LIFE SCIENCES: PAPER I

MARKING GUIDELINES

Time: 3 hours   200 marks

These marking guidelines are prepared for use by examiners and sub-examiners, all of whom are required to attend a standardisation meeting to ensure that the guidelines are consistently interpreted and applied in the marking of candidates' scripts.

The IEB will not enter into any discussions or correspondence about any marking guidelines. It is acknowledged that there may be different views about some matters of emphasis or detail in the guidelines. It is also recognised that, without the benefit of attendance at a standardisation meeting, there may be different interpretations of the application of the marking guidelines.

QUESTION 1

1.1   **COLUMN A**   **COLUMN B**

[I]   An embryonic plant and its food reserve enclosed in a   A   Anther
      protective coat.

[A]   The structure in a flower that produces pollen.   B   Pollination

[J]   The collective name for all the male reproductive parts   C   Filament
      of the plant.

[H]   An asexual reproductive process for growing many of   D   Ovule
      the same type of plant.

[D]   The structure in a flower that develops into a seed of   E   Fertilisation
      the flowering plant.

[G]   The structure down which the pollen tube grows to   F   Stigma
      reach the ovary of the flower.

[E]   The term for the fusion of a male gamete with a female   G   Style
      gamete.

[K]   A natural genetic condition where a plant has more   H   Tissue culture
      than two sets of chromosomes that may result in larger
      fruit.

[F]   The female part of the flower that produces a sticky   I   Seed
      substance for the adherence of pollen grains.

[C]   The thin stalk that supports the pollen-producing part of   J   Stamen
      the flower.

                                                                                    K   Polyploidy

1.2

Question	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.2.7
Answer	A	D	D	C	C	B	A

1.3   1.3.1

Hormone secreted	Letter of endocrine gland
Adrenalin	D
Thyroxin	B
Prolactin	A

1.3.2 Hormone: Growth Hormone/GH/HGH/somatotropin/STH
Letter of endocrine gland: A

1.4   1.4.1 (a)   The life expectancy has increased/slightly more people are living to old age/people live into the 90s age group/life expectancy was lower in 1980.

(b)   The birth rate has decreased/there are less people under the age of 30/birth rate was higher in 1980.

1.4.2 Reason for the decrease in birth rate:
- Increased use of contraceptives.
- Family-planning services/contraceptives more accessible.
- Women are choosing to have children later in life.
- Increased cost of raising children means women choose to have fewer children/increased cost of living.
- Improved education and empowerment of women.
- Increase in HIV/AIDS in younger, childbearing people = fewer children born.

1.4.3 B

1.4.4 (60 048 698 – 28 566 771) = 31 481 927

if calculated % increase:
(60 048 698 – 28 566 771) / 28 566 771 × 100
= 110 %
(working correct answer)

1.5

Item	Term	Answer
1. Determined by genes located on autosomes. 2. Determined by genes located on gonosomes.	Sex-linked trait	2
1. An mRNA molecule. 2. A random change in DNA sequence.	Allele	None
1. An organism's observable characteristics. 2. The genetic make-up of an individual.	Phenotype	1
1. Two variations of a gene present in a genotype. 2. The expression of the recessive gene will not be evident.	Heterozygous	Both
1. A technique used to make more copies of DNA molecules in a sample. 2. A micrograph of all the chromosomes in a cell.	CRISPR	None

1.6   1.6.1 (a)   Head: shape (oval) and labelled
                       Correct length of head (tail 8X longer than head/shorter than
                       midpiece)
                       (see diagram below)
                       (check length on final printed copy)

         (b)   Correct placing of nucleus with label
                 (see diagram below)

