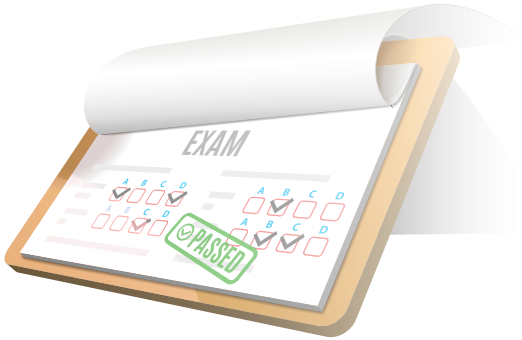


NATIONAL SENIOR CERTIFICATE 2022

DIAGNOSTIC REPORT

PART 1: CONTENT SUBJECTS

CONTENTS – PART 1

CHAPTER 8

LIFE SCIENCES

The following report should be read in conjunction with the Life Sciences question papers of the November 2022 NSC examinations.

8.1 PERFORMANCE TRENDS (2018–2022)

The number of candidates who wrote the Life Sciences examinations in 2022 increased substantially by 14 791 candidates.

The table below indicates a negative trend in the pass rate over the period 2018-2020 with an improvement in 2021. While candidates who passed at 30% (Level 2) remained static at 71,5% in 2021 and 2022, there was a decline in the pass rate at 40% (Level 3) over the past two years from 51,3% to 49,0%.

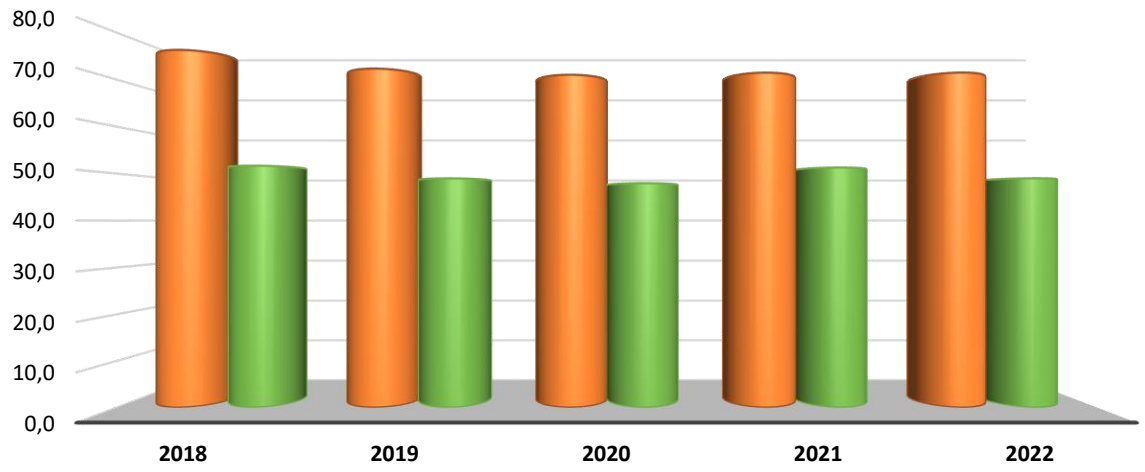
The percentage of distinctions over 80% (level 7) decreased from 3,7% in 2021 to 2,5% in 2022. This converts into a decrease of 4 241 in the total number of distinctions.

In view of disruption to academic programmes in 2020 and 2021, and despite some factors mentioned above, the results achieved by this cohort are commendable. Strategic intervention programmes at all levels (National, Provincial, Districts and Schools) ensured that learners were adequately prepared. The diligence and perseverance of the above-average candidates also contributed to the overall performance.

Table 8.1.1 Overall achievement rates in Life Sciences

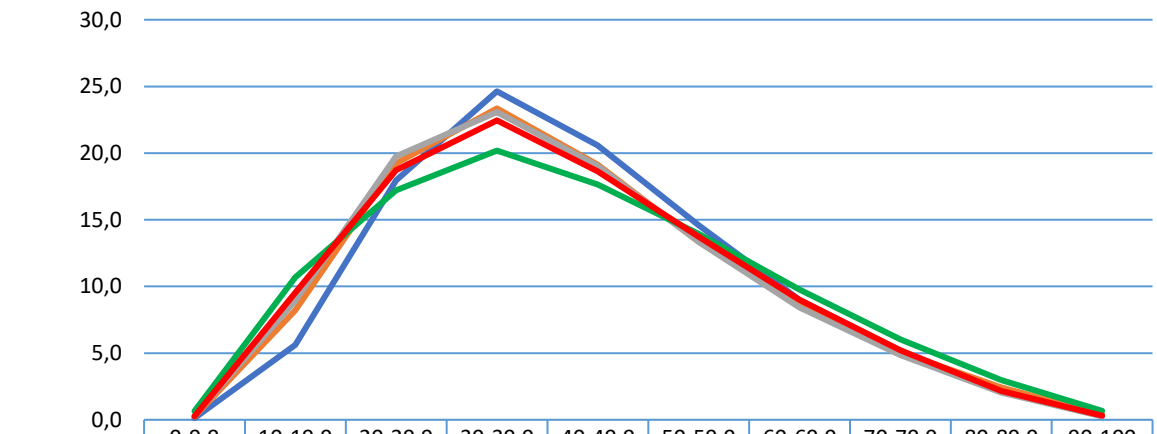
Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above	No. achieved at 40% and above	% achieved at 40% and above
2018	310 041	236 584	76,3	160 208	51,7
2019	301 037	217 729	72,3	147 436	49,0
2020	319 228	226 700	71,0	153 028	47,9
2021	384 216	274 584	71,5	197 017	51,3
2022	399 007	285 217	71,5	195 620	49,0

Graph 8.1.1 Overall achievement rates in Life Sciences (percentage)



	2018	2019	2020	2021	2022
% achieved at 30% and above	76,3	72,3	71,0	71,5	71,5
% achieved at 40% and above	51,7	49,0	47,9	51,3	49,0

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
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
2022	0,3	9,5	18,7	22,5	18,6	13,7	9,0	5,2	2,2	0,3

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. More time and resources should be provided to strengthening these sections.

There is no longer an essay in the 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) The Grade 12 NSC qualification in Life Sciences is a three-year qualification and content from the preceding years may be examined within the context of the Grade 12 curriculum. Teachers need to identify the links between content in Grades 10, 11 and 12 on cellular respiration, blood circulation, nutrition, gaseous exchange and excretion. These sections must be properly emphasised in Grades 10 and 11 and revised in Grade 12, with particular reference to *homeostasis* and the *negative feedback mechanism*. The topic, *Human Impact on the Environment*, is no longer assessed in Grade 12, leaving sufficient time for teachers to revise the aforementioned content.

(b) Candidates struggled to meet the response demand of instruction verbs such as 'name', 'state', 'describe', 'explain', 'tabulate' and 'calculate'. Misinterpretation of the instructional verbs reflects in low learner performance.

(c) Many candidates undermine the importance of correct spelling. In Life Sciences, the incorrect spelling may change the meaning of the response and candidates may lose marks. For example, correct spelling is necessary when writing terms such as *glucagon* and *glycogen*; *chorionic* and *chronic*; *uterus* and *ureter.*

(d) Particular attention must be paid to the disorders of human physiology. The questions based on *goitre, diabetes mellitus, spinal cord injuries* and *the use of grommets* in treating middle-ear infections were problematic for many candidates. It is evident that teachers merely brush over these disorders as they are encountered at the end of each topic. Knowledge of how the structures and processes of a system operate are best explained when application is made to the disorders.

