Mark scheme - Cellular Control

Question			Answer/Indicative content	Marks	Guidance
1			C	1	
			Total	**1**	
2			B	1	
			Total	**1**	
3			D	1	
			Total	**1**	
4			B ⟩	1	**Examiner's Comments** Around two thirds of candidates understood that meiosis was not involved in body plan development.
			Total	**1**	
5			**C** ✓	1	**Examiner's Comments** Many candidates selected the correct response, C.
			Total	**1**	
6			D ✓	1 (AO1.1)	
			Total	**0**	
7			B ✓	1 (AO2.2)	**Examiner's Comments** This was a challenging AO2 question, and only a few candidates got the correct answer (B).
			Total	**0**	
8			C✓	1(AO2.5)	
			Total	**1**	
9			D✓	1(AO1.2)	**ALLOW** A
			Total	**1**	

10			(shape of), proteins / glycoproteins / glycocalyx / antigens of the plasma / cell surface, membrane (1)	1	Look for (change to) that aspect of antigenic configuration that the immune system would recognise as foreign.
			Total	**1**	
11			sequence / order, of amino acids	1	**ALLOW** primary structure.
			Total	**1**	
12		i	some triplets, code for same amino acid / are degenerate (1) (so) the amino acid sequence is not altered (1) some alternative amino acids will not alter the shape of the protein (1) mutation occurs in intron (1)	2	
		ii	an insertion / deletion will cause frame shift (1) all triplets downstream will be different (1) the protein will have a different sequence of amino acids (downstream of the mutation) (1) the, tertiary structure / three dimensional shape will be different (1)	2	**ALLOW** stop codon / non sense mutation will cause truncation **ALLOW** downstream truncation
			Total	**4**	
13		i	anatomical ✓	**1**	***Mark the first answer only. If additional incorrect answer given, then 0 marks*** **ACCEPT** anatomy **Examiner's Comments** A minority of candidates scored this mark for identifying the adaptation as an anatomical adaptation. A range of answers were seen; 'physiological' was the most common mistake.
		ii	***Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.*** ***In summary:*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show*		

			relevance.) *Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1****,* ***Level 2*** *or* ***Level 3****, best describes the overall quality of the answer.* *Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* ○ award the higher mark where the Communication Statement has been met. ○ award the lower mark where aspects of the Communication Statement have been missed. ***• The science content determines the level.*** ***•The Communication Statement determines the mark within a level.*** ***A level annotation should be used where all marks for a level have been achieved eg for 6 marks*** **L3** ***If a candidate has achieved 5 marks then they have reached level 3 but with one mark omitted*** **e.g L3** ^ ***The same principle should be applied to level 2 and level1*** ***No marks (0) should have a cross*** **Level 3 (5–6 marks)** Provides a full and accurate description of natural selection **and** describes the role of regulatory gene(s) and mentions a correct role of a structural gene. *There is a well-developed line of reasoning, which is clear and logically-structured and uses scientific terminology at an appropriate level. The information*	**6**	**Indicative scientific points may include** *Natural selection* • mutations (e.g. of pigment gene, and of regulatory genes) • selection pressure of prey availability • the adaptation helped tigers hide from prey / ref to camouflage • striped tigers had a greater survival probability and were more likely to reproduce • beneficial alleles were passed on to the next generation

			presented is relevant and substantiated. **Level 2 (3–4 marks)** Provides a description of natural selection with few errors or omissions **and** mentions a correct role of a structural gene (e.g. for fur colour / pigmentation) *There is a line of reasoning presented with some structure and use of appropriate scientific language. The information presented in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Provides an outline of natural selection *There is an attempt at a logical structure with a line of reasoning.* *The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*		• the allele frequency for the relevant genes would have increased with each generation • after many generations, all tigers within a population were striped *Roles of regulatory genes* • (regulatory) genes control, the pattern / where pigments produced / expression of other genes • genes switched on or off during development (i.e. epigenetic changes / transcription factors) • correct roles for epistasis – e.g. recessive epistasis preventing expression of pigment gene • ignore role of hox genes as not relevant • ignore 'genes for striped fur' or 'striped pattern' alone as this is neither a structural or regulatory gene role **Examiner's Comments** Fewer than 5% of candidates accessed Level 3 on this question. The majority of the rest only accessed Level 1 due to the fact that they were able to identify that the evolution of a tiger with striped fur was due to natural selection, but they did not correctly identify a mutation in a structural gene as being the main cause. Many students who fell into this category wrote about a 'mutation in a gene for striped fur' rather than naming the structural gene as being responsible for fur colour or producing a coloured pigment. In a few cases, candidates correctly identified a structural gene, and gave a developed example of how regulatory genes may contribute to stripes, giving access to Level 3. However, the role of regulatory genes in controlling gene expression is an area which was poorly understood by the majority of candidates. The other main weakness in response to this question lies in the identification of the

