C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

REPORT ON CANDIDATES' WORK IN THE SECONDARY EDUCATION CERTIFICATE EXAMINATION

MAY/JUNE 2010

BIOLOGY
GENERAL PROFICIENY

GENERAL COMMENTS

The May/June 2010 examination in Biology at the General Proficiency level was the 36th sitting of this subject. Biology continues to be offered at both the January and June sittings of CSEC examinations. The Biology examination is one of the more popular of the single sciences offered at the CSEC level and this year the performance of approximately 14,000 candidates was assessed. The examination comprises four papers: Paper 01 - Multiple Choice; Paper 02 - Structured/Extended Essays; Paper 03 - the School Based Assessment (SBA) and Paper 03/2 - Alternative to the SBA (offered only to private candidates)**.**

The overall performance of candidates this year was similar to that of 2009, with candidates scoring across the full range of marks in almost every question. However, candidates were, as often happens, challenged by their lack of knowledge of the specifics of biological concepts, their inability to analyse data and account for trends, and most importantly, to make drawings that adequately represent biological specimens. Several candidates also found difficulty recalling the names of biological processes and events. Candidates are still unable to adequately display the skills they are supposed to acquire in pursuing practical work, for example, data representation and methods of investigation. These comments relate to teaching of the subject matter and calls for candidates having more opportunity to express for themselves the concepts, principles and processes–writing these down and checking for accuracy as well as for engaging in practical activity, including field work, and not merely writing up experiments in notebooks. Further, there is insufficient attention paid to several suggestions which the Biology examiners have repeatedly made over the past years. These comments take on more meaning with the new format of the Biology examination that has eliminated choice. Particular attention must be paid to the comments reiterated below in preparing candidates*, if the desired improvement in performance is to be realized and* ***sustained***. These comments relate both to test-taking techniques and means of addressing the content of questions.

- Teachers should remind students that there is more to taking an examination than memorizing the content. When preparing students for an examination, time should be spent practising *how to interpret* and answer questions clearly and concisely.

- Candidates waste time providing information that is irrelevant to the question. *This gains them no marks*. This is particularly important for the extended essay component of the paper. Candidates ought to make better use of the time allotted for reading through the questions and *planning* their responses *before* starting to write.

- Too many candidates still do not read questions well. They should be advised to take special note of the cues given in the questions and to *underline* key words to draw attention to what the question requires. When the question asks for two items, many candidates give one and thus lose marks unnecessarily.

- Also, many candidates have the tendency to select an obscure, partially correct response instead of the obvious, more familiar response to questions.

- In papers where limited spaces are provided for short answers, candidates insist on repeating the questions asked, leaving insufficient room for responses and then writing their responses in the margins. This wastes valuable writing time.

- Candidates should also use the question numbering as a guide to link the different parts of the question. They should note that the numbering changes when there is a change in concept or context. They should also make every attempt to use the information given in the various parts of a question to help focus the context and content of their responses.

- Biological jargon should be used where appropriate and **spelling** of biological terms **must** be correct. Spelling of common biological terms continues to be atrocious. Even when the biological term is used in the question, candidates will introduce their own incorrect spelling of the term. It is not possible to award marks for incorrectly spelt terms where they actually mean something different. Far too often candidates seemed unfamiliar with the meaning of common terms used in Biology, for example, *'annotate', 'adaptation', 'structural features', 'distinguish', 'precaution', 'limitations', 'factor implications' or 'types'*. Teachers should direct candidates to the glossary of terms available in the CSEC Biology syllabus.

It should be noted that candidates at this level are expected to demonstrate understanding of fundamental principles and concepts including *the relationship of structure to function in living organisms; the relationship of living organisms to their environment; the cell as the fundamental unit of living organisms; genetics and variation and their role in perpetuating species, the impact of disease on living organisms including social and economic effects on humans, and the impact of human activity on the environment*. The examining committee suggests that teachers use more constructivist approaches in the teaching of Biology in which candidates would be more involved in explaining their notions, clarifying the content and be more fully engaged in problem-solving activities.

It is repeated here that every effort must be made to encourage and facilitate the use of appropriate biological jargon including the correct spelling of terms. Candidates can lose marks for incorrect spelling as the badly spelt term might take on new meaning.

The examining committee also believes that there is very limited or no sharing of best practices in the subject area. Sharing best practices among science educators cannot be over emphasized. It is not good enough for us to be happy with the pockets of excellence in the 'choice' schools while the majority underperform. In addition, advanced technology is at our disposal and the timely introduction of e-learning programmes across the region is viewed as a potentially enabling opportunity. This innovation must be embraced by all as far as possible.

DETAILED COMMENTS

Paper 01 – Multiple Choice

Paper 01 consisted of 60 multiple-choice items. Performance on this paper was quite similar to that of 2009. The mean for the paper was 61 per cent compared with 62 per cent in 2009.

Some of the topics that were *most* problematic for candidates were:

- Role of bacteria in the nitrogen cycle
- Role of adenosine triphosphate (ATP)
- Water conservation in plants
- Identifying variables in an investigation
- Reflex arc and reflex action
- Surface area to volume ratio
- Function of endocrine organs in humans
- Functioning of the uriniferous (kidney) tubule
- Role of hormones in the menstrual cycle
- Monohybrid inheritance
- Sex linkage
- Sampling using a quadrat
- Soil properties

Misconceptions/Inaccuracies

- Many candidates believe that osmosis is the process by which water moves across the cell wall. This statement is NOT correct. *Candidates should note that water moves across the cell wall by* ***diffusion****. Water moves across the partially permeable cell membrane into the cell cytoplasm by* ***osmosis****.*

- Candidates believe that the primary role of ATP is to store large amounts of energy. While ATP does store large amounts of energy, its *primary role is for energy transfer*.

- Candidates do not connect the increased surface provided by plants with *large numbers of small leaves* with an increased capacity for transpiration, unless those leaves are adapted to conserve water.

Paper 02 – Structured Extended Essays

Paper 02 consisted of six questions, three of which were in the structured response format and three in the extended essay format. This paper tested all profile skill areas identified in the Biology syllabus. All questions were compulsory. Candidate performance on this paper was better than performance on the May/June 2009 paper. Candidates were able to gain marks across the range for almost all questions and the mean for almost every question was relatively close to the mid-point of the range, and, in some cases, exceeded the mid-point.