(e) Learners must use the correct biological terminology in their responses, e.g. reference must be made to *higher blood glucose levels* and not *high blood sugar*.

(f) Teachers should emphasise the difference between commonly confused terms, e.g. the difference between *sperm* and *semen*; between an *egg* and an *ovum;* between the *uterine wall* and the *uterine lining; the corpus callosum and the corpus luteum* and between the *amnion* and *amniotic fluid.*

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

(h) Poor performance was still evident in questions based on scientific investigations despite the support provided in the diagnostic reports of previous years. Candidates gave generic responses to questions that required specific information on the investigation provided.

(i) There was unusually poor performance in the sections on *reproductive strategies* and *plant responses to the environment*. These are relatively short topics and it appeared as if some teachers merely glossed over them. It is important to concentrate on these two topics, as they are a compulsory inclusion in the paper for 8 and 13 marks respectively.

(j) Poor performance was also noted in questions on *Human Reproduction* and *Homeostasis.* When teaching these topics, teachers must emphasise the importance of stating the levels of each substance and where these occur, e.g. *more CO_2 is transported to the lungs; the CO_2 levels in the blood decrease*. Candidates will not be credited for merely stating *more CO_2 is transported and levels drop*.

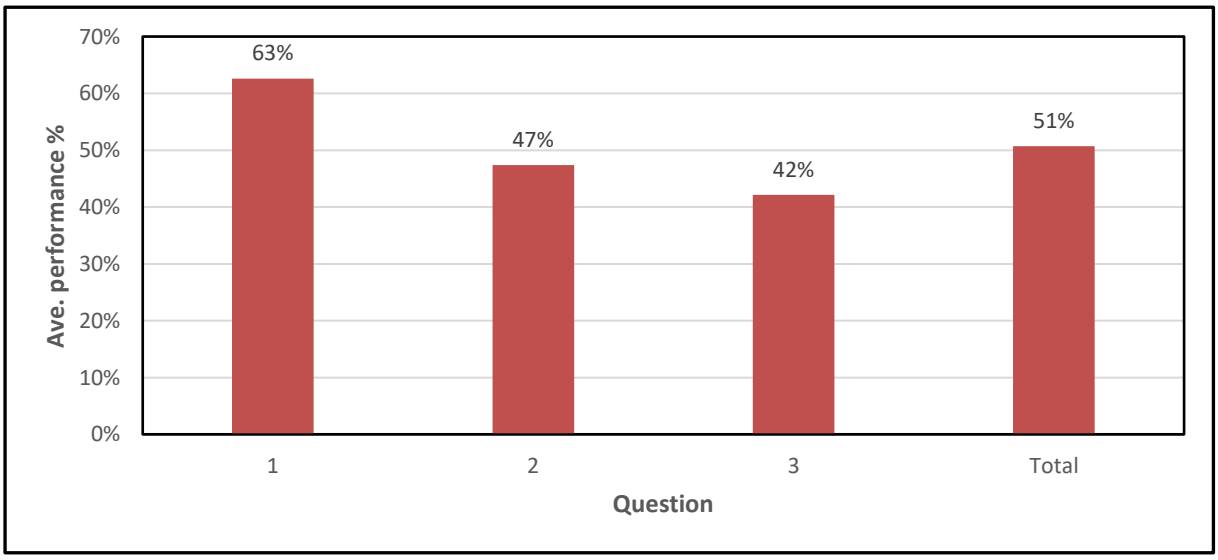
(k) When using past papers for revision, teachers must ensure that learners do not regard the marking guidelines as definitive or exhaustive on a particular topic. Scenarios might be different, depending on the demands of a question. Learners need to identify the requirements of a question to respond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

8.3 DIAGNOSTIC QUESTION ANALYSIS FOR PAPER 1

Based on the Rasch analysis, the weakest performance by candidates was recorded in the subquestions on the *Female Reproductive Hormones* and the *Menstrual Cycle*, *Homeostasis*, *Hearing and Balance in the Human Ear* and *Plant Responses to the Environment*.

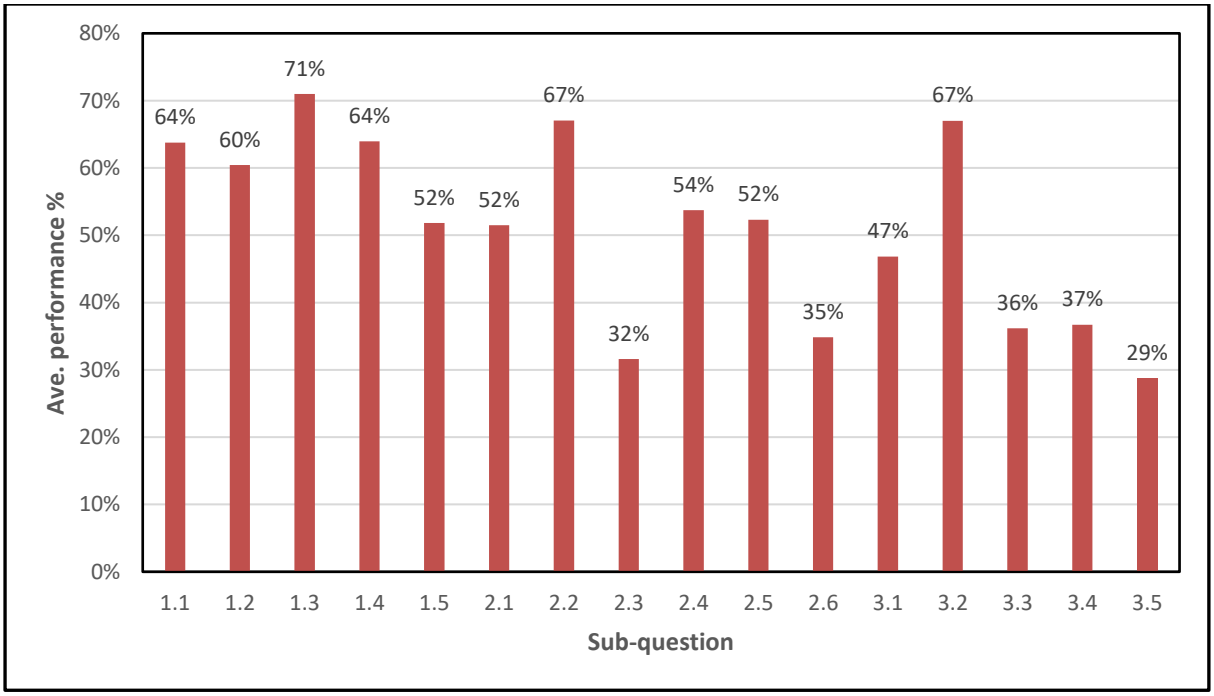
The following graph is based on data from a random sample of candidates. While this graph might not accurately reflect national averages, it is useful in assessing the relative degrees of challenge of each question as experienced by candidates.

