Assessment Schedule – 2019

Biology: Demonstrate understanding of gene expression (91159)

Evidence Statement

Q	Expected Coverage	Achievement	Merit	Excellence
ONE (a)	Phenotype is the physical expression of the genetic information in the lamb's DNA. The genotype is the alleles that the lamb possesses. The environmental factor that is affecting the phenotype in this example is the lamb's diet / B12 / vitamin intake.	• Describes phenotype AND describes genotype. • Identifies diet / B12 / vitamin intake.		
(b)	The study was conducted on twin lambs because they have identical / similar DNA. Therefore, any difference in phenotype would be due to the environmental influence of their diet, not their genotype. As this study used twins, if put under exactly the same environmental conditions the lambs should have identical phenotypes. This is because the phenotype of the lambs is produced by the interaction between the environment and its genotype. In this study, each lamb had the same genetic potential, but their diet prevented it from being realised. The lack of B12 didn't change their DNA / genes but did change their phenotype. In both lambs, the genotype is expressed by the production of enzymes. However, in lamb #1, without B12, these enzymes can't function. Therefore, lamb #1 genotype can't be realised and is expressed as a weak lamb with low rbc and poor wool. Comparatively, in lamb #2, the genes produce the same enzymes, but in this instance, the enzymes can function due to the B12 in their diet. Lamb #2 genetic potential is realised and they are healthy, normal rbc and strong wool. This experiment proves that an organism's phenotype is not only the result of its genotype but also its environment.	• States twins have identical/ similar DNA. • States that non twin lambs would /could be different due to different DNA. • Any correct description / example of environment affecting phenotype. • Identifies how lack of B12/diet did not change DNA • Describes how Twin 1 has genes that are not expressed OR how Twin 2 has genes that are expressed. • Describes one lambs phenotype in terms of functioning enzymes E.g. Twin #1 has enzymes that can't function /don't work.	• Explains the twin's identical/similar DNA ensures changes to phenotype are solely due to diet / environment not the genotype. • Explains that phenotype is produced by interaction between environment and genotype. • Explains that B12 / lack of B12 is not a mutagen / didn't change genotype / DNA, but did change phenotype. • Explains both lambs' phenotypes in terms of functioning enzymes without the link to genes producing the enzymes: E.g. Twin#1 has no B12, therefore the enzymes can't function and it is anaemic / weak wool, etc. Lamb #2 does have functioning enzymes so is healthy. • Briefly, explains the diet prevented the lamb from reaching genetic potential. • Explains that as soon as diet is changed / B12 is available enzymes will function and produce a healthy phenotype.	• Comprehensive discussion that is clearly linked to the example given. - BOTH phenotypes explained in terms of same / similar genetic information, but different phenotype due to the B12 difference influencing **enzyme activity** and therefore phenotype. Note: do not award this point if student states that Twin #1 enzymes are not being produced. - Clearly indicates that in both twins, the genes for enzyme production are still being expressed however B12 is needed for these enzymes to function and produce a healthy phenotype. As soon as diet is changed / B12 is available, enzymes will function and produce a healthy phenotype, therefore **this experiment proves** an organism's phenotype is not only the result of its genotype but also its environment.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	Describes any ONE statement from Achievement.	Describes any TWO statements from Achievement.	Describes any THREE statements from Achievement.	Describes any FOUR statements from Achievement.	Explains any TWO statements from Merit.	Explains any THREE statements from Merit.	Provides the criteria for Excellence for any ONE bullet point.	Provides the criteria for Excellence for any TWO bullet points.