         (c)   Correct placing of acrosome with label
                 (see diagram below – acrosome in front of nucleus)
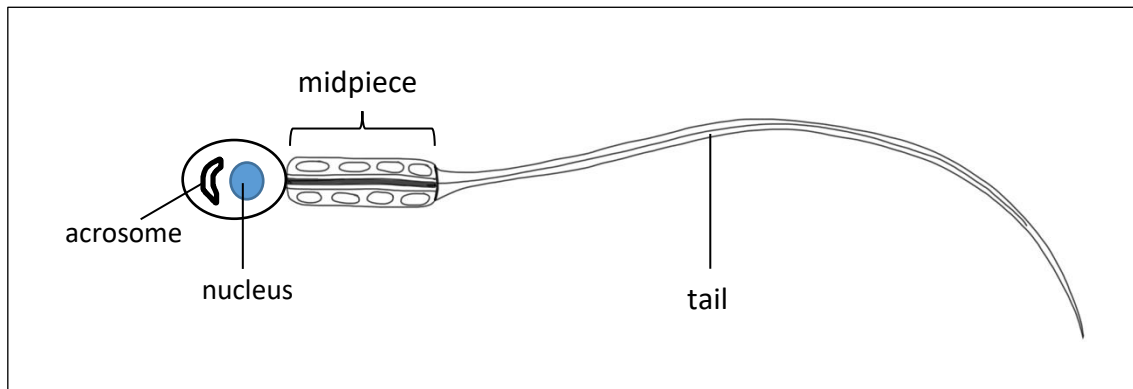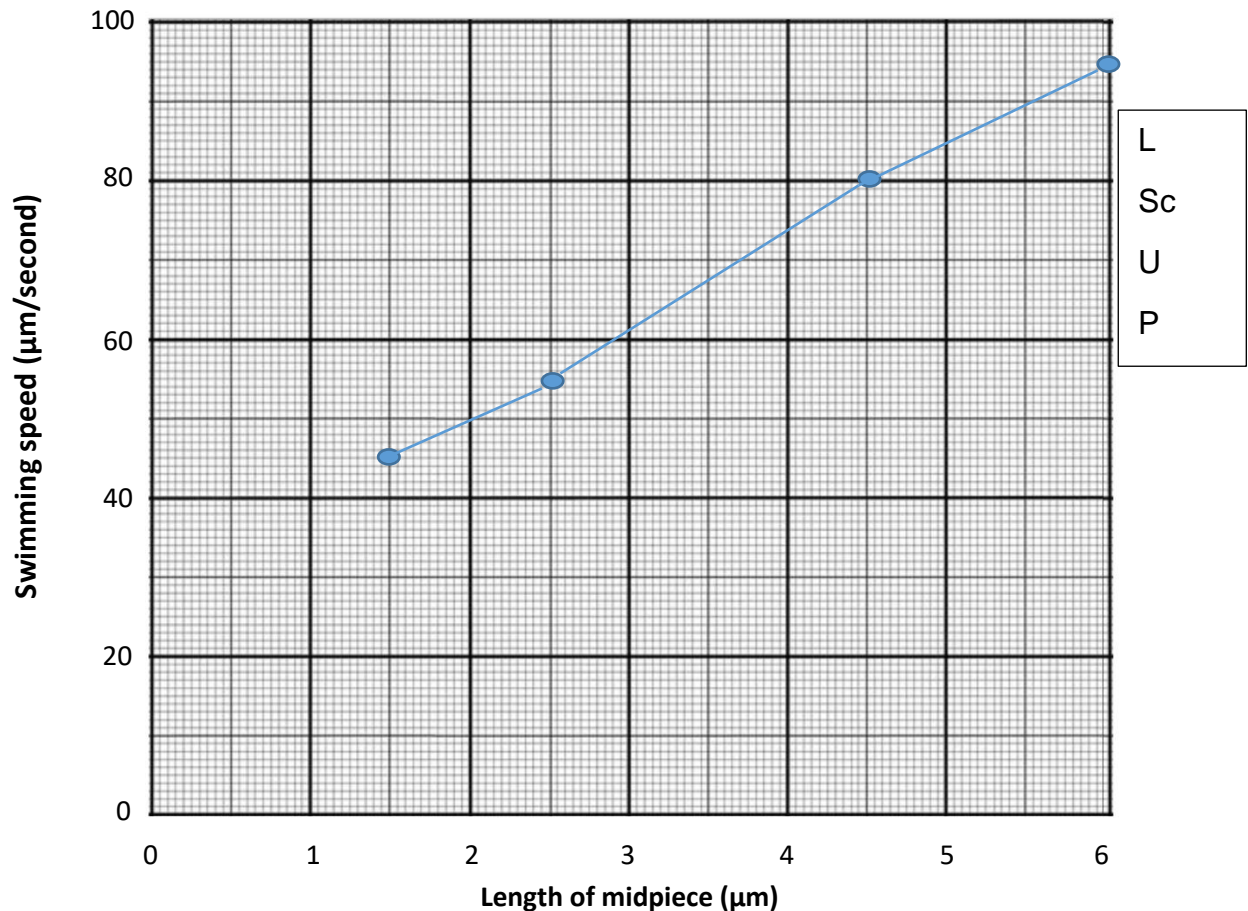