Since candidates were generally able to attain marks across the allotted range for the questions, it is evident that all the marks on the paper were available and attainable. However, in order for more candidates to give their best performance, attention must be paid to observations and suggestions the Biology examiners have repeatedly made. Observations and suggestions relate primarily to examination techniques which candidates should follow when writing this paper. In particular, candidate attention is drawn to the use of the stimulus material in responding to the questions and the guidance provided by the spaces allotted to each question where necessary. Candidates must note that they are not required to repeat the questions to begin their responses for the first three questions on the paper. Candidates also continue to display weak practical skills especially in *describing* methods of experiments and in drawing conclusions from data. These observations suggest that **teaching for developing practical skills** *must include discussions, explanations and rationalizing of procedures and outcomes on the* part of candidates so that they become capable of developing and manipulating experiments and experimental data on their own. Simply having candidates write up experiments without orally communicating what they are doing and providing appropriate explanations for occurrences squanders the opportunity practicals provide for *teaching and learning*. In addition, too many candidates are unable to produce accurate diagrams of common biological structures; and they do not observe the conventions of drawing, including giving the diagram or drawing a title, labelling neatly, using straight parallel lines, using sharpened pencils and providing the magnification.

Question 1

This question dealt with an investigation of photosynthesis under selected conditions, aspects of planning and designing for investigating respiration in plants and humans as well as aspects of storage organs in plants and humans, and flower structure and function. Candidate performance on this question was fair. The mean was approximately 8 out of an adjusted mark of 21 and the mode was 8.

Part (a) examined candidates' knowledge of aspects of investigative procedures and methods of recording data on biological phenomena. Candidates were required in Part (a) (i) to construct a table that was appropriate for the collection of specific data from an outlined investigation. While candidates seemed aware of the general format of tables, very few scored full marks on this part of the question. Designing a table to collect data from an experiment with several replicates seemed immensely challenging.

Generally, it is expected that candidates at this level should produce tables with *appropriate titles, appropriate headings including units of measure, a key as appropriate,* and *the table should be well ordered (neat) and closed*.

In Part (a) (ii), candidates were to explain why the investigation was done using three samples in each case. A number of candidates were unable to account for this fundamental precaution of scientific investigation. Candidates were expected to refer to ideas such as *better representation, reliability of data interpretation, role of averaging to compensate for variation among the specimens*. A good response that was grounded in the description of the investigation that was given was:

> *With a larger sample, the experiment becomes more accurate and also this can illustrate that for most plants the food product obtained would be found in those places.*

Part (b) examined candidates' knowledge of methods of investigation. They were to provide a diagram of the arrangement of the apparatus that could be used to illustrate that the root of a particular plant was the site of uptake of water. This part of the question was only fairly well done. Some candidates drew separate pieces of apparatus which did not adequately illustrate the investigation and some drew flow diagrams which were also inappropriate. Candidates were expected to show in their diagram the following: *the plant supported in an upright position; only the plant roots submerged in coloured water; a means of observing/measuring the water taken up by the roots.*

Candidates performed reasonably well on Part (c), which required them to identify a food storage organ of the human body. Most of them gave the expected responses of *liver* and *skin*, and in some instances, *fat in the gut*. However, many chose to interpret 'storage' as storage of waste products and pre-digested food for which they could not be rewarded, since the comparative organ given in the stimulus material was a food storage organ — the fleshy leaves of a bulb. Candidates were also not rewarded if they mentioned muscle tissue as the question specifically asked for an *organ*.

Part (d) of the question proved to be the most challenging for candidates. They were asked to explain how they would demonstrate, through an investigation, that respiration carried out by both plants and humans involved the same process. Many candidates gave the equation for respiration which earned no marks. Many also thought that respiration occurred in animals and photosynthesis occurred in plants. Candidates were expected to include in their responses ideas such as: *same products given off/carbon dioxide/water/heat given off in both cases; reaction the same/perform test to show products the same; same requirements/inputs/carbohydrate and oxygen required.* A response that gained full marks was:

> *This can be demonstrated by testing for carbon dioxide. When plants and humans respire, they produce carbon dioxide, therefore if the gas released from plants and humans is trapped and bubbled through limewater, respiration will be demonstrated if both form a white precipitate*.

Part (e) assessed candidates' knowledge of flower structure and pollination. In Part (e) (i), they were to label three parts of the flower using letters to indicate the stigma, stamen and ovary respectively. This part of the question was well done as was Part (e) (ii) which asked candidates to suggest how the flower illustrated in the diagram might be pollinated, and to offer an explanation for their response. Candidates were expected to suggest that the flower was *insect-pollinated*. In support of their responses, they were expected to indicate: *anthers are lower than stigma; well developed corolla; stigma not feathery*. A response that earned full marks was:

> *The flower may be insect - pollinated because of the large petals with guidelines and because the anther is inside the flower.*

<u>Misconceptions</u>

- Too many candidates erroneously believe that plants photosynthesize during the day and respire at night. Candidates must be taught that while plants photosynthesize during the day, they respire all the time, during the day and night.

- Further, many candidates believe that animals respire and plants photosynthesize. Students must be informed that true living organisms carry out *all* life processes, including *respiration*, and that photosynthesis is part of the mechanism of plant nutrition (*nutrition* being a life process), not respiration.

- Many candidates seemed to think that temporary holding areas for waste material such as the rectum and bladder are storage organs. More accurately, in biological jargon, storage organs usually refer to organs that store material for later use by the organism, for example, liver, skin and (fat around the) gut.

- Candidates felt that using more than one sample was a means of *averaging* the results rather than a means of obtaining more *accurate* results.

Question 2

This question tested candidates' knowledge of the process of germination in plant seeds. Candidate performance on this question was less than average. While candidates were able to access marks across the full range of the question, their performance showed a mean of 6 and mode of 3 out of 15.

It is reiterated here that candidates often, seem to perform poorly on questions that require specific knowledge of familiar biological content — concepts, principles and processes. Candidates often indicate that they 'know' the material, but cannot recall correctly the names of structures, definitions and processes. This relates to the teaching of the subject matter and calls for candidates having more opportunity to express for themselves various aspects of the content, writing these down and checking for accuracy. Further, too many candidates incorrectly spelt common biological terms, for example, *plumule*, *radicle* and *cotyledon*.

Part (a) of the question required candidates to label structures observed in a diagram of a seedling as shown on the fifth day of germination. This part of the question was only fairly well done as many candidates labelled parts shown on days other than the fifth day of germination, or did not know the names of the parts of a germinating seedling. Candidates were expected to label parts such as the *testa, plumule, radicle, root hair and cotyledon*.