					correct selection pressure for stripes being better adaptation for hunting due to camouflage. Only approximately 50% of candidates identified this. The Communication mark within a level was given in most cases, except where the odd candidate left out large amounts of detail or incorporated lots of irrelevant material.
			Total	**7**	
14		i	***Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. In summary:*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)* *Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1, Level 2 or Level 3****, best describes the overall quality of the answer.* *Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* ○ *award the higher mark where the Communication Statement has been met.* ○ *award the lower mark where aspects of the Communication Statement have been missed.* • ***The science content determines the level.*** • ***The Communication Statement determines the mark within a level.*** **Level 3 (5–6 marks)** *A reference to the nature of the genetic code* ***AND*** *an outline of how alleles are transcribed and translated* ***AND*** a detailed explanation of why the y allele results in a different primary structure. *There is a well-developed line of reasoning which is clear and logically structured and uses scientific terminology at an*	**6**	**Indicative scientific points may include:** **Genetic code (G)** • DNA base sequence codes for amino acid sequence • reference to mRNA base sequence • triplet code / 3 bases = 1 amino acid • degenerate code • substitution could result in same amino acid **Transcription (C)** • transcription then translation • complementary base pairing • synthesis of mRNA strand • role of RNA polymerase **Translation (L)** • mRNA binds to ribosome • tRNA binds to mRNA • tRNA brings specific amino acid • mRNA translated into polypeptide **Effect of y allele (M)** • substitution / frame-shif • different base sequence of DNA • different mRNA codon • different tRNA anticodon • tRNA brings different amino acid • different sequence of amino acids

			appropriate level. The information presented is relevant and substantiated. **Level 2 (3–4 marks)** An outline of some key aspects of transcription and translation **AND** an explanation of why a change in the sequence of bases in a gene causes a change in the primary structure of the polypeptide it codes for. **OR** A detailed explanation of why a change in the sequence of bases in a gene causes a change in the primary structure of the polypeptide it codes for. *There is a line of reasoning presented with some structure and use of appropriate scientific language. The information presented in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)** A reference to the mechanism of protein synthesis **AND** reference to the effects of a mutation or the nature of the genetic code. **OR** A description of some aspects of the mechanism of protein synthesis. **OR** A description of the nature of the genetic code or the effects of mutation. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*		• amino acid sequence is primary structure **Examiner's Comments** This level of response question allowed candidates to demonstrate their understanding of the key processes of protein synthesis and the effect of mutation on the polypeptide produced. Most candidates were able to gain some credit but the question discriminated well between candidates of differing ability. Many candidates made errors that prevented them from accessing either the higher marking levels or the communication mark within a level. Examples of this included failure to mention base or amino acid sequences, using bases in the context of amino acids, stating that bases code for the *production* of amino acids and stating that the amino acid sequence *codes for* the primary structure of a protein. The command word 'outline' should have encouraged candidates to give the main features of transcription and translation but many used the entire available writing space to detail every aspect of this process. Many answers described levels of protein structure beyond primary and even explored enzyme action. Although not incorrect, such information was outside the scope of the question and hence often resulted in the award of the lower mark within a level rather than the upper.
		ii	(active) enzyme / protein / product, will still be synthesized even if you only have one Y allele 〕	**1**	**CREDIT** you need 2 y alleles to prevent the (functional) enzyme being synthesized **Examiner's Comments** This question was intended to stretch the thinking of more able candidates and the mark was awarded to only 10% of answers. Many candidates did appear to understand the idea of dominant and recessive alleles but did not express their answer in terms of the proteins that would be synthesized. It was clear that many