   1.6.2 Haploid

1.7   1.7.1   Epididymis

         1.7.2   Increases the speed/more energy available/increased respiration
                   as there are more mitochondria in midpiece
                   and will therefore reach the ovum first

         1.7.3   **Graph showing the relationship between sperm midpiece length
                   and swimming speed**

H: Heading (both variables included)
x-axis label: Length of midpiece
y-axis label: Swimming speed
L: Graph Line – not joined to 0;0
Sc: Correct scale on both axes
U: Label units on both axes
Plotting: check 6 µm: 95 µm/s

         1.7.4   An <u>increase</u> in <u>sperm midpiece length</u> results in <u>increased</u> <u>swimming
                   speed</u>.

                   OR

                   The longer/shorter the midpiece of sperm the faster/slower the sperm
                   can swim.
                   (Statement must include relationship between the two variables)
                   (Accept alternative correct versions of statement)

1.8   1.8.1

		Statement	A, B or C
	(a)	A blood sample can be taken from a finger to test glucose levels.	A
	(b)	Obesity has increased in both men and women in South Africa since 1980.	A
	(c)	There are 14,2 million South African adults with diabetes.	B
	(d)	The risk of diabetes decreases over the age of 45 years.	B
	(e)	Diabetes is the leading cause of death in South Africa.	C

1.8.2   Insulin:
- Targets (body) cells to increase glucose uptake by increasing the permeability of the cell membranes/opening glucose channels on membranes so glucose is used as energy/in cellular respiration.
- Targets the liver/cells to store excess blood glucose as glycogen.

1.9   1.9.1   Transgenic bacterium contain:
- foreign gene/DNA/DNA from another organism/human insulin DNA/gene.
- DNA that has been introduced/inserted into bacterium.

1.9.2   (a)   Cuts/inserts/combines plasmid DNA/cuts insulin gene out of human genome

(b)   Joins insulin gene to plasmid DNA

1.9.3 *(See placement of X below – anywhere between sticky ends (not the blue portion) on recombinant plasmid)*
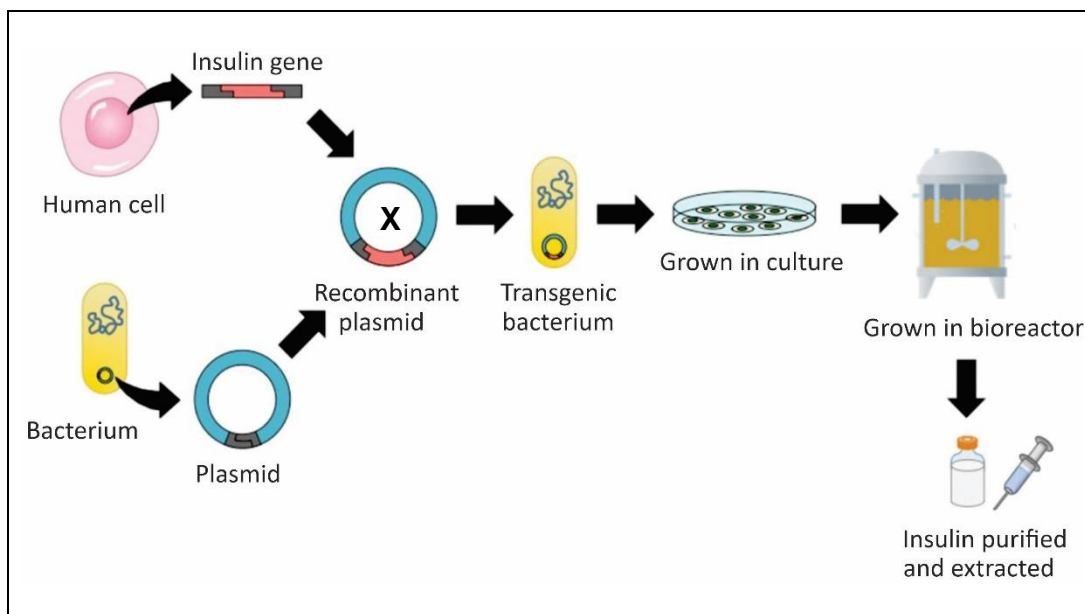