In Part (b) candidates were to outline the changes that took place in the seed to allow for germination. This part of the question was poorly done. Candidates were expected to indicate that the *seed takes in water, enzymes become activated, stored food is converted to food/structural material; production of energy for a range of processes/development of seedling tissues which is manifested as growth.* A candidate response that garnered full marks was:

> *The seed would have been placed in a region with an adequate supply of water. Water enters the seed through the micropyle. The water acts as a solvent and medium through which enzymes can break down the food stores … and use them for respiration. For example, carbohydrates are broken down by amylase to glucose for respiration. Other nutrients like proteins are translocated to growing points or meristems to help growth by mitosis.*

Part (c) tested candidates' knowledge about growth. In Part (c) (i), they were asked to identify the process illustrated in the diagrams of the germinating seedling. This part was well done. The majority of candidates were able to identify the process as *growth*. Part (c) (ii) required candidates to give two ways in which the growth movement shown by a germinating seedling differs from the movement of an earthworm moving through its burrow. Candidates were expected to focus their responses on aspects of the following: *seedling grows in different directions at the same time — growth; movements in seedling localized/limited to tips of radicle and plumule; growth movement vertical/seedling remains in one location.* A good response to this part of the question was:

> *An earthworm is capable of locomotion. It can move its whole body from one place to another. Plants remain rooted to one spot. Plants usually only move by growth movement which is irreversible. However, an earthworm can move back to its original position so the movement is not permanent.*

In Part (d), candidates were to identify physical factors that may impact an earthworm and its movement in its burrow. For (d) (i), they were to identify two physical factors that may cause an earthworm to move deeper into its burrow. This part of the question was reasonably well done; candidates were able to identify at least one of the factors from: *high temperature, high light intensity; decreasing moisture content in upper layers of the soil.* In Part (d) (ii), candidates were to explain why moving deeper into its burrow was important to the earthworm. This part of the question was quite well done. Candidates were generally able to suggest at least one reason why the earthworm moved deeper into the burrow. Candidates were expected to refer to: *protection from desiccation/drying out, protection from predators, guidance for feeding times*. A response that earned full marks was:

> *This response avoids detection by predators like birds, and also prevents from desiccation.*

<u>Question 3</u>

This question required knowledge of terrestrial food webs and the relationships among organisms therein. This is a popular component of the Biology syllabus and was generally familiar to candidates. Candidates performed well with a fair number obtaining full marks. The mean was 9 out of 15.

Part (a) asked candidates to identify a food chain of four trophic levels from the diagram of a food web provided. This part of the question was well done. The majority of candidates were able to provide a food chain with appropriate organisms. A few candidates still confuse the direction of flow of the arrows in a food chain. It should be noted that the arrows point from the lower to the higher trophic levels.

Parts (b) and (c) tested candidates' knowledge of different types of relationships that exist within a food web. In Part (b) (i), candidates were to identify, from the food web, one predator and one organism on which the identified predator was likely to prey. This part of the question was well done. Candidates were expected to select as the predator one of three organisms at the highest levels of the food web and an animal that was at the next lower level. Several candidates identified the 'caterpillar' as the predator and 'plants' as its prey. This is not the traditional conception of these terms. *A predator is usually a higher order carnivore that hunts, captures, kills and eats other animals. The hunted animal is described as the prey*. In Part (b) (ii), candidates were to identify two characteristics that would distinguish the predator population from that of the prey. This part of the question was also well done. Candidates were expected to refer to the following factors: *predator population is much smaller; predator population is carnivorous/bear carnivore characteristics, for example in their dentition; predator population is found at a higher trophic level.* A well-stated response was:

> *The predator population is smaller than that of the prey, since energy decreases along the food chain.*

In Part (c) (i), candidates were asked to identify one relationship other than predator/prey which may exist in a food web. This part of the question was fairly well done. They were expected to indicate any type of symbiotic relationship, among *parasitism*, *commensalism* or *mutualism,* with an appropriate example. For Part (c) (ii), candidates were to give one advantage of having special relationships within a food web. They were expected to refer to any of a variety of options: *conservative — helps to recycle finite resources; better use made of a variety of resources; occupy a variety of niches; system for food/energy distribution; utilization of a range of resources*. Responses that gained full marks were:

> *Special relationships between organisms help to maintain balance in the ecosystem as it allows some organisms to aid others in survival and it can also be used to keep populations in check and reduce competition.*

One advantage is that an organism is better able to survive due to lack of competition.

Misconceptions

- Predators are larger, stronger or faster than prey.
- Termites are parasitic to trees. Students must understand that termites usually feed on dead wood, while parasitism describes a relationship in which an organism feeds on another living organism.
- Caterpillars are predators to plants.
- Caterpillars are parasitic to plants.

Question 4

This question assessed candidates' knowledge of the life history of an insect vector of disease as well as mechanisms to control vectors at various stages in their life history; their knowledge of viruses and their role in the transmission of certain diseases; and the challenges faced in controlling certain diseases caused by viruses. This question was fairly well done as illustrated by a mean and mode of 7 out of 15.

Part (a) of the question dealt with the life history of an insect vector of disease. In Part (a) (i), candidates were asked to identify, with the aid of diagrams, the main stages in the life history of a *named* insect vector of disease. This part of the question was not very well done, although several candidates correctly named either the mosquito or the housefly and produced accurate well-drawn diagrams. Many candidates drew only a flow diagram of the stages which were often not in the correct order. They did not draw diagrams to represent the stages and when they did, these were poorly done. The drawings looked like any of a range of animals in the Animal Kingdom and some were animated or humanized, much like cartoon characters.

Candidates were expected to have drawn the adult mosquito, clearly indicating the structural features of an insect, namely, three distinct body segments — *head, thorax* and *abdomen* — with *wings* and *three pairs of legs*. Many candidates lost marks for not showing these details. The larva and pupa should have been drawn with structural features such as the *respiratory tubules*. The concept of life history was clearly not mastered. Candidates presented a plethora of incorrect answers such as the characteristics of living things; food chains; genetic diagrams showing a cross between two heterozygotes; drawings of persons being bitten by mosquitoes; and the life cycle of the malarial parasite. Although the question clearly indicated that the insect should be a vector of disease and should be named, many candidates provided examples that were not vectors, naming organisms such as beetles, butterflies and aphids.