Graph 8.3.1 Average performance per question in Paper 1



Q	Topics
1	Multiple choice, Terminology, Matching Items, Receptors – the human eye, negative feedback mechanism (thyroxin)
2	Male reproductive system, gametogenesis - sperm, menstrual cycle, reproductive strategies, homeostasis - negative feedback mechanism (glucose)
3	Brain, receptors - the human ear, scientific investigation and plant responses to the environment.

Graph 8.3.2 Average performance per subquestion in Paper 1



Sub-Q	Topic	Sub-Q	Topic
1.1	Multiple-choice question	2.4	Endocrine – ovarian hormones
1.2	Terminology	2.5	Reproductive strategies
1.3	Matching items question	2.6	Homeostasis of blood glucose
1.4	Receptors – the human eye,	3.1	The brain
1.5	Thyroxin - negative feedback	3.2	Data response (brain injuries)
2.1	The male reproductive system	3.3	Receptors - the human ear
2.2	Structure of sperm	3.4	Scientific investigation (homeostasis)
2.3	Menstrual cycle – FSH and LH	3.5	Plant responses

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

QUESTION 1: MULTIPLE-CHOICE, TERMINOLOGY, MATCHING ITEMS, THE HUMAN EYE AND THYROXIN (NEGATIVE FEEDBACK)

Common errors and misconceptions

(a) In Q1.1 candidates performed well except for Q1.1.9 and Q1.1.10. Candidates had to apply their knowledge of *auxins* to *geotropism*, rather than to *phototropism*, which is

frequently asked. The question was based on an investigation and was pitched at a higher cognitive level.

(b) Q1.2 required candidates to provide the correct biological terminology for a phrase or description. This section required accuracy and attention to detail. Candidates:

- Used the abbreviation *PNS* instead of the full term *Peripheral Nervous System* in Q 1.2.6. It is also evident that the branches of the nervous system are not well taught.
- Lost marks in this question due to poor spelling, e.g. Q1.2.7 *chronic villi* instead of *chorionic villi*.
- wrote *umbilical cord* instead of *umbilical artery* in Q 1.2.4 and *amnion fluid* instead of *amniotic fluid* in Q1.2.9.

(c) In Q1.3.3 many candidates selected 'none' as the option. Although some other hormones (GnRH and FSH) *initiate* the sexual development, both *testosterone* and *oestrogen* stimulate the changes that are a part of puberty.

(d) The poor performance in both Q1.1.6 and Q1.4 was a clear indication that candidates confused the *pupillary mechanism* and *accommodation*. Too many candidates wrote *ciliary muscles* instead of *circular muscles* in response to Q1.4.3(a) and (b).

(e) Q1.5 was the most poorly answered question in Section A. The concept of the mechanics of the *negative feedback mechanism* was elusive for many candidates. The disorder of the thyroid gland, *goitre*, is a new inclusion in the revised examination guidelines. This may be the reason that this disorder was unfamiliar to many candidates.

Suggestions for improvement

(a) It is important to teach learners to write only one letter in multiple-choice questions. If a learner gives more than one letter for a response, he/she should not be awarded any marks.

(b) School and district-based assessments must cover the full range of instructional verbs to afford learners the opportunity to master the type of responses required. These should include, inter alia, verbs such as 'name', 'state', 'describe', 'explain', 'tabulate' and 'calculate'.

(c) Learners must be exposed to past question papers, not only to familiarise themselves with the format, but also to familiarise themselves with actual content. The answer to Q 1.2.6 was in Q1.3 of the November 2021 question paper.

(d) When there is overlapping or confusing content like the *pupillary mechanism* and *accommodation,* it is best to give learners a side-by-side visual – this could be in the form of labelled drawings on a chalkboard and worksheets or a digital presentation.

(e) Biological terminology can only be mastered through practice after each section is taught. Learners must be made to write these terms out, so that they can perfect their spelling skills.

(f) Learners should be encouraged to read questions with proper understanding. There may be subtle differences that alter the response required, e.g. Q1.2.1 *the part that protects the brain* could be the *meninges*, but the question asked, *the part of the <u>skull</u> that protects the brain*, which changes the response entirely.

(g) Learners must strategize their approach to the investigation and data-response questions, e.g. Q1.1.9, Q1.1.0, Q2.3, Q2.5 and Q3.4. They must analyse the source material thoroughly during the allotted reading time.

(h) Learners must be sensitised to the fact that the diagrams they encounter in the examination may differ slightly from the ones they encounter in the classroom. This should not derail them; the strategy is to find the familiar, and work backwards from there, e.g. in Q1.5 the first step would have been to identify the *thyroid gland* (gland B) and its secretion *thyroxin* (hormone C); thereafter, attempt to answer the questions.

(i) Teachers should use the information provided by the *Examination Guidelines* and not teach unnecessary content which might be provided in some textbooks, e.g. *Grave's disease* is not a prescribed disorder to be taught and some candidates lost marks when referring to it in Q1.5.3.

QUESTION 2: THE MALE REPRODUCTIVE SYSTEM, STRUCTURE OF SPERM, MENSTRUAL CYCLE, OVARIAN HORMONES, REPRODUCTIVE STRATEGIES, HOMEOSTASIS OF BLOOD GLUCOSE

Common errors and misconceptions

(a) Candidates struggled to identify the male *accessory glands* in a diagram. This might be because they had only encountered the front view of the structures and could not identify them in a side view.

(b) The terms *semen* and *sperm* were used interchangeably by candidates in response to Q2.1.2, even though there is a distinct difference between the two.

(c) Q2.1.3 required ~~that~~ candidates understand the definition of an *endocrine gland*, by asking two reasons why the labelled structure was *not* an endocrine gland. Most candidates were only able to give one correct reason.

(d) In Q2.1.5 candidates were not only expected to describe the secretions of the male *accessory glands* but had to explain how the secretions increased the chances of *fertilisation*. Most candidates lost the two marks as they failed to give the explanation.

(e) Q2.2.4 required candidates to evaluate the suitability of two differently structured *sperm cells* for *fertilisation*. The question asked why sperm 1 was better suited than sperm 2. Candidates had to understand which structures made a sperm cell well-structured for fertilisation and essentially attribute these structures to sperm 1. Candidates struggled to do this, as was the case with most application-style questions.

(f) Q2.3 and Q2.4 were both based on the female reproductive hormones and the *menstrual cycle*. The average performance in Q2.3 was 22% lower than the candidates' performance in Q2.4. This may be because Q2.3 required the application of content learned to a new scenario, whereas Q2.4 required simple recollection of content.

(g) In Q2.3 many candidates identified the hormones on the graph as *oestrogen* and *progesterone* because they did not read the stem of the question which stated that the graph shows the levels of *pituitary* hormones. The pituitary hormones were *FSH* and *LH*. Once candidates identified the incorrect hormone, the subsequent questions could not possibly be answered correctly.

(h) Q2.3.2 and Q2.3.3 required the application of content knowledge to a new scenario which ~~always~~ challenged the average candidate.

(i) Although Q2.4 was a lower-order question, many candidates failed to obtain maximum marks as their descriptions just fell short of being complete, e.g. candidates were able to identify the *ovarian hormones*, but could not explain their role in the *menstrual cycle.*

(j) Q2.5 was based on an extract that described the *reproductive strategies* of two fish species and a graph that showed the survival rate of each species. This data-response question is a classic example of how candidates are challenged by higher-order questions. Q2.5.2 required that candidates had to have knowledge of what constituted *oviparous* development and then they had to evaluate why the species represented were considered to be oviparous. This application-style question was challenging for many candidates. Candidates were confusing the location of *fertilisation* with the location of *embryonic development*.