1.9.4 It is important because:
- It saves time/money for others so work is not repeated.
- Work can be compared/improved/revised so errors are corrected/ not repeated.
- Learn from mistakes made/progress can be made so future methods can be improved.
- Scientists are aware of the experiment and so won't use it as it is

(Accept other reasonable answers)

1.9.5 Advantage of insulin made by recombinant DNA technology:
- Bacteria reproduce very quickly so large quantities can be produced/insulin produced quickly.
- Fewer side effects as insulin is human/not from another organism.
- More cost effective than obtaining insulin from animals that have to be farmed, etc.
- More ethically acceptable as animals are not harmed/does not violate religious/cultural observances.
- Bacteria are easy to keep under controlled conditions so insulin produced quickly

1.10   1.10.1   All chromosomes are single stranded/no homologous/paired chromosomes in cells/all cells are genetically different/crossing over has taken place/recombinant chromosomes/4 gametes or daughter cells produced

       1.10.2   Any centromere labelled correctly
(see diagram below)
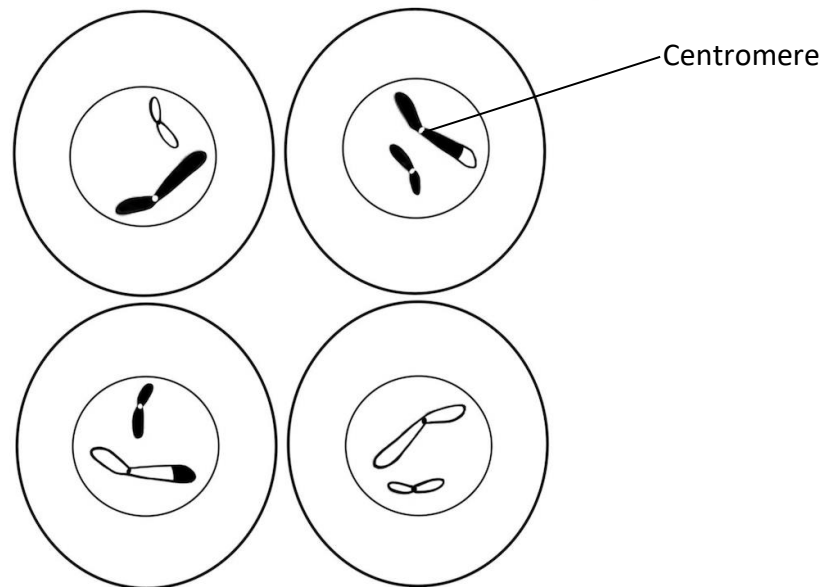
       1.10.3   Importance of meiosis:
- Introduces variation/recombination of genes through crossing over/exchange of genes between homologous chromosomes/ independent assortment.
- Reduces the chromosome number by half for gamete formation/ to counteract the doubling of chromosomes during fertilisation OR ensures after fertilisation the diploid number is restored to remain the same as parent
- Increased variation results in better chance of survival in a changing environment

       1.10.4   **Drawing of the parent cell at the end of prophase I of meiosis**
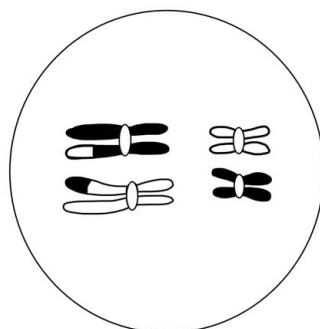
4 chromosomes drawn (in one cell)

Chromosomes are double stranded

2 long + 2 shorter chromosomes shown

Homologous pairs shown

Indication of recombination on one chromosome pair

QUESTION 2

2.1   2.1.1   Nucleotide

        2.1.2   (a)   Adenine

                (b)   Cytosine

        2.1.3   Differences between the two models:
                - Accepted model has hydrogen bonds joining the strands while the incorrect model has magnesium bonds joining the strands.
                - Accepted model has the bases in the centre of the double stranded molecule while the incorrect model has the bases facing outwards.
                - Accepted model has bonds between the nitrogenous bases while the incorrect model has bonds between the phosphate molecules.
                - Two sugar molecules are joined to the phosphate molecule instead of one sugar molecule joined to the phosphate molecule.
                - The accepted model is helical/a helix while the incorrect model is flat
                - The accepted model shows antiparallel strands/sugar orientation changes on each strand while the incorrect model shows parallel strands/sugar orientation is the same on each strand.
                -
                (First two comparative differences described)
                (Accept other appropriate differences regarding nucleotide orientation and structure)

