechanics of how to analyse a DNA profile differs for *forensics* and *paternity testing* must be clarified with learners. Refer to the *Diagnostic Report of 2020* (page 160) on how to assist learners with this concept.
https://www.education.gov.za/2021NSCExamReports.aspx

(e) Where there is poor performance of candidates, it is mostly due to interpretation errors. Teachers must train learners in active reading. Learners must check whether the response requires the naming of a structure or a process; a phenotype or a genotype; a list or a description; a type or a location etc.

(f) Learners need to be trained to write down the various biological terms. Very often the spelling by learners is phonetic, which means that they have only heard the word and not written it down themselves. The importance of correct spelling cannot be overemphasised, especially in Q1.2.

(g) Teachers need to train learners to write the *phenotypes* in exactly the same way as they are described in the question paper and not introduce their own descriptions.

(h) Learners must use only the letters prescribed to represent specific *alleles* and not introduce their own symbols and letters.

(i) Curriculum advisors should draw up lists of similar sounding and confusing terminology, together with their descriptions and avail these to teachers and learners.

QUESTION 2: DNA, MEIOSIS, GENETICS AND GENE MUTATIONS

Common errors and misconceptions

(a) Q2.1 and Q2.2 were well answered as they had a lower cognitive demand with a lower degree of difficulty. A minority of candidates lost marks in Q2.1.3 because they could not differentiate between *transcription* and *replication*. Some candidates could only give a partial explanation of the effect of *non-disjunction* in Q2.2 and only described the effect up to the formation of *gametes* and did not include descriptions of *fertilisation* and *zygote* formation.

(b) Most candidates could list only two of the three required characteristics of *homologous chromosomes* correctly. This question had a high degree of difficulty within a high cognitive demand. Candidates who understood the processes of *meiosis, crossing over, gamete formation, fertilisation* and the *loci of genes* were able to score the maximum marks.

(c) Q2.3.4 posed a challenge for many candidates in that they could identify the difference between the two *karyotypes*, but could not accurately explain it.

(d) Although Q2.4 proved challenging to some candidates, it is encouraging to note that interpretation of *pedigree diagrams* is improving. Candidates were able to use the key to describe the *phenotype* correctly. Q2.4 was scaffolded and candidates who could not identify the *dominant phenotype* in Q2.4.2 were generally not able to respond correctly to Q2.4.3 and Q2.4.4. Candidates who were able to identify the dominant phenotype were, in many cases, unable to articulate how they arrived to that answer.

(e) Q2.5 required a genetic cross based on gender determination in humans. This question had a lower cognitive demand with a moderate degree of difficulty and should have been well answered. This was a separate question to Q2.4, which was based on deafness. Candidates assumed that these two questions were linked and therefore based their genetic cross on deafness and not on gender.

(f) Candidates are still confused as to which letters/symbols to use to represent the *alleles* in the different types of inheritance. Some candidates incorrectly assumed that since the genetic cross referred to gender, that it was based on a *sex-linked trait*, which was not the case. There is also confusion on when and how to use superscripts in *genotypes.*

(g) In Q2.6.2 many candidates, including those above average, failed to give a correct definition of a *gene mutation*. The correct response to this lower-order question was clarified in the *2020 Diagnostic Report on Life Sciences* Paper 2 (page 166). It appears that teachers may not be implementing the recommendations of the Diagnostic Report.

(h) The response to Q2.6.4 was not based on prior knowledge and required reading with comprehension. The high number of incorrect responses shows that candidates are unable to select relevant information from an extract.

(i) The skill in the calculation of percentages has improved substantially. Those candidates who did not score the maximum marks scored at least 2 of the 3 marks in Q2.6.5.

Suggestions for improvement

(a) The confusion between *DNA replication* and *transcription* is common. Both processes involve the same early steps, but that is where the similarity ends. Teachers must emphasise the differences between these two processes. The following similarities exist between the processes of DNA replication and transcription

- Occurs in the nucleus
- The DNA double helix unwinds
- The hydrogen bonds between the N-bases break/the DNA molecule unzips

The table below outlines differences in the processes of DNA replication and transcription.