(k) Many candidates lost marks in Q2.6.2(a) as they incorrectly stated that *insulin* converted *glucose* to *glycogen*, instead of stating that insulin *caused* the *liver* to convert *glucose* to *glycogen*. Furthermore, the terms *glycogen* and *glucagon* are still confused and used interchangeably.

(l) Poor performance in Q2.6.3 can be attributed to the fact that candidates ignored the comparison to hormone C (*glucagon*) and simply stated the functions of *adrenalin*.

Suggestions for improvement

(a) Certain sections of work, especially those that involve structure and function, such as the reproductive system in Q2.1 and the sperm in Q2.2, are best taught using diagrams. Teachers should give learners multiple opportunities to label and annotate diagrams. Furthermore, learners should be given the opportunity to draw the diagrams themselves - this facilitates a better understanding of specific features of structures. Different views of structures must also be made available for learners, e.g. the side view and the front view.

(b) Classroom activities need to centre on exercises that allow learners to write down a description of a given term, e.g. *semen*, *oviparous*, *ovarian hormones*, *pituitary hormones*, *endocrine glands* etc. This is an exercise that is the corollary of Q1.2, where a description is given in the question paper and the term must be provided as a response.

(c) The concept of *structural suitability* needs to be emphasised in the classroom as it is an integral concept in Life Sciences. In order to effectively respond to this type of question, the candidate must first describe the feature of the structure itself and then explain how it is suited to its specific function, e.g. the sperm has a long, whip-like tail to facilitate rapid movement.

(d) Learners must be exposed to more data-response type questions in school-based assessments. Deciphering the hormones on a graph or identifying which data corresponds with theoretical information is a skill that can only be acquired with practice.

(e) In the classroom distinguish between the *ovum* and the *egg*. The ovum is the unfertilised female *gamete*, whereas the egg is the structure where *embryonic development* occurs.

(f) Distinction must also be made between the *location of fertilisation* and the *location of embryonic development.* The tables below may provide further clarity:

Location of fertilisation	**Type of fertilisation**
Inside the female body	Internal fertilisation
Outside the female body	External fertilisation

Location of embryonic development	**Term**
Inside the female body	Vivipary
Inside an egg, but *outside* the female body	Ovipary
Inside an egg, and *inside* the female body	Ovovivipary

Learners must also be taught the features, advantages and disadvantages of all the *reproductive strategies*.

(g) Informal and formal assessments must incorporate higher-order questions that require learners to analyse and evaluate diagrams, graphs and data tables that they may not have encountered before.

(h) Teachers must expose learners to more questions that require comparison and differentiation. Learners must be able to identify the deviation from the normal state and describe this change. It is not correct to state that the blood glucose level in a *diabetic* patient is high, as this may be the case in a *non-diabetic* after a meal – it must be stated that the blood glucose level will *remain* high.

(i) When asked to compare scenarios, structures or effects, learners must be taught that their responses have to be qualitative and comparative, e.g. 'longer', 'faster', 'higher', 'more', etc.

QUESTION 3: THE BRAIN, DATA RESPONSE (BRAIN INJURIES), THE HUMAN EAR, SCIENTIFIC INVESTIGATION (HOMEOSTASIS) AND PLANT RESPONSES TO THE ENVIRONMENT

Common errors and misconceptions

(a) In Q3.1.1 some candidates confused the *corpus luteum* and the *corpus callosum*

(b) In Q3.1.2 and Q3.1.3(b) most candidates only obtained 50% of the marks. The instructional verb in these questions was *Explain* and candidates generally presented poorly expressed explanations. In Life Sciences, to assess if candidates understand the function of a structure, a question is posed to indicate what would happen in the absence of the structure. Candidates, therefore, have to start their response with a description of the function of the structure in question and then move on to explain what would happen if those functions ceased. In Q3.1.3(b) the examiners were assessing if candidates understood which part of the brain *controlled* the *skeletal muscles*.

(c) The skill of drawing ~~of~~ graphs has definitely been well developed over the years and many candidates scored well in this area. Some responses to Q3.2.3 did not get maximum credit due to the:

- Incorrect type of graph being drawn – too many candidates presented a histogram instead of a bar graph;
- Caption being incomplete or containing only one variable;

- X-axis not being labelled ‘Regions of the World’;
- Label on the Y-axis not including a unit;
- Incorrect plotting of the co-ordinates; and
- Inconsistent drawing of the bars.

(d) Q3.3 highlighted the fact that candidates were capable of responding to lower-order questions based on a source but faltered when the questions demanded a higher cognitive ability. Q3.3.1; Q3.3.2 (a) and Q3.3.2 (b) were well answered, but candidates struggled with Q3.3.3 and Q3.3.4. The following common errors were observed:

- In Q3.3.3 most candidates assumed that the build-up of wax was in the *auditory cana*l as was the case in previous question papers. This question, however, referred to a build-up of wax at the *tympanic membrane*. Candidates referred to the inability for sound waves to pass through to the tympanic membrane, rather than the inability of the tympanic membrane to vibrate.
- Q3.3.4 was very poorly answered by most candidates. The understanding of various disorders and their treatments was an area that was unfamiliar to most candidates.
- Candidates were unable to distinguish between the stimuli in each division of the ear. They used the terms *sound waves*, *vibrations* and *pressure waves* interchangeably.
- In Q3.3.5 most candidates were able to name the *receptors* involved as the *cristae* but could not explain their role in the maintenance of balance. Also, when referring to *receptors*, candidates failed to identify their role in converting a *stimulus* into an *impulse*.
- Many candidates failed to include the role of the *auditory nerve, cerebellum* and the *skeletal muscles* in the maintenance of balance. Some candidates also named the *auditory canal* instead of the *auditory nerve*.

(e) In Q3.4.1 many candidates gave an incomplete description of the variables. In Q3.4.1(a) they simply wrote *facemasks* instead of *the wearing of facemasks* and in Q3.4.1(b) wrote *CO_2 levels* instead of *CO_2 levels in the blood*.

(f) Candidates who did not score well in Q3.4.3, Q3.4.4 and Q3.4.5 gave generic responses instead of responses that are specific to the investigation. Candidates were expected to analyse the design of the investigation given and critically comment on it. The generic responses of *to increase sample size*, *repeat the investigation* and to *ensure validity* were not acceptable responses in this context.

(g) Q3.4.6 was a lower-order question and candidates should have scored well, but did not. This question was based on the *negative feedback mechanism*, which clearly still posed a challenge to the candidates.

(h) From the responses obtained in Q3.5.1, it was clear that candidates knew the location of *auxins* in *stems*, but not their exact location in *roots*.

(i) The responses to Q3.5 provided further evidence that candidates coped well with lower-order questions based on a source but struggled when the questions based on the same source had a higher cognitive demand.

(j) In Q3.5.2 candidates could not recognise that *auxins* caused an increase in stem length by stimulating *cell division* and *cell elongation*. This might seem an obvious deduction, but candidates failed to express their responses correctly.