In Part (a) (ii), candidates were expected to explain how *each* stage in the life history of the insect identified at a (i) might be controlled. The candidates performed well on this section with many gaining full marks. A response in which the mosquito was identified as the vector, and which earned full marks was as follows:

Egg. This stage can be controlled by identifying places where stagnant water may be present, like old tyres that can collect water when rain falls or the containers at the bottom of plant pots that collect excess water from watering plants, and emptying them. This stagnant water should be emptied in sinks and drains, rather than grass, which may become waterlogged, to ensure that there are no stagnant water sources where eggs can be laid or remove those that already exist. Water guttering must be cleaned regularly, as those may also contain stagnant water.

Larva and Pupa. These stages can be controlled by removing stagnant waters or throwing oil or soap on stagnant water to disrupt the breathing process of the larva and pupa as their spiracles touch the surface of the water.

Adult. The adult can be controlled by spraying mosquito repellent or insecticide to kill most of the existing population. Thick grass can also be cut down. Removal of the habitats means removal of the vectors.

Part (b) of the question investigated candidates' knowledge and understanding of the difficulties in finding a cure for diseases caused by viruses. Part (b) (i) required candidates to offer an explanation for the general difficulty and or impossibility of finding a cure for viral infections. This part of the question was fairly well done by the candidates. Many candidates discussed damage to the red blood cells and blood stream and used the terms 'virus' and 'bacteria' interchangeably. Candidates were expected to refer to the ways in which viruses operated: *affecting the host at genetic level/sub-cellular level/DNA/level of genes; difficulty in detecting their presence until too late; lengthy incubation period; rapid mutation* and so on. Good candidate responses to this part of the question were:

> *Viral diseases are usually difficult to cure mainly because viruses … do not have a true cellular structure but only strands of DNA (deoxyribonucleic acid), which multiply rapidly and cause infection in organisms. Because they do not have a cellular structure it is very difficult …. to find ways to control or cure the multiplication of the viruses. They do not have nucleii which enclose the DNA, therefore, it is impossible to eradicate them by using methods such as killing the nucleii which stop all the activities.*
>
> *A viral infection such as AIDS (Acquired Immune Deficiency Syndrome) … is very difficult to cure as it can become resistant to various treatments by mutating and changing its structure. It also lives inside the body cells of humans, hiding itself and can remain dormant … for many years, and that same individual, unknowing that he/she is infected go about spreading the disease to other individuals.*

In Part (b) (ii), candidates were to suggest factors, other than the nature of the AIDS virus, that make its control difficult. Candidates performed reasonably well with the majority obtaining more than half the marks. Candidates were expected to explore ideas that involved, *human attitudes and behaviours; humans not taking necessary precautions; continued risky behaviours; insufficient education/not taking information seriously; complexity of treatments/difficulty in following treatment*. Many candidates persisted in producing responses that related to the nature of the virus. A good candidate response to Part (b) (ii) was:

> *Control of the disease is very difficult as it is spread by one of the basic human drives, that is, sexual intercourse…. If people continue to be promiscuous and continue to have sex with various partners without protection (that is, the use of condoms), AIDS will continue to spread. Also, in poorer regions, due to lack of education on the spread of AIDS and use of contraceptives (that is, condoms), people will continue to contract AIDS and the population of AIDS-infected individuals will continue to be high in those regions and the mortality rate due to death from AIDS will also be high.*

<u>Misconceptions</u>

- 'Control' of a vector population means 'containment'. It should be noted that control of a population in biological terms refers to means of keeping the numbers of the population down, not limiting their movement to certain places.

- Viruses singularly attack the immune system. It should be noted that almost any organ or tissue in the human body can succumb to diseases caused by viruses.

<u>Question 5</u>

This question required knowledge of genetics including the role of genotypes and the advantages and disadvantages to populations of homogeneity. Candidate performance on this question was fair with a mean of 6 out of 15 and a mode of 5.

Part (a) examined candidates' knowledge of the role and function of genotype in determining characteristics of organisms and the advantages/disadvantages of having a population with identical genotype. For Part (a) (i) candidates were asked to explain why a population with the same genotype may exhibit differences in phenotype. This part of the question was not well done. While many candidates were able to indicate that *environmental conditions* may account for the differences, they failed to expand on this idea. In addition, candidates were expected to indicate that *phenotype is based on both the genotype and the environment; environmental conditions might be variable; some plants may have greater access to water, light and/or minerals.* A good response to this part of the question was:

> *Phenotype, the outward characteristics of an organism, is determined by environmental factors as well as genetic ones. Therefore, even though the plants have identical make-up, environmental factors can affect them, causing differences in development. Factors such as … the amount of water, the nutrients available or lacking in the soil, and the treatment given* to a *plant affect its phenotype. Thus, two genetically identical plants in different environments will show differences.*

In Part (a) (ii), candidates were asked to suggest why it might be necessary to breed plants with identical genotype. This part of the question was also not as well done as was expected primarily because candidates did not elaborate on their answers or where they did, they referred to outcomes of having special features without mentioning the features. Candidates were expected to focus responses on the biology of having a specific genotype in terms of *desirable characteristics, such as larger organs, higher yields or resistance to disease*. A good response to this part of the question was:

> *Sometimes, to improve or maintain high yield, gain large flowers or fruits, high quality fruit or any superior characteristic in a plant population, it is necessary to breed plants of the same genetic make-up. As genes control the characteristics of an organism, to maintain the desired characteristic, the offspring must be of the same genetic make-up. Therefore, this action would result in the offspring being nearly identical to parents with desired traits.*

Part (b) of the question asked candidates to explain how natural selection differed from artificial selection. This part of the question was not very well done. Candidates displayed a number of misconceptions in distinguishing the processes. They were expected to consider that *natural selection preserves useful characteristics relative to the environment/survival of the species; is a slow process; results in survival of the fittest/preservation of the best characteristics to serve the species.* On the other hand artificial selection *is based on human intervention; humans select characteristics beneficial to humans; changes the balance of populations; more rapid process of change of population characteristics,* and other comparisons along those lines. These responses gained full marks:

> *Natural selection occurs when individuals that are best suited to the environment, survive, reproduce and pass superior genes on to offspring. Hence, nature 'selects' beneficial traits giving organisms the best chances of survival. However, in artificial selection, MAN selects the organisms with the beneficial traits. This means that the organisms which are bred aren't necessarily well adapted to the environment or have the highest chance of survival. They are instead well adapted to man's needs, as they have characteristics that man sees as beneficial*.