					candidates did not really understand what recessive means; many thought that merely being mutated or less frequent in a population makes an allele recessive.
			Total	**7**	
15		i	*If cell B is measured and formula applied…* 1.7 (± 0.4) **or** *If working back from information given about cell A…* 2.2 (± 0.4) ✓✓ _____ _ (number less than 10) ×10^4 (μm^3) ✓	3 (AO2.8)	*Max 1 if given to 1 only or more than 3 sig. fig.* *Max 1 if no attempt at standard form* **ALLOW** any number that has 17 (± 4) as the first 2 significant figures **ALLOW** any number has 22 (± 4) as the first 2 significant figures If answer is incorrect, **ALLOW** 1 mark for evidence of r = 16 (± 1) mm _____ _ **Examiner's Comments** Around half of candidates could apply the scaling formula correctly and most did answer in standard form. However, many candidates appeared to struggle with converting units, or measuring using the correct units, and answered with incorrect and implausible orders of magnitude. Many candidates did not appear to realise that their answer should be quite close to the size of cell A, which was given.
		ii	*light (microscope) because* magnification , (only) 1000 / < 2000 / within LM range ✓ colour visible ✓ (other) subcellular structures / (named) organelles , not visible ✓ wide field of view ✓	2 (AO3.1)	*Electron microscope = 0 marks* **ALLOW** not black & white **IGNORE** stain / dye **ALLOW** whole cell visible **IGNORE** refs to resolution unqualified **Examiner's Comments** Most candidates were aware that it was a light microscope and then achieved 1 or 2 marks, usually for reference to

					magnification or colour. A number of uncredited responses mentioned the cells being alive, which was not obvious from the image, or the 2D nature of the image, which is not an exclusive feature of light microscopes. A number of candidates incorrectly identified the electron microscope as the source of images and a small minority suggested laser scanning confocal microscopes.
		iii	*any **two** from* **1** asexual / vegetative , reproduction **2** (development of) body plan **3** proliferation of white blood cells **4** producing gametes from haploid cells **5** production of <u>new</u> stem cells ✓	1 (AO1.2)	**1 ALLOW** cloning **2 IGNORE** embryonic development **3 CREDIT** e.g. clonal expansion **4 IGNORE** gamete production unqualified **<u>Examiner's Comments</u>** This question required candidates to bring together their learning from different areas of the specification. Many candidates were able to give asexual reproduction as a response but most struggled to find a second example. Body plan and clonal expansion were the most common additional creditworthy responses.
			Total	**6**	
16	a	i	promoter (1)	1	
		ii	hormone enters cell and binds to a transcription factor (1) transcription factor activated (1) binds to, site A / promoter region (1) RNA polymerase able to bind (1)	3	
	b		primary mRNA is modified (1) removal of introns to produce mature mRNA (1) Alternative splicing can produce different versions of mRNA (1)	3	

			protein must be activated by cAMP / phosphorylation (1) binding (of cAMP) alters shape of protein (1)		
			Total	**7**	
17		i	bonds contain energy ⟩ (bonds) can be broken by (respiratory) enzymes ⟩ soluble so, can move (within cell) ⟩ H / OH, (groups) can form H bonds with water / allow solubility ⟩ AVP ⟩	**3 max**	**CREDIT** used in glycolysis / converted to pyruvate / phosphorylated / (easily) converted to glucose **Examiner's Comments** Few candidates achieved full marks for this question, many candidates focused on their knowledge of respiration rather than applying their knowledge of the structure and function of glucose from module 2 and so were only awarded the AVP as respiration is not directly tested in this paper. All other marking points were seen, but not particularly often. Some candidates who wrote about bond energy were unable to gain the first marking point because they said that that hydrogen or glycosidic bonds were the source of energy. References to energy being produced, made or created were not credited. Many candidates confused galactose with glycogen – perhaps as a result of having studied mark schemes on previous papers. A significant number wrote about glucose and galactose having similar structures but then failed to gain more marks by stating explicitly how the structure of glucose is related to its function, which they ought to have learned when studying module 2.
		ii	(too) big ⟩ unable to pass between phospholipids ⟩	**2**	**IGNORE** charged / polar **CREDIT** needs, channel / (lactose) permease

			OR no / small, concentration gradient ⟩ needs, carrier protein / pump ⟩		**IGNORE** phospholipid bilayer **DO NOT CREDIT** channel **ALLOW** needs <u>active</u> transport protein **Examiner's Comments** This question could be answered in two ways. A large majority of candidates correctly suggested that lactose was too big to cross the membrane. Fewer followed this up with the correct explanation in terms of fitting between phospholipids or needing the presence of a channel. A less common suggestion was the idea of the lack of a concentration gradient, but again few went on to talk about the need for a carrier protein or pump. Many candidates were unable to express the concept of a low concentration gradient well enough to be awarded the mark. Many candidates suggested both explanations but failed to explain them as directed and so received only one mark.
		iii	(mammal diet high in milk, so) high lactose concentration ⟩ (structural) gene for protein channel / lactose permease gene / lac Y, is, transcribed / expressed switched on ⟩ (protein is) lactose permease ⟩	**2 max**	**ORA** for older mammals **ALLOW** lactose is present **ALLOW** description of lactose causing repressor protein to leave operator **ALLOW** *lac* operon is switched on **Examiner's Comments** This question was intended to be challenging but fewer than half of candidates gained even one mark. Although E. coli was mentioned three times in the question, around half of candidates discussed the use of lactose by mammals, the presence of proteins in mammalian cell membranes, ageing in mammals or lactose intolerance, without any reference to E. coli. Some candidates realised that the question was about the lac operon but still discussed this in terms of the young mammals rather than E. coli. Very few candidates were awarded both available marks.
			Total	**7**	