(k) Q3.5.4 was poorly answered as it required candidates to extrapolate from the extract given. The term *propagation* was explained in the extract and candidates had to make the link to *nature conservation*. A Life Sciences learner at Grade 12 level should be *au fait* with the concept of nature conservation.

Suggestions for improvement

(a) The structure of the brain is best taught using annotated diagrams. Learners must be issued with unlabelled diagrams of the brain. They must label all the relevant structures and write in the respective functions alongside them.

(b) The skill of active reading must be reinforced. In Q3.1.3(b), the operative word was *control*. When engaging with the stem of the question and the question itself, candidates must highlight or underline potentially operative words or phrases.

(c) Learners must be given the skills to respond to higher-order questions. Examiners often describe the removal or damage of a structure and candidates must then explain the consequences of this, e.g. Q3.1.2 describes damage to part C. To respond to this application-type questions, candidates must:

- First identify the structure and name it;
- State its function under normal circumstances;
- Describe the consequences in the absence of this function;
- Describe how the body may respond to compensate for the change (where applicable).

(d) Learners' graphing skills need to be refined. Learners must be given exercises that require them to draw *all* graph types. Teachers must then provide leaners with the marking rubrics, copied from the *National Marking Guidelines*, and allow for peer-marking and self-assessment. Once learners see the necessary criteria, they will be able to achieve them in the examination.

(e) The distinction between the different stimuli for each part of the ear must be emphasised in the classroom. The following summary could assist in this regard:

Region of the Ear	**Stimulus**
Outer ear	Sound waves
Middle ear	Vibrations
Inner ear	Pressure waves

(f) Learners must be cautioned against pre-empting the question and actively read what is required, e.g. in past examination papers the effect of *cerumen* build-up in the *auditory canal* was required; in this question paper, the question asked the effect of cerumen *build-up* at the *tympanic membrane*.

(g) Although the essay question no longer features in the examination, learners must still be trained in extended writing. Marks are not given for merely listing the terms and phrases. Responses have to be described or explained concisely to receive full credit.

(h) When delivering content on *homeostasis*, teachers need to consolidate and conduct baseline assessments on the following Grade 11 topics:

- Control of *blood glucose* levels;
- Regulation of *blood carbon dioxide* levels;
- Water balance (*osmoregulation*);
- Control of salt levels in the blood.

(i) The concept of *negative-feedback mechanisms* has application across a number of topics and its consolidation is therefore pivotal to improved learner performance. The mechanics of a *negative feedback loop* needs to be workshopped by subject advisors. This is clearly a topic about which many teachers do not feel confident. 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. In *negative-feedback*, a change of a variable causes the body to effect a correcting change in the opposite direction.

The following summary could be used and adapted to each scenario as is applicable:

	Stimulus or variable	**Receptor**	**Control Centre**	**Effector(s)**	**Effect**	**Outcome**
e.g.	Low CO_2 levels in the blood	Chemoreceptors in the carotid artery are stimulated and convert the stimulus into an impulse	The Medulla Oblongata is stimulated	- Heart and - Breathing Muscles are stimulated	- Increased heart rate - Increased rate and depth of breathing	More $CO_{2\ is}$ taken to the lungs and exhaled. Decreased CO_2 levels in the blood

(j) Teachers should focus on *all* the functions of *auxins* in plants, i.e. *phototropism, geotropism* and *apical dominance*. Wherever possible, the investigations involving plant responses to the environment should be done. If not, then learners must be exposed to the practical design of these experiments through worksheets, notes, slides and past examination papers. Learners must be familiar with the use of *coleoptiles* and *clinostats* in the design of these investigations.

(k) Teachers must place more emphasis on scientific investigations and their design. Learners should be taught the value of each design element and how it contributes to a valid investigation. The use of generic responses in investigations must be discouraged and candidates need to respond to the specific context of the investigation presented. Every formal assessment should assess Specific Aim 2, to familiarise learners with the scientific skills.

(l) Learners must be able to identify variables using the aim of the investigation and not the results. Furthermore, they must be able to express them in full, e.g. *carbon dioxide levels in the blood*, not just *carbon dioxide levels*.

(m) Candidates must be able to present, inter alia, the ‘aim’, ‘results’, ‘conclusion’ etc. for an investigation.

(n) A greater emphasis on practical work and practical tasks of good quality in Grades 10 and 11 will also assist in preparing learners more adequately for questions based on scientific investigations. Learners must be challenged to design their own investigations, given an ‘observation’, ‘hypothesis’ or ‘aim’. This is especially important since knowledge of scientific investigations is assessed in both Paper 1 and Paper 2.

8.5 OVERVIEW OF CANDIDATES' PERFORMANCE IN PAPER 2

General comments

(a) The poor responses of some candidates emanated from their not reading and following instructions in each question/subquestion.

(b) Learners should be provided with the official *2021 Examination Guidelines* before a particular topic is taught. This will give them clear guidance on the terminology to be mastered per subtopic, as well as the content that they should know and learn for examinations. Candidates often refer to terminology, e.g. *point mutations*, that is outside the parameters of the *Examination Guidelines* and the *CAPS* document.

(c) Teachers must always consult Chief Markers' reports and Diagnostic Reports and apply all the necessary recommendations in their teaching.

(d) Teachers must emphasise the schematic outline of the human life cycle to show the role of *meiosis*, *mitosis* and *fertilisation* as part of the introduction to human reproduction. This will assist learners to understand the concept of prevention of the *doubling effect of fertilisation* and the *maintenance of constant chromosome number* from generation to generation.

(e) Many candidates underestimate the importance of correct spelling. In Life Sciences, incorrect spelling may change the meaning of the response and candidates may lose marks, e.g. *cross over* cannot be accepted as the correct terminology for *crossing over*.

(f) Teachers should emphasise the difference between commonly confused terms, e.g. the difference between *centromere, centrosome* and *centriole.*

(g) Candidates give generic responses to questions that require specific information on questions, e.g. *natural selection*.

(h) Candidates must always use the correct genetic notations given in the paper and not their own, e.g. X^B and not X^D.

(i) Teachers should re-visit the IM report as well as the Diagnostic Report when starting to teach a new topic.

(j) The 2020 and 2021 Diagnostic Reports are also an invaluable tool in planning and teaching content.