> *Natural selection is the process by which organisms evolve and survive due to their suitability for nature. With this process, the individuals and traits which survive are good and therefore passed down for survival. However, artificial selection is the process by which man interferes and produces characteristics he chooses.*

Part (c) (i) and (ii) focused on genetic engineering. In Part (c) (i), candidates were to indicate how genetic engineering differed from artificial selection. This part of the question was also not very well done. Candidates displayed a number of misconceptions in their responses. They were expected to indicate that *artificial selection involved the 'normal' reproductive process; used gametes* while *genetic engineering was done at the sub-cellular level/level of genes; offspring can be produced from a somatic cell* and so on. A response that obtained full marks was:

> *Genetic engineering is where genes of one organism are transferred to another organism. Genetic engineering occurs at a microscopic level and involves specific laboratory works, while artificial selection involves simply selecting and breeding organisms. Genetic engineering involves the selection of specific GENES which results in beneficial characteristics and placing it into another organism. However, artificial selection involves the selection of an organism with a specific phenotype that is desirable, and breeding so that the offspring have beneficial traits as well. Therefore, genetic engineering deals more specifically with genotype while artificial selection is based on phenotype.*

In Part (c) (ii), candidates were to suggest two concerns people might have about using genetic engineering to alter characteristics of organisms. This part of the question was reasonably well done. Candidates were expected to refer to ***physiological reasons*** — *unpredictable outcomes, impact on metabolic processes, generational issues* and so on; or ***moral/ethical/social*** *reasons — potential to be used to produce a master/dominant race; manipulation by special groups in the population* and so on; or ***economic reasons*** *— wealthy more likely to gain benefits/influence change, abuse of technology* and so on. A response that obtained full marks was:

(1) Genetic engineering involves the placement of genes from one organism into another. Should an error occur in this placement, a potentially harmful organism can be created which could pose a great threat to society, for example, a new deadly virus.

(2) Genetic engineering may seem immoral to some persons. Some people may have the view that organisms are the way they are for a reason, and tampering with genes and chromosomes is questioning the work of a superior being.

<u>Misconceptions</u>

- Difference in phenotype arises through co-dominance, meiosis and mutation even though it is expressedly stated that the genotype is identical.
- Artificial selection is used to control the characteristics of an organism whereas genetic engineering changes its characteristics.
- Sometimes candidates confused genetic engineering with cloning or artificial selection. It should be noted that genetic engineering refers to the physical manipulation of genes.

<u>Question 6</u>

This question assessed candidates' understanding of the function of locomotion in humans and organization of the hind limbs for this phenomenon as well as dispersal of seeds and their adaptations for this process. Performance on this question was good with a mean of 7 out of 15 and a mode of 6.

Part (a) examined candidates on their knowledge of aspects of locomotion in human beings. In Part (a) (i), they were asked to explain, with the aid of a diagram, how the hind limb in humans allow for locomotion. This part of the question was not well done. The vast majority of candidates could not produce a fair representation of the human hind limb. Candidates were expected to show in diagrammatic form the relationship among *femur, tibia/fibula, and metatarsals,* with at least *one pair of antagonistic muscles* organized to allow for stepping or striding. They were also expected to indicate some of the following in their description: *antagonistic muscles between femur and tibia/fibula; raise and lower knee/foot; antagonistic muscles from pelvis to femur; allow leg to swing forward; coordinated movement between both sets of antagonistic muscles; foot stabilizes after movement forward* and so on.

Candidates generally mentioned the role of antagonistic muscles in facilitating movement but they seemed unaware that these muscles are located opposite to each other, and must have their origin and end attachments on different bones across a joint to allow for movement.

In most of the diagrams they showed antagonistic muscles starting and ending on the same bone. A few candidates were able to provide well-annotated diagrams that earned them full marks. In Part (a) (ii), candidates were asked to give some advantages to humans of the process of locomotion. This part of the question was very well done. A large number of candidates were able to provide expected responses which included ideas that fell within the concepts of *to find/grow food, to socialize, to find a mate, to find work/shelter* or to *flee from danger.*

Part (b) examined candidates' knowledge of seed dispersal and their adaptations for this process. In Part (b) (i), candidates were to identify two mechanisms of seed dispersal. This part of the question was generally well known and almost all candidates were able to secure the marks allotted. They indicated mechanisms such as *wind, water, animals* or *explosive mechanisms*. In responding to Part (b) (ii), which required candidates to explain how characteristics of the seed were adapted for dispersal, many were challenged. Candidates were expected to refer to the variety of ways in which the seed coat is adapted, or to the nature and form of the seed itself to include concepts such as *the seed coat may be extended into wings, grow appendages, have air spaces/may be fibrous* or *tough* or *that the seed itself may be small and light to facilitate wind dispersal.* A good response was:

> *The extension of the testa and the size and weight of the seed are two adaptations. Wind dispersed seeds weigh less and are inflated so that they can be carried easily by the wind. Some seeds have wings (extension of testa) or umbrellas to catch wind. Animal dispersed seeds have hooks to hook onto animal fur so that animals may carry the seeds to other places. These seeds are not inflated and weigh more.*

Paper 03/2 – Alternative to the School-Based Assessment (SBA)

This paper assessed most of the practical skills required of Biology students. Candidates continued to display weak practical skills especially in aspects of Planning and Designing, including the assembling of apparatus, *describing* methods of experiments and in drawing conclusions from data. These observations indicate that **in developing practical skills** students should be *exposed to actual experimenting and investigating scientific phenomena, discussions, explanations and rationalizing of procedures and outcomes* so that they can become capable of developing and manipulating experiments and experimental data on their own.

Candidates continue to display weak drawing skills and lack of knowledge of the conventions of biological drawings, such as the inclusion of magnification and titles of the drawings. In addition, far too many candidates presented untidy drawings with crooked labelling lines.

<u>Question 1</u>

This question tested a range of candidates' experimental skills as required to investigate the release of carbon dioxide during aerobic respiration of germinating seedlings. Candidate performance on this question was reasonable although there were no candidates gaining marks at the top of the range (19 – 21); few candidates obtained scores at the bottom of the range (0 – 2). Candidates once more were challenged in providing descriptions for the conduct of biological investigations and thus displayed weak experimental skills. The mean for this question was approximately 8 out of 21 available marks, while the mode was 7.

Parts (a) to (c) of the question tested candidates' knowledge of the process of germination and the use of limewater to indicate the presence of carbon dioxide. Most candidates were able to state in Part (a) *that the air supplies oxygen*. In Part (b), several candidates were able to state that carbon dioxide was removed from air *to show that the gas produced came only from aerobic respiration by the germinating peas*. Candidates were also able to state in Part (c) (i) that the *presence of carbon dioxide caused the limewater to get cloudy and this was produced from aerobic respiration occurring in the germinating peas*.