        2.1.4   **No/not ethical**
                - Viewed Franklin's research without her awareness/knowledge.
                - Only after viewing Franklin's work, did they have the knowledge to correct their mistake.
                - Did not credit her in their publication of results.
                - Was her intellectual property needed her permission

                OR

                Yes
                - Maurice Wilkins was Franklin's colleague and was also working on the DNA research.
                - Led to a ground-breaking discovery for the betterment of all humans.
                - Changed the scientific landscape/understanding of life, which allowed for new areas of research.
                - Argue that there is no intellectual property in science and so use of the photos allowed for collaboration

2.1.5 **Flow diagram to show the steps in DNA replication**

> (1) DNA helix unwinds (helicase unwinds DNA) →
> (2) Hydrogen bonds break/unzip →
> (3) Free nucleotides pair with corresponding bases on exposed DNA strands in complementary base-pairing/(A with T/G with C) →
> (4) DNA polymerase/enzymes form bonds between the bases on the strands →
> (5) DNA rewinds

(Heading + correct sequence + 4 correct facts)
(Correct sequence = steps (1), (2) and (3) in consecutive order)

2.2   2.2.1 Translation

2.2.2 (a)   X

(b)   W

2.2.3 tRNA brings amino acids to the mRNA/ribosome by linking anticodons with mRNA codons to place amino acid in the correct order for synthesis of a protein/to form a peptide bond.

2.2.4 Peptide bond

2.2.5 3: Arg
4: Ser
5: Thr

2.3   2.3.1 Positive impact of HGP on society:
- Identifies the genes that influence risk of human disease.
- Determines what features/proteins are being coded for in human genome.
- Helps diagnose diseases/improved diagnostic tests for diseases
- Improves understanding of gene function diseases, e.g., cancer.
- Allows detection of genetic predispositions/earlier detection to disease
- Improves medicines/drug design (pharmacogenomics)/gene therapy/molecular medicine
- Useful in understanding of human evolution/human migration
- Established an open approach to data sharing/improved access to data
- Development of improved sequencing technologies and tools

2.3.2
- It was a collaborative effort/many scientists working on it so information needed to be shared.
- Prevents duplication of data.
- Speeds up the research process/time is not wasted.
- Allows further research into debilitating/inherited diseases, etc., to commence immediately
- It is life changing research

2.4   2.4.1 A   change/rearrangement/deletion/addition/substitution/translocation in the DNA structure/DNA sequence/composition of genes/order of nitrogenous bases/chromosomes/genetic make-up of an individual

2.4.2 B

2.4.3 mtDNA
- Only mitochondria in the ovum will be included in the zygote.
- Midpiece of sperm containing mitochondria is excluded during fertilisation.
- Only head of sperm with nuclear DNA is incorporated into the egg cell during fertilisation.
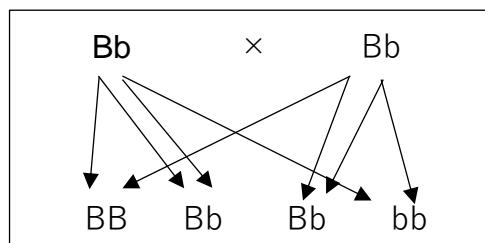
2.4.4 (a)   Individual 3:
- is male
- has mutation/is affected/has Leigh syndrome
- is homozygous recessive
- is deceased/did not survive

(b)   P$_1$:   Bb   ×   Bb   *(can mark parent genotypes in Punnett square)*

F$_1$: *Punnet diagram*

	B	b
B	BB	Bb
b	Bb	bb

OR *Genetic cross*

Bb   ×   Bb

BB   Bb   Bb   bb

F$_1$ genotypes: 1 BB : 2 Bb : 1 bb
          Or 1 homozygous dominant: 2 heterozygous : 1 homozygous recessive
F$_1$ phenotypes: 3 unaffected: 1 affected/Leigh syndrome
(1 normal, 2 carriers, 1 affected)

- *(If parental genotypes incorrect then max 2: carry error forward and mark only the Punnett square/offspring in genetic cross)*
- *(Genotypes and phenotypes can be written alternatively as percentages/fractions, etc.)*

QUESTION 3

3.1   3.1.1 C

        3.1.2 Improves reproductive success because:
               • It increases the chance of fertilisation so more offspring can be produced.
               • Some gametes can be carried away by water currents and so would not be fertilised.
               • Eggs can be eaten by predators and reduces the number of offspring produced.