18		i	aaBB ✓ AAbb ✓ white / no pigment ✓	**2**	**ALLOW** BBaa / aBaB **ALLOW** bbAA /AbAb **DO NOT ALLOW** colourless **Examiner's Comments** The majority of candidates gained at least one mark for this question, with a high proportion gaining 2 or 3 marks. Where marks were not credited it was often for candidates selecting one copy of each allele instead of two (AB,ab) or for giving the heterozygous genotypes (AaBb , Aabb).
		ii	(dominant) epistasis ✓	**1**	**DO NOT ALLOW** recessive epistasis **DO NOT ALLOW** complementary epistasis **ALLOW** antagonistic epistasis **Examiner's Comments** The majority of candidates correctly identified the type of gene interaction as epistasis, though co dominance was a common incorrect term seen. A few candidates gave recessive epistasis as the answer which was not credited.
		iii	B, produces / codes for, repressor protein / repressor polypeptide / enzyme / transcription factor ✓ (protein / polypeptide / product of B) binds to, promoter (of A) / mRNA / ribosome ✓ (product of allele B) stops, transcription / translation (of allele A) / protein synthesis / described✓ product of B inhibits the enzyme (encoded by A) ✓	**2 max**	**IGNORE** ref to genes instead of alleles **IGNORE** B is a regulatory gene **IGNORE** binds to operator **IGNORE** 'allele B turns off allele A' **ALLOW** 'product of allele B stops production of (named) product of allele A' **DO NOT ALLOW** 'B produces an enzyme which breaks down pigment produced by A'(as this is happening after expression of allele A) **Examiner's Comments** This question proved to be a good discriminator. Many candidates talked about 'allele B turning off allele A', rather

					than 'allele B producing a product that prevented the expression of allele A', and so did not gain credit. A few candidates mentioned allele B coding for repressor proteins or transcription factors which can bind to promoter regions and prevent transcription of allele A.
			Total	**6**	
19	a		homeobox ✓ DNA ✓ transcription ✓ plant ✓ kingdoms ✓	5 AO1.1	
	b	i	**1** low cost ✓ **2** rapid reproduction (rate) / more generations in a given time ✓ **3** *idea that* fruit fly genetics / development is well understood ✓ **4** simple , genetics / body plan ✓ **5** (many) mutations / structures , observable with , light / low powered , microscope ✓	2 max AO3.4	**1 ALLOW** easy to keep **1 IGNORE** small **2 ALLOW** short lifespan / grow quickly
		ii	low cost / rapid reproduction (rate) **or** genetics / development , well understood ✓ (more) similar / AW , to humans ✓ idea that can show effects are generalisable to more than one species ✓ idea that more than one species is needed to demonstrate conservation of base sequence ✓	2 max AO3.4	**ALLOW** easy to keep / short lifespan / grow quickly **IGNORE** small **ALLOW** share more genes with humans **IGNORE** homeobox sequence similar to humans **ALLOW** because they are mammals
			Total	**9**	
20			hox gene does not produce transcription factor / transcription factor not activated (1) molecules signalling apoptosis not produced (1)	3	

			apoptosis (to separate fingers) does not occur (1)		
			Total	**3**	
2 1		i	0.177 ± 0.004 ⟩⟩	**2**	Max 1 if answer not given to 3 s.f. **ALLOW** 1 mark for a number between 5.2 and 5.3 ÷ 30 **Examiner's Comments** Around half of candidates were able to calculate a rate from a straight line on a graph but some of those did not then appreciate that the y-axis of the graph was already expressed as a percentage and so wrote 17.7%. Many such responses were able to get a mark if they had shown their working out.
		ii	*time since divergence* *5.25 ± 0.25 million years* ⟩ *range* 4.2 ± *0.2* to 6.3 ± *0.3* (million years) ⟩	**2**	Unit is required for mark **ACCEPT** 2.1 ± 0.1 (million years) **Examiner's Comments** Around half of candidates gained the first mark. Fewer achieved the second marking point – it often appeared that candidates were attempting a much more complex calculation than their first answer plus and minus 20% written out as a range. Candidates are reminded to read over their answers to see if they make sense, for example an answer of 5 million years was given a range of 7 to 14 million years.