Part (d) tested candidates' ability to plan and design an experiment to show that heat is also a product of aerobic respiration. Few candidates were able to score full marks. They should have included *a thermometer* and *viable seeds* among the list of apparatus for the investigation, and described the apparatus as set up with a *conical flask/container* containing *viable, treated seeds* in an *incubator* or *environment at room temperature*, *covered with a bung or cotton wool* which allows for a *tube to conduct air into the flask* and a *thermometer to detect a rise in temperature* if heat is given off from the process.

Part (e) required candidates to construct graphs to represent athletes' rate of breathing after light and heavy exercise, and then to explain the shapes of the graphs. Most candidates were able to score full marks for plotting suitable line graphs but some candidates lost marks for omitting a title and using an inappropriate scale. A few candidates used bar charts to represent the data. Candidates are required to know how best to represent continuous data. They must note that *bar charts* are best used for *discontinuous data* representation. Several candidates were able to provide the expected explanation that *after heavy exercise the breathing rate took longer to return to normal because of a higher gaseous exchange rate, faster rate of respiration* or *higher oxygen debt compared with that after light exercise*.

<u>Question 2</u>

This question tested candidates' ability to make observations and carry out investigations on the rate of transpiration in plants, including the assembling of relevant apparatus. Candidate performance on this question was fair. The mean score was approximately 9 out of a total of 18 and a mode of 9.

Part (a) asked candidates to write a suitable aim for an experiment to test the hypothesis that the amount of water lost from a plant changes during the day. A good candidate response was:

> *To investigate whether a well watered plant loses water throughout the day.*

Part (b) required candidates to explain the shape of the graph showing the changing mass of a well-watered plant between 8.00 a.m. and 10:00 a.m. and between 2:00 and 4:00 p.m. respectively. This part of the question was generally well done by candidates who were able to attribute the steady decline in the mass of the plant *to an increasing rate of transpiration in the morning, caused by rising room temperature, opened stomata and increasing water uptake by the plant*; and in the afternoon the *mass of the plant changed marginally because the amount of water lost was decreasing because the stomata were gradually closing and transpiration rate was decreasing*.

In Part (b) (ii), most candidates were able to accurately estimate the weight of the plant at 12 noon by reading the graph.

They were also able to construct neat tables to represent the data presented in the graph as required in Part (c). However, quite a few candidates lost marks because they did not include a title and appropriate column headings for the table. Candidates should be reminded that units of measurements should be included along with measurements when writing column headings.

Part (d) tested candidates' ability to describe how the apparatus and materials were likely to have been set up and used to obtain the data shown in the graph in Part (b). While candidates were able to score marks for listing appropriate apparatus such as a *well-watered plant, balance/scale and polythene bag/string* for doing the investigation, they lost marks for failing to describe a logical procedure for setting up the apparatus to collect the data. Candidates were expected to mention that *the plant would first be watered and weighed, then placed in the polythene bag and weighed, then placed in a fully enclosed room and re-weighed. Weights were to be recorded at two hour intervals thereafter*.

Question 3

This question tested candidates' drawing capabilities as well as their ability to plan and design an investigation, including arriving at an hypothesis, devising an aim relevant to the hypothesis and suggesting a method to prove the aim. Candidate performance on this question was weak. The mean was approximately 4 out of 21 and the mode was 2.

Part (a) tested candidates' knowledge of the characteristics of a fruit. Most candidates scored at least one mark on this question for correctly identifying the presence of *seeds.* Only a few candidates also included in their response *the presence of two scars at the points where the ovary was attached to the style and the receptacle respectively*, or the *presence of three layers (the epicarp, mesocarp and endocarp).*

In Part (b), candidates were to make a drawing of a cross-section of cucumber from a stereo-diagram of a half of the cucumber. Candidates generally displayed poor drawing skills, and equally important, did **not** observe many of the biological drawing conventions. These are reiterated here:

- Use only sharpened pencils with points. Drawings should not be done in ink.
- Clarity of drawings relate to the size and technique for drawing lines. Lines should be of even thickness and drawings should be of reasonable size.
- Drawings should include magnification which should be as accurate as possible.
- Drawings must have a title that indicates the view of the specimen being drawn.
- Drawings must be accurate line representations of the specimen.
- Drawings should **not** be shaded.

In Part (c), the candidates were given an observation that the fruit was eaten by a kiskedee bird and the seeds were thus dispersed by animals. They were then asked to propose a suitable hypothesis for this observation and to provide an aim to test their hypothesis. This section was poorly done. A reasonable hypothesis based on the student's observations would have been that *'the seeds are adapted for dispersal by birds or animals'* and a likely aim for that hypothesis could be '*To show that seeds are not destroyed after passing through the alimentary canal of a bird*'.

Very few candidates scored marks on Part (c) (iii) which required that they describe a suitable method to investigate the aim they wrote. Candidates were expected to include in their description that they would *identify the birds/animals and their haunts* and *ensure that the seeds were consumed by the birds*, *collect the droppings from the birds* and *examine the droppings for seeds, seeds would then be exposed to conditions suited for germination to see if they are still viable.*

Part (d) examined candidates on their knowledge of feeding relationships. In Part (i), candidates were to give a biological term for the kiskedee that fed on both plants and animals. Most recognized that, based on the kiskedees' feeding habits, it was an *omnivore*. In Part (ii), they were to explain the advantages to the bird of feeding on both plant and animal material. Their responses should have included that a *varied diet increases the chances of survival of the species in times of scarcit*y or reduces *competition for foo*d and *ensures that their diet is more likely to be better balanced*.

Paper 03 – School-Based Assessment

GENERAL COMMENTS

Performance on the School-Based Assessment was commendable at some centres. Favourable trends observed include: *good syllabus coverage (that is, a minimum of nine syllabus topics covered) by most of the centres that were moderated; an increase in the number of centres where both quantitative and qualitative fieldwork were done and the number of times practical skills were assessed generally complied with syllabus guidelines*. This suggests that most teachers recognize the value of providing sufficient opportunity for students to develop and master all the specific practical skills.

However, while the skill of Observation Recording and Reporting (ORR) was generally well done, Drawing (Dr), Analysis and Interpretation (AI), and Planning and Designing (PD) continue to present candidates with the most difficulty.

While the level of organization and presentation of books submitted from most centres was good, there were still some centres that submitted books without the requisite information. The Biology syllabus (page 44) provides guidelines for candidates' preparation of practical books for submission. Some important requirements often not met include: the presence of a Table of Contents providing a list of the aims of practical activities, page numbers, dates, as well as *clear* and *specific* indication of the activities used for the SBA together with the skills being assessed for each activity. In addition, the marks awarded for each practical activity must be placed alongside the practical and not simply listed at the front or back of the books.