        3.1.3 (a)   *r*-strategist
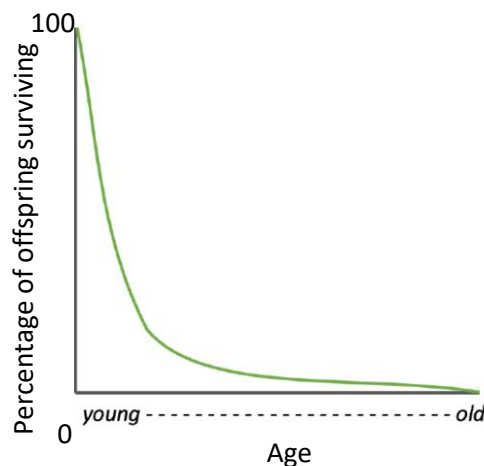   Very high/98% mortality rate in larvae
                       Very large number of eggs produced/10 000–10 million eggs
                       Very low survival rate/fewer than 1 in 10 000 reach maturity
                       (strategist identified + 2 facts)

               (b)

                       X-axis label
                       Y-axis label
                       Correct shape of curve
                       (Accept appropriate correct alternate axes labels/scale)

        3.1.4 If poachers target 20 cm abalone:
               • Numbers of mature abalone in wild are decreased.
               • Fewer eggs released/10 000 eggs vs 10 million eggs.
               • Reduces natality rate
               • Decrease population size.
               • Poachers will target the immature abalone when 20 cm abalone cannot be found/only immature abalone left
               • Species at risk of extinction/won't be able to maintain population.

3.2   3.2.1 • Accurate identification of threatened species.
               • It can be used in courtroom prosecutions to identify specimens that were poached.
               • It can be used for border inspections to identify specimens that are exported/illegally traded.

3.2.2 • Would need to know where on the coastline abalone are located/ difficult to locate abalone.
- Time-consuming to locate abalone.
- Biologists would need to scuba-dive to get samples.
- Scuba diving requires special equipment/skills.
- Training/hiring of people/boats to collect samples must be done.
- This could be expensive.
- Collection of samples will be dependent on weather.
- Abalone hide between rocks making them difficult to find.
- Small numbers are left in the wild populations due to poaching so difficult to find.

3.2.3 (a)   C
All the bands match/align with unknown specimen.

(b)   Non-coding DNA is highly variable/unique profile for every individual

(c)   • Stricter controls at border crossings to check contents leaving the country.
- Increase penalties/fines/jail sentence for poachers to deter them from the activity.
- Stricter guarding/patrols of coastline/hotspot areas to look out for/catch/deter poachers.
- Create/train law enforcement unit to investigate/target hotspot areas with poaching of abalone.
- Create more job opportunities/employment

3.3   3.3.1 An offspring of two dissimilar parents (may be different breeds/ varieties).
OR two homozygous parents producing heterozygous offspring

3.3.2 • High quality/large amount of meat
- Fast growth rate

3.3.3 Scientific importance of the criteria in the breeding programme:

Criterion 1:
- Must be *closed* so that no migration occurs and that any hybrids produced in the breeding programme would not be introduced into wild populations; known genetic outcome/no foreign DNA introduced.

Criterion 2:
- Must have *genetically diverse individuals* for greater variation to prevent inbreeding/frequency of harmful traits.

Criterion 3:
- Must have *healthy individuals* that are bred/able to breed themselves to improve success of reproduction programme/ healthy offspring are produced ensure ethical standards are maintained maximise potential profits/yield increased genetic health prevent spread of disease.

(For each criterion – 2 facts)

3.4   3.4.1   (a)   Density of abalone population

        (b)   Water temperature/18 °C water/type of diet/seaweed diet/ water quality

        3.4.2   0,04 mm/day (*check final printed copy*)

        3.4.3   (a)   High densities:
                - The competition for food was high/less food/less space/ accumulation of waste/increased spread of parasites or diseases.
                - So, the shell length growth was less/low/0,03 mm/day.