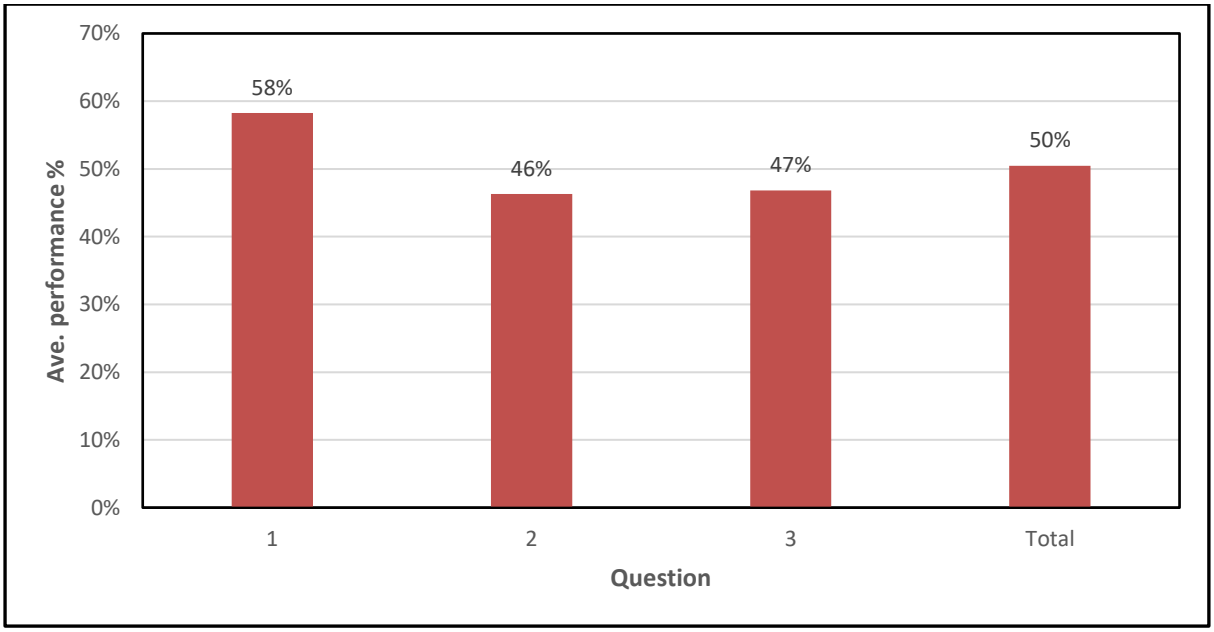
(k) Subject advisors should organise more content workshops (every term) to share best practices and to update teachers who were not at the marking centres, on the latest developments in the subject.

8.6 DIAGNOSTIC QUESTION ANALYSIS FOR PAPER 2

Based on the Rasch analysis, the weakest performance by candidates was recorded in the subquestions on *Transcription*, *Gene Mutation*, the *Sex-linked Monohybrid Cross* and *Evolution*.

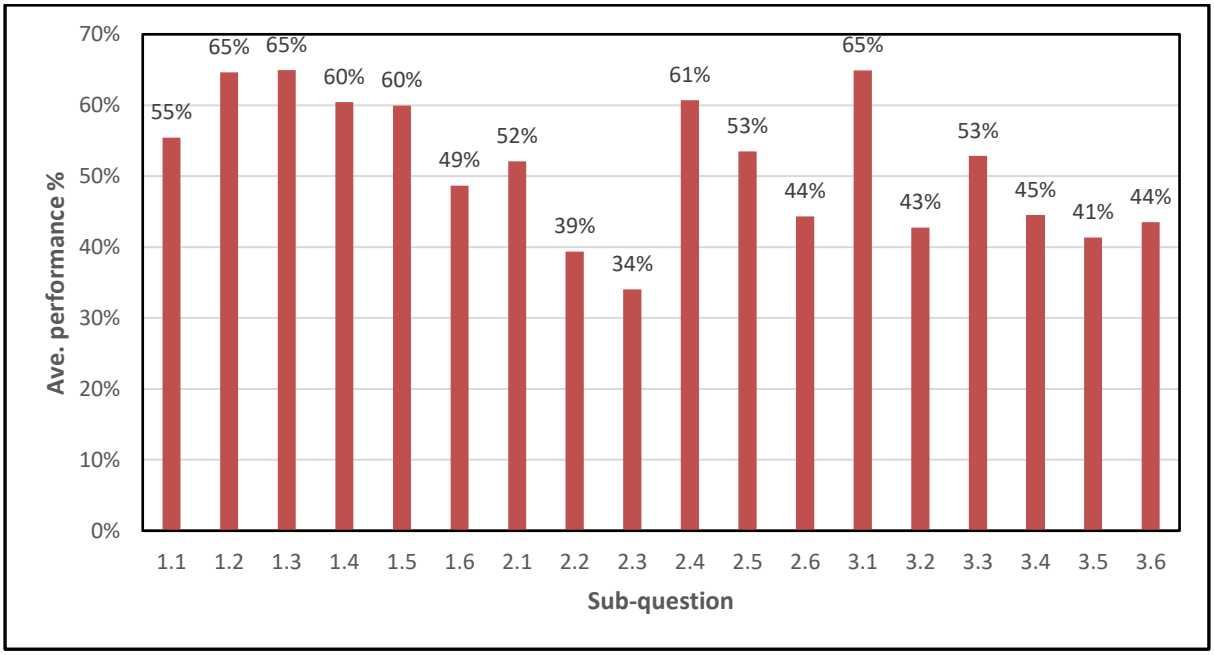
The following graph is based on data from a random sample of candidates. While this graph might not accurately reflect national averages, it is useful in assessing the relative degrees of challenge of each question as experienced by candidates.

Graph 8.6.1 Average performance per question in Paper 2



Q	Topics
1	Multiple choice, Terminology, Matching items, Pedigree diagram, Karyotype – abnormal meiosis, dihybrid cross
2	Transcription, Mutation on mRNA, Meiosis, Blood groups, DNA profile, Monohybrid cross (sex linked)
3	Stem cells, species – reproductive isolation, human evolution, phylogenetic tree, evolution – transitional species and Lamarck, scientific investigation - evolution in present times and natural selection

Graph 8.6.2 Average performance per subquestion in Paper 2



Sub-Q	Topic	Sub-Q	Topic
1.1	Multiple-choice question	2.4	DNA profile
1.2	Terminology	2.5	Blood groups
1.3	Matching items question	2.6	Monohybrid cross (sex linked)
1.4	Pedigree diagram	3.1	Stem cells
1.5	Karyotype – abnormal meiosis	3.2	Species – reproductive isolation
1.6	Dihybrid cross	3.3	Human evolution
2.1	Transcription	3.4	Phylogenetic tree
2.2	Mutation on mRNA	3.5	Evolution (transitional species and Lamarck)
2.3	Meiosis	3.6	Scientific investigation - evolution in present times and natural selection

8.7 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN PAPER 2

QUESTION 1: MULTIPLE-CHOICE, TERMINOLOGY, MATCHING ITEMS, PEDIGREE DIAGRAM, KARYOTYPE – ABNORMAL MEIOSIS AND DIHYBRID CROSS

Common errors and misconceptions

(a) In Q1.1 candidates performed well, except for Q1.1.8 and Q1.1.9. Candidates could not differentiate between the events of *meiosis I* and *mitosis*. Q1.1.9 was a calculation based on the application of *complementary-base pairing*. Many candidates failed to read the information given in the stem of the question.

(b) Spelling errors in Q1.2 caused candidates to lose marks. Candidates frequently:

- Confused the terms *centromere* and *centrosomes/centrioles* in Q1.2.3 and Q1.2.6;
- Confused *homologous structure* with *homologous chromosomes.* They even gave answers such as *modification by descent* and *analogous structures* in Q1.2.7;
- Stated the site of *translation* in a cell instead of the *organelle* in which translation occurs in Q1.2.9.

(c) Q1.4.2(b) on the pedigree diagram was not well answered. Some candidates incorrectly wrote the format required for a sex-linked trait as X^RX^r instead of the correct *autosomal trait annotation* of Rr.