The lack of comments in the lab books, especially for skills performed poorly, suggest that candidates are not being given adequate feedback on their progress throughout the period of study. Frequently, only ticks are observed, along with the final score awarded for the skills, but students appear unaware of their strengths or deficiencies.

The moderation exercise was often hampered by poor mark schemes. Teachers are being reminded that mark schemes must be legible and preferably bound together instead of on loose sheets of paper. There must be a *clear* and *direct* relationship between the marks awarded to the appropriate activities in the practical books and the marks on the tally sheets. It should also be noted that no more than two skills should be assessed in a single practical activity. New teachers in particular should consult pages 38 – 44 of the Biology syllabus for guidance in preparing and presenting mark schemes.

The following is a list of criteria which teachers should follow in marking SBA activities.

- Marks should be awarded for each skill separately. It is noted that in some cases, marks were given for each skill then tallied to give a composite score. This is unacceptable.

- Marks awarded to students' work should be a fair indication of its quality. Too many students received high marks for work that fell short of the CXC standard. This was particularly noticeable for Planning and Designing, Analysis and Interpretation and Drawing. When the CXC standard is not observed, there is great disparity between the teacher's score and that of the moderator. This circumstance is usually **disadvantageous** to candidates.

- Marks submitted on the moderation sheet should reflect the candidates' marks in each of the samples. Consistency of marking and submission of marks relate to the reliability of the process and thus acceptability of marks submitted.

- Teachers are once again reminded that body fluids such as saliva, blood and urine are not to be used for practical work. These can be sources of infection and may have serious legal implications should a student become infected while conducting practical work. Plant materials must be removed from books before they are submitted to CXC, since these are also potential agents of infection when moved from place to place.

The examining committee would also like to recommend that there be greater cooperation among teachers of similar subjects at the same centre and mentoring of new teachers to ensure that standards are consistently maintained.

A review of previous school reports will provide additional suggestions for developing practical skills. Further suggestions are reiterated in this report and *each* teacher is alerted to the specific strengths and weaknesses displayed by his/her candidates in the Moderation Feedback Report sent to schools from CXC, after moderation. The Moderation Feedback Report, which is sent to each centre, provides constructive and useful information relevant to the particular teacher(s).

This report offers specific recommendations and is intended to assist teachers in the planning, conducting and assessment of practical work - in the laboratory and field. Improvement of candidates' practical skills will have a direct influence on the overall performance in the examination, since certain questions, notably Question 1 on Paper 02, and where applicable, questions on Paper 03/2 are based on knowledge and application of these practical skills.

SPECIFIC COMMENTS ON THE ASSESSMENT OF SKILLS

The following information is to assist especially new teachers of Biology in interpreting the information given on the Moderation Feedback Report. *It should first be noted, however, that the number of times a skill is assessed is considered sufficient if assessed a minimum of four times, except for the Planning and Designing skill which is assessed twice* (see page 37 of the Biology syllabus).

Observation, Recording, Reporting (ORR)

These skills appear to have been mastered at most centres. For most of the work observed, the method was clearly described with a logical sequence of activities. It was also observed that generally, the past tense was correctly used in the presentation of the report on the practical activity as required. Candidates should be encouraged to give careful attention to grammar, quality of expression and giving as much details as possible when reporting their procedures and observations, as science students need to appreciate the importance of clarity in explaining their results. Where possible, students should also be encouraged to repeat procedures and give average results to improve the reliability of their results.

The tables and graphs were usually clear and provided adequate details which allowed for clear description and discussion of the experiment. The examining committee recommends that teachers give more activities where students construct their own tables and graphs using their results. This will allow them the opportunity to develop these skills.

When using tables, teachers should remind candidates that the TITLE should be written in capital letters, and appropriate column headings should be given. See example below.

Example:

TABLE 1: FROG POPULATION OBSERVED FROM OCTOBER 1997 TO OCTOBER 2004

Year	Number of frogs
2004	5
2001	110
1997	125

When presenting graphs, the TITLE should be *written below the graph* and *underlined*; *axes should be labelled* with *units* stated and a *key* should be given if necessary.

If calculations are required, all necessary calculations should be presented neatly and in an organized fashion. Units should also be included where necessary.

Where drawings are used in reporting observations, they should meet standard SBA drawing criteria.

Drawing (Dr)

There has been a general improvement in the clarity of drawings done by candidates at most centres. Some teachers continue to reward with high marks, drawings that do not meet the CSEC standard. The examining committee does not expect drawings to be works of art but they should meet the criteria for accuracy, clarity, labelling and magnification. Teachers should ensure that students are given several opportunities to practise and develop drawing skills.

It is a requirement that drawings must be practised from actual specimens and **not from textbooks**. Specimens MUST include drawings of **flowers, fruits, storage organs and bones**. Additional examples may be included in practical books. However, **microscope drawings, models and apparatus should NOT be used for SBA assessment**. Drawings of cells, while useful for teaching, should not be assessed at this level. Similarly, dissections may help students to understand structures such as the digestive system but they are too complex to be drawn accurately at this level. These difficult drawings do not provide a fair test of ability at the CSEC level.

Accuracy and labelling continue to be problem skills and there appears to be some degree of inconsistency — even among teachers at the same school — in how they are assessed. Label lines should be drawn with a ruler and as much as possible, labels should be written in script so that they can be easily read. Annotations that accompany drawings should be as brief as possible and clearly and neatly written.

Table 1 is a list of 'DOs' and 'DON'Ts' applicable to SBA biological drawings at the CSEC level.

TABLE 1. DO'S AND DON'TS' OF BIOLOGICAL DRAWINGS

DOs	DON'T's
• Use pencils for all drawing activities - drawing, label lines, labels. • Use drawings of actual biological specimen (not diagrams, models or textbook drawings); • For assessment, ensure that there are drawings of flowers, fruit, seeds and bones. • Let the size of drawings be at least half page. • As far as possible, have label lines and labels positioned at the right side of drawings. • Let all label lines end at the same vertical plane. • Let label lines be drawn parallel to the top/bottom of the page. • Ensure label lines end on part being named. • In the title, use the word 'drawing' and not 'diagram'. • Position titles under drawings and indicate the actual name of the specimens (for example, cervical vertebrae of a goat, mango leaf, hibiscus flower) **and** the view drawn. • Underline the title. • Include the magnification and state where appropriate, actual length and width of specimen, as well as place 'x' in front of the magnification. • Write magnification to one decimal place. • Use a key to explain symbols where appropriate, for example, stippling/cross hatching.	• Do not use arrow heads. • Do not cross label lines. • Do not use dots or dashes. • Do not join the letters of words for label or title.