DNA replication	Transcription
Both strands act as templates	Only one strand acts as a template
Free DNA nucleotides from the nucleoplasm attach to each strand	Free RNA nucleotides from the nucleoplasm attach to the template strand
Complementary base pairing occurs (A-T) and (G-C)	Complementary base pairing occurs (A-U) and (G-C)
Two identical DNA molecules are formed	An mRNA molecule is formed

(b) Concepts like *non-disjunction* (Q2.2), the types of *chromosomes* (Q2.3.2), the similarity of *homologous chromosomes* (Q2.3.3(b)) and the difference in male and female *gonosomes* (Q2.3.4) may all be clarified for learners by using a *karyotype*. An example is provided in the *Diagnostic Report of 2020* (page 157)
https://www.education.gov.za/2021NSCExamReports.aspx

(c) Pedigree diagrams are often used as an assessment tool in genetics. Curriculum advisors need to train teachers on how to facilitate the interpretation of these diagrams. The following steps are generally useful on how to interpret a pedigree diagram:

- Read the stem carefully to identify the inherited trait
- Check if information is given on which trait is *dominant* or *recessive*
- Identify if the trait is sex-linked
  - Use the letters **X** and **Y** in the genotype only if the trait is sex-linked
  - Only the **X** has a superscript and not the **Y**
- Check if there is a key and use it for the proper description of the phenotype
- Write in the phenotype of all the individuals as given in the key/question
- Fill in the genotypes
  - All individuals with the dominant phenotype will be homozygous dominant (e.g. AA) or heterozygous (e.g. Aa).
  - All individuals with the recessive phenotype will be homozygous recessive (e.g. aa)
- An individual with two recessive alleles will have obtained one from each parent
- Work backwards and fill in one recessive allele for each parent
- This will exclude one genotype for individuals with the dominant phenotype.

(d) When asked to explain inheritance of alleles in an individual/s, as in Q 2.4.3, learners must apply the following steps:

- Give the phenotype of the individual(s)
- State the genotype of the individual(s)
- State which allele is inherited from each parent or which each allele is passed on from each parent to the offspring.

(e) To train learners on which notations to use for each of the different types of inheritance, teachers could use the following table:

Type of inheritance	Brief description of the mode of inheritance
Complete dominance	One allele masks the expression of the other allele; e.g. B is dominant over b
Incomplete dominance	Neither of the alleles is dominant over each other. An intermediate phenotype is obtained when both alleles are present.
Co-dominance	Both alleles are equally dominant and both are expressed in the phenotype, e.g. I^A and I^B
Sex-linked	The allele causing the disorder is found on the X-chromosome, e.g. X^HX^h & X^HY
Dihybrid cross	Two characteristics are investigated and therefore there will be four letters in the individual's genotype, e.g. RRYy (two for each characteristic) Gametes will have two different letters, e.g. Ry

(f) To enable learners to develop the necessary skills in calculations and reading with comprehension, teachers should engage learners with past examination papers and their associated marking guidelines. The calculations are generally based on extracting data from a table, graph or extract and candidates must be trained on how to select the relevant data.

QUESTION 3: CLONING, BIOGEOGRAPHY, SPECIATION, EVOLUTION IN PRESENT TIMES, NATURAL SELECTION AND HUMAN EVOLUTION

Common errors and misconceptions

(a) Q3.1 was poorly answered as candidates did not understand the process of *cloning* and the significance of using a *somatic* cell inserted into an 'empty' *ovum*. Candidates also assumed that the *diploid* number of chromosomes in cows is 46.

(b) Candidates were challenged with Q3.2 in general, because it covered two separate concepts, namely *biogeography* and *speciation*. It also appears as if most candidates were familiar with the formation of only two species during speciation and this question had three species.

(c) Candidates used the terms *population* and *species* interchangeably, thereby losing credit. It has to be emphasised that only a population is separated by a geographical barriers and not a species.