Q	Expected Coverage	Achievement	Merit	Excellence
TWO (a)	A metabolic pathway is a series of linked biological reactions where the product of the first reaction is needed for the second reaction to proceed.	• Defines metabolic pathway.		
(b)	A mutation is a change in the DNA\base sequence. A mutagen is an environmental factor that changes the DNA base sequence / increases the rate of mutations. An example of a mutagen is ionising radiation, X-rays, alcohol, cigarette smoke, microorganisms etc. NOT just chemicals / toxins. A gene is a section of DNA that codes for one protein / polypeptide chain. Genes influence metabolic pathways because they code for the enzymes that catalyse the reactions in the pathway. If a gene is mutated, this will mean that the resulting enzyme will not function and the end product can't be made. This is because the change/mutation in the DNA will result in the enzyme being a different shape/contain different amino acids. In the eye colour pathway, both of the enzymes, PTP synthase and PDA synthase, must be functional in order to produce red eye colour. A mutation in either gene 1 or gene 2 will make colourless eyes. If gene 1 is mutated, then PTP – synthase enzyme will be dysfunctional. This will cause a build-up of GTP, since it can't be converted to 6-PTP. Without 6- PTP, PDA synthesise has no substrate to catalyse and thus there end product of Drosopterin will not be produced and the fly will have colourless eyes. If Gene 2 is mutated, the enzyme PDA synthase will be dysfunctional and the conversion of 6-PTP to drosopterin / red pigment can't happen and the eye will be colourless. Since GTP can still be converted to 6-PTP, GTP will not be present and 6-PTP will build up.	• Describes mutation AND describes mutagen. • Gives a specific example of a mutagen. • States that enzymes catalyse reactions • Identifies that a mutation or a dysfunctional (*cannot say mutated)* enzyme will result in no red pigment / colourless eyes. • States genes code for enzymes. • Identifies no mutations = red eye colour.	• Explains that genes code for the enzymes that catalyse the reactions <u>in the pathway</u>. • Explains that both enzymes have to be functional to produce red eye OR Explains that a dysfunctional (*cannot say mutated*) enzyme anywhere in the pathway will stop the red pigment being made / produce colourless eyes. • Explains that a dysfunctional (*cannot say mutated*) PTP synthase will prevent 6-PTP from being made and the eye will be colourless. • Explains that dysfunctional (*cannot say mutated*) PDA-synthase will prevent the conversion of 6-PTP to drosopterin / red pigment. • Explains **how** a mutation will result in the enzyme being dysfunctional / different shape.	• Comprehensive discussion that shows the link between the gene, the enzyme, the reaction and the products of each reaction. - Discusses how red eye colour is produced in a functioning pathway AND links mutated gene 1 with correct dysfunctional PTP-synthase and the lack of 6-PTP production, which prevents drosopterin production and therefore there is a build-up of GTP and the fly will have colourless eyes, even if Gene 2 is functional. - Discusses how red eye colour is produced in a functioning pathway AND Links mutated gene 2 with dysfunctional enzyme PDA-synthase, which prevents conversion of 6PTP to drosopterin and therefore there will be a build-up of 6-PTP and the fly will have colourless eyes even if Gene 1 is functioning. (A link to negative feedback that shuts off overproduction of 6-PTP could demonstrate understanding but is not required at this level.) Must be clear that the GENE is mutated (not the enzyme). The enzyme is dysfunctional / different / new.

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Q	Expected Coverage	Achievement	Merit	Excellence
THREE (a)	RNA is a single-stranded nucleic acid, while DNA is double-stranded. RNA has a ribose sugar backbone and DNA has a deoxyribose sugar backbone. In RNA the base uracil replaces the base thymine of DNA. RNA is a short-lived molecule while DNA is long-lived.	• Describes TWO differences between DNA and RNA (may use a labelled diagram) E.g.: - ribose v deoxyribose - uracil v thymine - single v double - Etc.		