The examining committee also encourages teachers to ensure that standard drawing criteria are applied whenever drawings are required in laboratory activities, especially when reporting observations and/or illustrating biological processes such as germination, regardless of whether DR skills are to be assessed or not. This should help students appreciate the importance of the skill.

Teachers should also ensure that students draw on plain paper and then neatly insert drawings into lab books, if the books are not designed with plain sheets of paper for drawing. Distinguishing features and labelling lines are often unclear when drawings are done on ruled sheets of paper.

Analysis and Interpretation (AI)

This skill continues to present problems for the majority of candidates. Many teachers continue to use questions to stimulate discussion. This device is good for helping candidates to develop their AI skills. However, it should not be used excessively, nor should it be the *only* means of assessment. These questions must guide candidates to provide the required background information, give explanations for the results, draw conclusions and show an awareness of possible limitations. The information provided in this way should then be written as a paragraph of continuous prose, as is normally done for the discussion/conclusion. In many cases, candidates seemed to have learnt a formula for writing up the discussion but showed no real understanding of how to interpret their own results. As a learning strategy, teachers may ask students to orally explain the results to obtain a clearer view of their understanding, and to help them develop their analytical skills.

The marking criteria used by some teachers did not include 'limitations' as one of the criteria. It was sometimes observed that precautions/control/sources of error were often accepted as limitations by teachers.

The use of controls should also be emphasized in discussions as they are a point of comparison for the experimental set up in which a particular variable has been omitted. This comparison should be included in the discussion since it is the key to drawing the conclusion. Conclusions should relate directly to the aim of the investigation. Candidates should also be reminded to discuss at least one limitation of the investigation. It is important for them to recognize that the conditions present in a school laboratory are rarely ideal.

The processes involved in demonstrating the AI skill are reiterated here:

- Background information may be written in the 'Discussion', or in the introduction section.
- Background information for the experiment must be related to the theory.
- 'Discussion' should be an analysis or interpretation of the recorded experimental results. Discussion must not simply answer posed questions for AI.
    a. Questions may be used to guide students but answers must be written in paragraph format (without the questions, or written comprehension style).
    b. Questions should not to be included in the lab report.
- Conclusions must be based on the aim. (It is a brief answer to the aim.)
- Limitation(s) should be included among the AI marking criteria.
- Identifying source(s) of error and precaution(s) are necessary. These are both different from each other and from limitation(s).
- All components of AI (background knowledge, explanation of results, limitations and conclusion) should be included in the mark scheme for the skill.

The examining committee is again reminding teachers that food tests *on their own* are not appropriate for assessing AI. Simple investigations can be designed in which food tests are used. For example, candidates can be given unknown mixtures and asked to find out which food would be most suitable for an infant. Food tests can also be used to determine the presence of a particular food before and after digestion by an enzyme. These types of exercises will allow candidates to develop the necessary skills. Knowledge of the food tests and the nutritional requirements can then provide the background information on which they will base their conclusions.

Manipulation and Measurement (MM)

As has been the trend in previous years, this skill continues to be the one that most candidates appear to have achieved mastery of, based on the observation that most are awarded full marks. However, evidence such as performance on the practical question in the final examination suggests that these marks may not be the result of rigorous marking. Also, if virtually all candidates in a class gain full marks on an activity, this suggests that the task may not be demanding enough or the criteria not detailed enough to allow the necessary discrimination between different levels of performance.

The examining committee recommends that teachers expose students to as wide a range of apparatus and their use in collecting data as is possible. This would help to ensure the development of candidates' manipulation skills and allow for a more fair assessment of their competence in MM.

Planning and Design (PD)

Performance on this skill has shown some improvement relative to former years, and teachers should be commended for demonstrating more creativity in the types of observations/problem statements provided to candidates on which to base their hypotheses and design their experiments. The examining committee continues to emphasize the importance of using examples from candidates' local environment as this will help them better appreciate how they can apply their biological knowledge and practical skills to solve problems they frequently encounter. Teachers are reminded that it is inappropriate to have candidates copy procedures from textbooks and reproduce them verbatim for assessing candidates' PD skill.

The experiments designed by candidates from some of the centres moderated indicated that there was some understanding of the procedures involved in planning and conducting an experiment but, in some instances, there were no replicates in the investigations. There are still a few areas of difficulty where candidates were unable to state their hypotheses clearly and relate the aim to the hypothesis. A hypothesis is an explanation, based on particular observations, about how things work or why something happens. A hypothesis can usually be tested.

It is also important that development of the skill start with the commencement of the teaching of the syllabus. In many cases it was obvious that practical activities targeting the development of the PD skill was among the last set of activities in which the candidates engaged prior to the examinations. The following example (Figure 1) is given to illustrate how a PD activity might be effectively developed. It is not meant to be copied verbatim and given to students as a PD activity to be marked and submitted for SBA.

Example:

This Planning and Design activity submitted by a centre was based on the following observation:

Whilst digging his garden, a gardener noticed that there were a lot of earthworms in one area but few in another.

The teacher's instructions to students were:
Suggest one possible hypothesis for the gardener's observation. Design an experiment which you could carry out to test your hypothesis. Your design must include:

- Your hypothesis, which clearly relates to the observation given.
- Your aim which clearly relates to your hypothesis.
- A list of the apparatus and materials you would use.
- A clear method, written in instruction format, stating the steps you would use and including a suitable control.
- At the end of your method, clearly identify the manipulated variable, the responding variable and the controlled variable.
- A summary of the expected results — if your hypothesis is correct (can be supported) — and if your hypothesis is not correct (cannot be supported).
- An explanation of the limitations of your method.

Figure 1. **Example of a Good Planning and Design Activity**

Two hypotheses related to the example at Figure 1 are:

- *Earthworms live only in shaded areas*.
- *Earthworms are found only in moist habitats*.

Relevant aims for the proposed hypotheses include:

- *To investigate the distribution of earthworms in well-lit and shaded areas.*
- *To investigate the distribution of earthworms in moist and dry areas*.

The PD activity shown in Figure 1 generated different experimental designs from the candidates at this centre, which underscores the point that if candidates are given clear instructions and guidance, they can develop this skill and demonstrate a high level of proficiency.