                (b)   Low densities:
                - Less competition/more food/more space available/less waste accumulation.
                - So, the shell length growth was more/higher/0,09 mm/day.

QUESTION 4

4.1   4.1.1   Organisms that catch/kill and eat prey/another animal

        4.1.2   (a)   Possible food chains below:

                        plankton → small fish → squid → large fish → killer whale

                        OR

                        plankton → small fish → large fish → great white shark → killer whale

                        OR

                        algae → sea cucumber → seal → great white shark → killer whale

                        OR

                        algae → small fish → squid → large fish → killer whale

                        OR

                        algae → small fish → large fish → great white shark → killer whale

                        OR

                        algae → sea cucumber → large fish → great white shark → killer whale

                        Food chain must:
                        • *Start with either plankton or algae*
                        • *Have 5 organisms that ends with the killer whale*
                        • *Have arrows in correct direction to show energy flow*

                (b)   Energy is lost at each trophic level due to life processes/ growth/waste production, etc. very little energy remains for the next trophic level to use.

        4.1.3   Pods/groups:
                • Contain 2 to 15 individuals so there are many of them for safety in numbers
                • This leads to more successful hunting because of learned hunting techniques/communication during hunts.
                • It increases chance of locating prey as more individuals can look out for prey.
                • It allows for larger prey to be caught. so more food for the pod
                • Older whales teach younger whales hunting techniques.

4.1.4 Females are dominant in the group
Consist of 2–15/large number of individuals in the group
Females care for young
Co-operative hunting
Communication/vocal behaviour between members

4.2 4.2.1
- Provides nutrients from mother's body.
- Excretion/removes metabolic wastes.
- Acts as a microfilter/prevents entry of pathogens.
- Passive immunity/allows maternal antibodies to pass to foetus.
- Endocrine function/secretes oestrogen and progesterone.
- Gaseous exchange between foetus and placenta.
- Oxygenates the blood to foetus

4.2.2 Attaches the foetus/offsprin to the placenta/between the foetus and the placenta.

4.3 4.3.1 Number of sightings of great white sharks decreased.

4.3.2 Interspecific
They are different species

4.3.3
- It is not a direct count/census/not every individual is counted.
- There is no random sampling of sharks.
- Sharks are not tagged to prevent them being counted twice/shark may be counted more than once.
- Identification of sharks is biased/subjective.
- Sightings are dependent on water conditions.
- Only large sharks can be seen.
- No mathematical/statistical formula is applied to get an estimate.
- It is not a closed population
- Sharks not visible in deeper waters/only near shoreline

4.3.4
- Provides employment.
- Provides scientists/tourists/surfers/fishermen with valuable information on sharks' location.
- Creates awareness of sharks.
- Warns/alerts swimmers of shark presence/improves public safety in the water.
- Prevents shark attacks.

(Accept other feasible answers)

4.4   4.4.1   Primary succession
                Pioneers established on bare rock/no soil present initially/plants did
                not exist previously.

       4.4.2   (a)   2 5

                (b)   (i)   C

                         (ii)   A

                (c)   **Table comparing differences in climax and pioneer
                         communities**

Pioneer Community	Climax Community
Consists of small-sized species	Consists of large-sized species
First community to appear	Last community to appear
Species establish themselves quickly (1–2 years)	Species take a long time to establish (100+ years)
Species are poor at competition	Species are good at competition
Species tolerant to extreme environments (wind exposure)	Species are less tolerant to extreme environments/require more fertile soil.
Low/limited biodiversity	Supports great biodiversity
Species are fast growing	Species are slow growing
Species are short lived	Species live long
r-selected species	*K*-selected species

                         (Heading)
                         (Table construction)
                         (*2 Comparative differences*)

4.5   4.5.1   34 × 52/13 = 136

       4.5.2   Precautions:
                • Enough time given for mice to mix freely with the rest of the
                  population.
                • Mark must remain on mice/not fall off the mice for entire
                  investigation.
                • Short period of time between sampling to reduce numbers of births/
                  death.
                • Must be a closed population
                • Mark must not harm/hinder mice/attract predators

                                                                          Total: 200 marks