(b)	Transcription begins with enzymes unwinding and unzipping the DNA double helix to expose the bases of the gene. Free RNA nucleotides then match join onto the DNA template strand according to the base pairing rule of A–T, C–G, G–C. The exception is that RNA does not contain a T, so the RNA nucleotide U will bond with the DNA nucleotide A. (This rule may be demonstrated in the diagram.) Another enzyme will bind the backbones of the mRNA nucleotides together. When the gene is transcribed, the mRNA leaves the nucleus and goes to the ribosome, where translation takes place. A gene is a piece of DNA that codes for one specific protein / polypeptide / trait. Each three bases on the DNA is a triplet and codes for one amino acid. Since DNA doesn't leave the nucleus, mRNA is a complimentary copy of the DNA template strand where uracil is substituted for thymine. Since mRNA is single stranded, it can pass (fit) through the nuclear membrane (pore) to reach the ribosome in the cytoplasm. Each three bases on the mRNA is a codon that is complimentary to its triplet. Each codon codes for one amino acid. The order of the amino acids of the protein is determined by the order of the bases on the DNA. This order of amino acids is important, because it determines how the polypeptide will fold or join with other polypeptides / which parts of the chain are attracted to each other. The folding of the polypeptide is crucial for the protein to take its final shape in order to carry out its function. Sometimes a polypeptide must join with another polypeptide in order to create a functional protein. Accurate transcription is ensured by the base pairing rule. As you can see from the diagram, the size of the bases determines which bases can bind together. A large (double ring) base can complement only a small (single ring) base. For example, A can bind only with T, because A is large and T is small. Adenine and Guanine are both large, so can't fit together in either DNA or RNA. In addition, the placement of hydrogen bonds prevents other bonding combinations. A and T form the same number of hydrogen bonds together, and C and G form the same number of hydrogen bonds together. Adenine can't bind with cytosine, because they have different numbers of hydrogen bonds and can't chemically fit together.	• Describes transcription as making mRNA from DNA. • Gives 3 basic steps of transcription, e.g.: - DNA unwound - DNA unzipped - RNA nucleotides match up to DNA - mRNA backbone joined together. • Describes triplet as three bases on the DNA. • Describes codon as three bases on mRNA. • Defines gene AND describes DNA as carrying the genetic code / info of an organism OR describes structure of DNA. • Defines mRNA as the molecule that carries a copy of the gene to the ribosome / cytoplasm/ out of the nucleus. • States base pairing rule for DNA AND RNA.	• Describes transcription AND **explains** at least TWO steps. - role of at least ONE enzyme - template strand of DNA is used - unzipping exposes the DNA bases - unzipping breaks H bonds between DNA middle bases - transcription starts / stops with promoter / termination region on DNA. • Explains that each triplet AND codon codes for one amino acid / carries the code for amino acid to ribosome. • Links accuracy of transcription with the base pairing rule. • Briefly explains that the number of hydrogen bonds OR the size of the bases is the reason behind the base pairing rule. • Explains that a copy of the gene / mRNA must be made since DNA doesn't leave the nucleus and translation takes place in the cytoplasm / ribosome. • Explains that a polypeptide must fold / join another polypeptide to be functional.	• Comprehensive discussion that includes how the DNA is transcribed and: - links the size of the nucleotide bases with accurate transcription, e.g., since single ring / small bases can only fit with double ring / larger bases the base pairing rule ensures accurate transcription - links the chemical properties / number of hydrogen bonds that can form between nucleotide bases with the reason only certain combinations are possible, therefore, the base pairing rule ensures accurate transcription - clearly links order of DNA bases to order of amino acids in the polypeptide which creates the folding / joining / needed to make the protein functional. Sample minimum E answer for 2nd bullet point: A gene is transcribed into mRNA by enzymes unwinding the DNA. Enzymes then bind to the DNA strand and synthesize mRNA as they move along the gene. Accurate transcription is ensured by the base pairing rule. Since C-G can only bind together, A-T and A-U can only bind together. This ensures that mRNA is accurately transcribed. The number of hydrogen bonds ensures that A can bind only only with T, U can bind with A, and C and G can only bind with each other. Therefore, mRNA makes an accurate, complimentary copy of the gene.

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Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 – 13	14 –18	19 – 24