		iii	***Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.***
			
			In summary:
			Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.) Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors, ***Level 1, Level 2*** *or* ***Level 3****, best describes the overall quality of the answer.*
				6	**Indicative scientific points may include:**
					
					valid (V) because
					the indicative point may be subsumed within reference to a supporting figure
					
					• recent divergence
					  ○ figs to support from Fig 19.3
					• occupy same branch on phylogenetic tree
					  ○ as seen in Fig 19.1

			Then, award the higher or lower mark within the level, according to the ***Communication Statement*** *(shown in italics):* ○ *award the higher mark where the Communication Statement has been met.* ○ *award the lower mark where aspects of the Communication Statement have been missed.* • ***The science content determines the level.*** • ***The Communication Statement determines the mark within a level.*** **Level 3 (5–6 marks)** A supported reason for **AND a supported reason against reclassification AND** discussion of the basis of the classification system. *There is a well-developed line of reasoning, which is clear and logically structured and uses scientific terminology at an appropriate level. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** A supported reason for **OR** against reclassification **AND** a reference to how organisms are classified. **OR** A reference to some evidence that supports **AND** does not support reclassification **AND** a reference to how organisms are classified. *There is a line of reasoning presented with some structure and use of appropriate scientific language. The information presented in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)**		**invalid (I) because** *the indicative point may be subsumed within reference to a supporting figure* • divergence less recent than chimpanzee and bonobo ○ figs to support from Fig 19.3 ○ as seen in Fig 19.1 • different anatomy ○ as seen in Fig 19.2 **prinicples of classification (P)** *may be implied during discussion of V and I points* • phylogeny is basis of classification • species that, diverged recently / share similar base sequence, occupy same group • original classification based on comparative anatomy • recognition that biochemistry is more accurate than comparative anatomy • scientific knowledge develops over time • change justified by new molecular evidence **Examiner's Comments** It was less common to see Level 3 answers here than in the other Level of Response question. The command word was 'evaluate' which ought to have guided candidates to discuss the evidence for reclassification from both sides, for and against. The best answers did just that, backing up their points with evidence from the figures provided and relating their evidence to the principles of classification they had learned. Many candidates looked at only one side of the debate, which meant Level 3 could not be achieved. Candidates were asked to use their own knowledge about classification but many gave their own knowledge and opinion about chimpanzees. This approach gained no credit and often meant the

			A supported reason for **OR** against reclassification. **OR** A reference to some evidence that supports **OR** does not support reclassification **AND** a reference to how organisms are classified. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* ***0 marks*** *No response or no response worthy of credit.*		communication mark within a given level was not awarded. Within Level 1 answers, there was a lot of confusion, misconceptions and incorrect use of key terms. Some candidates thought that pentadactyl limbs were relevant to classification at the level of genus while some discussed the possibility that humans and chimps had similar hands because of convergent evolution. Others thought that humans could not possibly be in the same genus as chimps because of the presence of bonobos in that genus already. It is worth noting that 'they have a common ancestor' rarely gains any credit – any two species have a common ancestor. The insertion of the word 'recent' would have gained some candidates an extra mark.
		i v	no / little, because, homeobox genes / they, are highly conserved (within animal kingdom) ⎫ (only) that humans and chimpanzees, belong to the same kingdom / are animals ⎭	**1 max**	**Examiner's Comments** This was designed as a challenging question and the mark was rarely achieved.
			Total	**11**	
2 2		i	editing of primary, mRNA / transcript ✓ not present in mature mRNA ✓ not translated ✓ regulatory, sequences / genes ✓	2 max(AO 1.2)	**IGNORE** introns are non-coding (as this is not an explanation) **ALLOW** introns removed **ALLOW** used to make , tRNA / rRNA **Examiner's Comments** Many candidates offered descriptions of what 'non-coding' might mean rather than explaining the reasons why some sections did not code for a polypeptide.
		ii	not selected against / AW ✓	1(AO 2.5)	**ALLOW** doesn't affect survival
			Total	**3**	