(d) In Q1.5.1 and Q1.5.2 some candidates could not differentiate between *autosomes* and *gonosomes*. In Q1.5.3 they also confused the *disorder* (Down syndrome) with the *process* causing it (*non-disjunction*).

(e) Q1.6 on the *dihybrid cross* was the most poorly answered question in Section A. Many candidates could not give the *phenotype* correctly. They had to write the complete characteristic namely *Brown fur rabbit with long ears* but only wrote *brown* and *long* which were not credited. In Q1.6.2(c) candidates confused the *genotype of an individual* with the *genotype of a gamete*. Many candidates wrote the correct *allele* combination but did not leave a space to indicate that the alleles were separated into the gametes.

Suggestions for improvement

(a) Learners should be provided with the *2021 Examination Guidelines* before a particular topic is taught. This will give them clear guidance on the terminology to be mastered per subtopic, as well as the content that they should know and learn for the examinations.

(b) Teachers should extract topic-focused questions from previous years' question papers and use these in informal assessments. This will enable learners to acquire question interpretation skills and to mitigate against confusing related terminologies.

(c) Teachers must be trained on how to approach the topic of *meiosis*, highlighting the events that take place during *meiosis I* and *II* as well the differences between the two divisions.

(d) Teachers must give learners more exercises on *dihybrid* crosses. They must emphasise the difference in the writing of the *genotypes* and *gametes* for a *dihybrid cross* as compared to how they would write it for a *monohybrid cross*. Genotypes of parents, gametes and offspring should not be confused. Teachers should emphasise the difference between *genotype of an organism* and the *genotype of their gametes*.

(e) Teachers must use diagrams, including that of a *karyotype*, when teaching *abnormal meiosis* so that learners can relate the terminology to the actual process. Emphasis should be on *Down syndrome* being a consequence of *non-disjunction* and that the terms cannot be used interchangeably.

(f) Teachers should make an effort to pronounce terms correctly. Often learners are spelling the words as they hear them. Learners should practise writing out the terminology.

(g) There is clear evidence pointing to the fact that candidates studied their content, but lost marks due to poor examination skills. Thorough analysis of the question phrasing and mark allocation must be taught as a skill to the learners.

(h) Learners must be exposed to past question papers, not only to familiarise themselves with the format, but also to familiarise themselves with actual content.

QUESTION 2: TRANSCRIPTION DURING PROTEIN SYNTHESIS, MUTATIONS ON A MRNA MOLECULEMEIOSIS, BLOOD GROUPS, DNA PROFILE, SEX-LINKED MONOHYBRID CROSS

Common errors and misconceptions

(a) The question was generally answered fairly well, although there seemed to be challenges in questions that needed explanations and descriptions.

(b) In Q2.1.3 some candidates did not present their answers in the form of a table. They wrote the whole process of *transcription* and could not extract the differences in the

processes. They gave general differences between RNA and DNA. Also, for *DNA replication*, they indicated that an identical strand of DNA is formed instead of *two identical DNA molecules*. Some wrote *a double stranded molecule* is formed which refers to one DNA molecule.

(c) In Q2.2.1 many candidates answered the type of mutation incorrectly as a *genetic mutation* rather than a *gene mutation*. They also referred to the causes of gene mutations, such as point mutation which, although applicable to this question, was outside the parameters of the *2021 Examination Guidelines* and the *CAPS* document.

(d) In Q2.2.2 and Q2.2.3 (c) candidates gave general answers, not specific to the question. Instead of describing the exact change and position of the mutation that occurred in the *codon/anticodon*, they generalised without referring to the specific *codons*/*anticodons*. Some knew that there was a change in amino acids but did not specify the amino acids that changed.

(e) Many candidates incorrectly wrote 6 as an answer to Q2.2.3(a). They counted the number of amino acids but did not exclude the repeated amino acids, which were coded twice by 2 different codons.

(f) In Q2.3.2 candidates incorrectly stated that the *gamete or sperm cell* underwent *meiosis* rather than *diploid cells underwent meiosis to form the sperm*.

(g) Many candidates wrote in Q2.3.4 that *chromosomes* were pulled to the opposite poles without indicating that the *homologous pairs* first separate or are pulled apart, and then move to the opposite poles. Some answered that *spindle fibres constrict* which showed that they confused the terms *contract* and *constrict*.

(h) Poor performance in Q2.4.3 was evidence that many candidates could not distinguish between *alleles* and *genes* and they were not familiar with the concept of *multiple alleles* in blood grouping. They could identify that the child was blood group AB, but failed to describe how the child inherited this blood group. They incorrectly stated that the child *inherited blood group A from the mother* instead of stating that the child *inherited the allele (I^A) for blood group A from the mother*.

(i) In Q2.5.2 many candidates wrote that the *DNA matched* instead of saying that the *DNA profile bands/bars of the children matched with that of their parents*.

(j) In Q2.5.3 many candidates failed to correctly state other uses of DNA profiling than those mentioned in the question, i.e. paternity testing and identification of relatives. Some wrote *to develop cures for genetic disorders* instead of *identifying genetic disorders*. Some wrote *to identify criminals* or *to solve crimes* instead of *identifying suspects in crime*. They also wrote *for organ transplants* instead of *identification of matching tissues for organ transplants*.

(k) In Q2.6.1 candidates could not deduce that *white teeth* was caused by a *recessive allele* because *brown teeth* was caused by a *dominant allele.* Many explained their response in terms of the dominant allele causing brown teeth rather than the recessive allele.

(l) In terms of Q2.6.2 some candidates had difficulty stating the *phenotype* in the *monohybrid cross*. They had to write that *a male with brown teeth was crossed with a female with white teeth* and not just *brown teeth were crossed with white teeth*.

(m) Some candidates gave their own genetic notations, e.g. X^D when showing the genetic cross.

(n) Candidates gave the phenotypic ratio as *2 females with brown teeth **:** 2 males with white teeth* instead of stating *the smallest ratio of 1 **:** 1* and lost the compulsory mark.

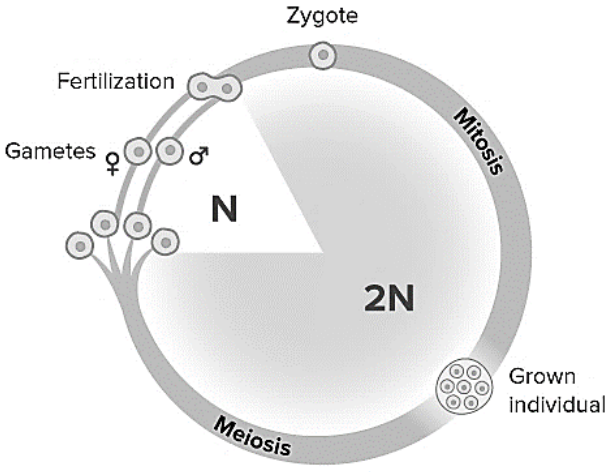
Suggestions for improvement

(a) Learners should be given sufficient exercises on how to do *base-pairing* in protein synthesis from *DNA* → *mRNA* (codons) → *mRNA* (anticodons) → amino acids as well as in the reverse process.

(b) Learners must only be taught what is required with reference to *chromosome* and *gene* mutations, as stipulated in the *2021 Examination Guidelines* and the *CAPS* document. Further details on gene mutations such as *point* and *frame-shift mutations* are not required.