(d) Q3.3 was based on *natural selection*. Candidates had a good idea of how natural selection works, but struggled to apply this knowledge to a new scenario.

(e) Q3.4 was based on a scientific investigation. This question had a high cognitive demand and a very high degree of difficulty. Most candidates were unable to provide correct responses to Q3.4.3 and Q3.4.4, as it required interpretation of an extract together with data analysis.

(f) In Q3.4.5 candidates were required to draw a line graph. It is encouraging to note that there is a marked improvement in this skill and most candidates were able to score maximum marks. Some candidates, however, lost marks for:
- Transposing of axes
- Selecting an incorrect scale
- Excluding the (%) sign in the label of the Y-axis.

(g) The performance of candidates in Q3.5 was more encouraging. Candidates seem to have mastered the interpretation of diagrams on human evolution.

Suggestions for improvement

(a) The question on cloning is very similar to one asked in the November 2020 examination. Previous examination papers had also outlined the process of cloning diagrammatically. Teachers should use these questions as teaching tools to clarify the need for the various steps in the process of cloning.

(b) Although learners need to know only the chromosome complement of humans, they must be made aware that different species have different chromosome numbers.

(c) Teachers need to clarify the following concepts in *speciation*:
- A population is separated, not a species
- Speciation occurs due to natural selection
- More than two species may be formed.

(d) Teachers need to clarify the following concepts in *biogeography*:
- *Biogeography* is used as evidence for evolution
- A *common ancestor population* becomes separated generally due to *continental drift* and this further leads to *speciation.*

(e) Teachers must advise learners on how to identify the favourable and unfavourable traits in questions on *natural selection*. They should be trained on how to include the exact description of these traits in their responses.

(f) Learners must also be trained to state the variables exactly as they are stated in the data provided and not to paraphrase.

(g) Curriculum advisors should prepare and distribute a composite document showing the assessment criteria for all the different types of graphs. These may be extracted from previous marking guidelines.

(h) The scientific process is frequently assessed in Life Sciences at a higher cognitive level. Questions on the scientific investigation will always be text and data-rich and learners must be sensitised to not be intimidated by this. Careful and repetitive reading of the stem and investigative process is required. Also, multiple exposures in a classroom situation can acclimatise learners to the style and format of these questions. The list below provides some terms associated with investigations and their meanings:

Term	Meaning
Observation	What the scientists saw, heard or encountered that encouraged them to investigate further.
Hypothesis	A possible prediction and/or explanation of the relationship between the two variables.
Aim	Usually starts with the words *to investigate …* and includes both variables. It describes what the investigation is trying to find out.
The independent (manipulated) variable	This is the variable that the scientists will control.
The dependent (responding) variable	This variable is what reacts or responds to the independent variable.
The controlled variables	All other variables that must be kept constant to ensure the validity of the investigation so that any effect is due only to the change in the independent variable.
The control	A second set up in the investigation that allows a comparison with the results of the experiment. The control is identical to the experiment except that it excludes the variable being tested.
Accuracy	Refers to the care taken when making measurements.
Validity	This refers to the experimental method and how appropriate it is in addressing the aim of the investigation. For example, keeping all other factors constant/identifying the controlled variables help in making an investigation valid.
Results	The evidence produced during the investigation that will either support or refute the hypothesis. These may be presented in the form of an extract, a table, a graph or a diagram.
Improving the reliability of results	Results can be made more reliable if: • The investigation is repeated • A bigger sample size is used • The samples are taken randomly • Many readings are taken to obtain an average reading (these depend on the nature of the investigation),
Conclusion	This is directly linked to the aim of the investigation and confirms or refutes the hypothesis

(i) There are numerous digital platforms available for training, development and support of teachers and learners. Curriculum officials must share the links with teachers and learners on a termly basis to ensure that if this information was missed it may be accessed in the next term.

(j) Teachers should consult all past diagnostic reports when they prepare their lessons to address misconceptions identified in previous years.

(k) The preparatory examinations set by provinces must mimic the NSC examinations as closely as possible in format, content and scope.