(c) Teachers should expose learners to questions on genetics, based specifically on *sex-linked inheritance* where *dominant/recessive alleles* are involved.

(d) Learners should clearly understand the *haploid* and *diploid* status of cells. They must be able to differentiate whether the question refers to the *halving of the chromosome number during meiosis* or to *the duplication of chromosomes during fertilisation*. A cyclical diagram like the one shown below could help to consolidate this content.



(e) Learners must be taught to use the correct terminology when interpreting DNA profiles, e.g. *bars*, *bands* and not *lines* or *barcodes*. They must emphasise that for a paternity

test, each band of the child's DNA profile should match with either that of the biological mother or that of the biological father.

(f) In a criminal case, however, the DNA profile of the suspect must be an exact match of the DNA profile taken from the crime scene as evidence. Teachers should emphasise that using language precisely is important in the answering of questions, e.g. criminals are not identified or traced using DNA profiles because a suspect must first be arrested and identified before they are convicted and become criminals.

(g) When asked to explain why males/females have more/less of a specific trait, the *gonosomes* or the *recessive/dominant allele* must be used in the explanation.

(h) Learners must use the correct notations given for a genetic cross, i.e. X^B and not X^D.

(i) When discussing the inheritance of traits, learners must state that *alleles* are inherited and not *genes.* Refer to page 163 of the *2021 Diagnostic Report* which outlines the general format of how to answer this type of question.

(j) Generic answers from previous *2021 Examination Guidelines* cannot be given when a question provides contextual data. Teachers must ensure that learners practise adapting the generic versions to the specifics in the questions.

QUESTION 3: STEM CELLS, SPECIES, POPULATIONS AND REPRODUCTIVE ISOLATION, HUMAN EVOLUTION, PHYLOGENETIC TREE, EVOLUTION (TRANSITIONAL SPECIES AND LAMARCK) AND SCIENTIFIC INVESTIGATION (EVOLUTION IN PRESENT TIMES AND NATURAL SELECTION)

Common errors and misconceptions

(a) In Q3.1.1 some candidates lacked the skill to extract information from the text. Instead of naming the sources of *stem cells*, some rewrote the paragraph as it was. In Q3.1.2 they also referred to using stem cells for replacing organs instead of cells/tissues.

(b) In Q3.2.1 many candidates failed to give all three parts of the definition of a *population* and mixed up the definition of a *population* with that of a *species* or a *community*.

(c) In Q3.2.3 candidates lost marks for describing examples of *reproductive isolation* instead of listing the *mechanisms of reproductive isolation.* Many candidates listed examples of reproductive isolation that were not in the *2021 Examination Guidelines*.

(d) In Q3.3.1 candidates wrote *to share a common ancestor* instead of *to show a common ancestor*. Candidates stated that opposable thumbs are for *holding things* rather than *providing a power grip or a precision grip* in Q3.3.2.

(e) The following common errors were observed in Q3.4 on the evolution of some *hominids*:

- Some candidates could not to spell *phylogenetic* and were not credited for writing *polygenetic tree* or *phylogenic tree* in Q3.4.1.
- In Q3.4.2 many candidates did not know the difference between a *genus* and a *species*. They counted the number of species instead of counting the *genera*. Many did not know that the term *genera* is the plural form of *genus*. Some gave the number of generations instead.

- Many candidates only wrote the species name instead of the full scientific name of the genus and species in Q3.4.4.
- In Q3.4.5 some candidates confused evidence to support the theory of evolution versus evidence to support trends in human evolution. Some of the responses given included *modification by descent, biogeography* and *genetic evidence from mitochondrial DNA.* Many gave examples of evidence for evolution, e.g. *mitochondrial DNA* and rock paintings and artefacts, instead of *genetic* or *cultural* evidence.
- In Q3.4.7 many candidates were not clear on how fossil evidence supported the *Out of Africa hypothesis.* The *2021 Examination Guidelines* state which fossils were only found in Africa and which oldest fossils are found in Africa implying that the youngest have been found outside of Africa. Many wrote *fossils/organisms originated in Africa* instead of *modern humans originated in Africa*.

(f) In the responses to Q3.5 candidates were able to identify *Ambulocetus* as a *transitional species* between *Pakicetus* and whales but could not explain why this is the case. This indicated that they were not familiar with the characteristics of a transitional species.

(g) In Q3.5.2 some candidates failed to extract the relevant characteristics from the table to support their answer. In Q3.5.1 they omitted *flipper-like* or *large* in describing the feet of *Ambulocetus*.

(h) In Q3.5.4 many candidates referred to *Lamarck's law of use and disuse* but could not apply it to the given question. Most wrote that *the legs were not needed* instead of *the legs were used less*.

(i) In Q3.6.1 some candidates could not extract the variables from the aim of the investigation. This was thoroughly discussed in the *2021 Diagnostic Report*.

(j) In stating the conclusion in Q3.6.3, many candidates could not show the relationship between the independent and dependent variable, i.e. describe how the change/increase in the number of missed treatments affected the probability of the HI virus developing resistance to antiretroviral medication. Some incorrectly described the relationship between the variables as being directly proportional, implying that the increments were equal, which was not the case when analysing the given data. The conclusion often did not include all aspects (variables, virus name, drug name and the relationship shown).

(k) Most candidates had difficulty answering Q3.6.4. This question was based on a scientific investigation into evolution in present times; candidates instead focussed on the resistance of the HI virus to antiretroviral drugs. They gave a generic description of *natural selection* without contextualising it. They also mentioned variation without describing the variation as it applied to the resistance of the HI virus to antiretroviral medication.

Suggestions for improvement

(a) Instructional verbs such as 'state', 'explain' and 'discuss' should be thoroughly explained to the learners. Learners should be exposed to questions requiring them to discuss/explain to enable them to know the difference.

(b) Learners must be cautioned against using slang language when writing examinations. No marks are awarded for writing *K-nines* instead of *canines*.

(c) Open-ended questions should be asked in both formal and informal tasks for learners to understand that where their opinions are asked, these should be relevant.

(d) Teachers must use questions from past papers to expose learners to exam-type questions pitched at different cognitive levels and levels of difficulty and not only rely on textbook activities.

The principles of taxonomy need to be thoroughly covered in Grade 10 in preparation for *human evolution* in Grade 12. The terms *genus, species* and *genera* as the plural of *genus* must be consolidated thoroughly. Learners must be instructed in scientific nomenclature; that when a species name is requested that both the *genus* and species must be named.

(e) Teachers must teach the concept that a *transitional fossil* displays the intermediate phenotype between a predecessor (which comes before it) and the current organisms of which it is part OR that it has the intermediate phenotype of those organisms that it is currently part of and a descendant (which comes after it). This knowledge should then be applied to information given in the source-based question.

(f) Teachers must support learners to learn the sequence of steps describing *natural selection* found in the *2021 Examination Guidelines*. Learners should also be able to apply this generic process to the source material provided. Special care needs to be taken to tailor their answers to the context of the question given.

(g) Application questions on the process of *natural selection*, and also on Lamarck's theories, should be extracted from previous years' question papers and given to learners for daily assessment so that they do not provide generic responses to questions that require application.

(h) Teachers must emphasise that the conclusion of an investigation would come from altering the aim to show the relationship between the variables.