OCR A-LEVEL BIOLOGY A · H420

BIOLOGY



EXAM QUESTION PACK

6.1.1 CELLULAR CONTROL

SCORE	PERCENTAGE
/54	%

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Answer **all** the questions.

1. What is an operon?

A The binding site for a repressor protein.
B Any group of genes responsible for the metabolism of lactose in prokaryotes or eukaryotes.
C A cluster of genes under the control of a promoter.
D A regulatory gene.

Your answer ☐

[1]

2. There will be outbreaks of new infectious diseases in the future. They will arise from mutations in the genomes of existing organisms. The mutating organisms may not at present be pathogenic, or they may be animal pathogens that mutate to become able to infect humans.

What feature of a pathogen such as *Mycobacterium tuberculosis* could be altered by a mutation, making a vaccine ineffective?

[1]

3. A gene codes for the production of lactase. This gene is normally switched off after an infant moves to adult food. Almost all adult mammals are unable to digest lactose. They are said to be **lactose intolerant.** Humans are an exception.

Most humans have a genetic mutation that prevents the shutdown of lactase production.

State what structural detail of a polypeptide is altered by gene mutations.

[1]

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4. The table shows the genetic code in a short length of DNA, the corresponding codons on mRNA, and the anticodons on the corresponding tRNA.

Row	Original DNA	mRNA	tRNA
A	CCG TTA GCA	GGC AAT CGU	CCG TTA GCA
B	CAT AAT ACG	GUA UUA UGC	CAU AAU ACG
C	ATA CGC ATC	AUA CGC UAG	UAU GCG AUC
D	ACG GTA AAA	ACG GAU UUU	ACG GTA AAA

Which of the rows, **A** to **D** shows the correct codons and anticodons?

Your answer ☐

[1]

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5. The bacterium *E. coli* produces lactase only when the sugar lactose is available. The mechanism to control production of lactase is called the *lac* operon.

Statements 1 – 3 describe the role of molecules in the way the *lac* operon controls lactase production.

1 – lactose binds to the repressor protein
2 – the repressor protein binds to lactase
3 – lactase leaves the cell

Which of the options, **A** to **D**, identifies the correct statements?

A 1, 2 & 3
B Only 1 & 2
C Only 2 & 3
D Only 1

Your answer ☐

[1]

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6(a). A gene mutation is a change in the sequence of nucleotides within a gene.

(i) Explain how it is possible for a mutation to have no effect on the protein produced from that gene.

---

[2]

(ii) Explain how a mutation could alter the protein so that it no longer performs its correct function in the cell.

---

[2]

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(b). Gene transcription is controlled by transcription factors. Fig. 16.1 shows how a transcription factor can control transcription.

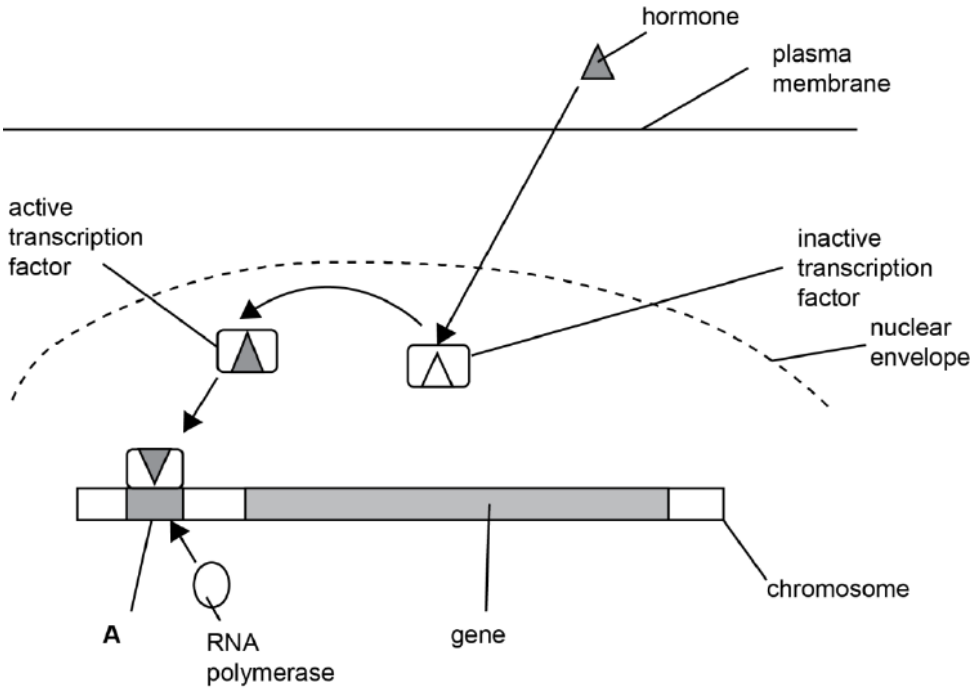


Fig. 16.1

(i) Name site **A**.

---

[1]

(ii) Using the information in Fig. 16.1, describe how transcription can be controlled in eukaryotes.

---

[3]

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(c). Hox genes code for transcription factors and control the development of the body plan. Fig. 16.2 shows a congenital deformity caused by failure of the control mechanism.

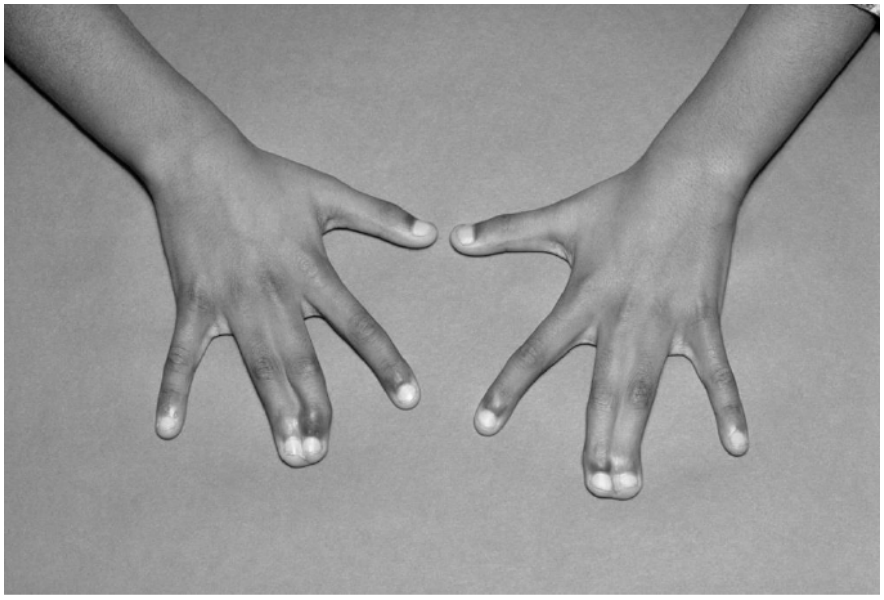


Fig. 16.2

Explain how failure of the control mechanism during development could lead to such a deformity.

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[3]

(d). Describe how gene expression can be regulated after transcription.

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[3]

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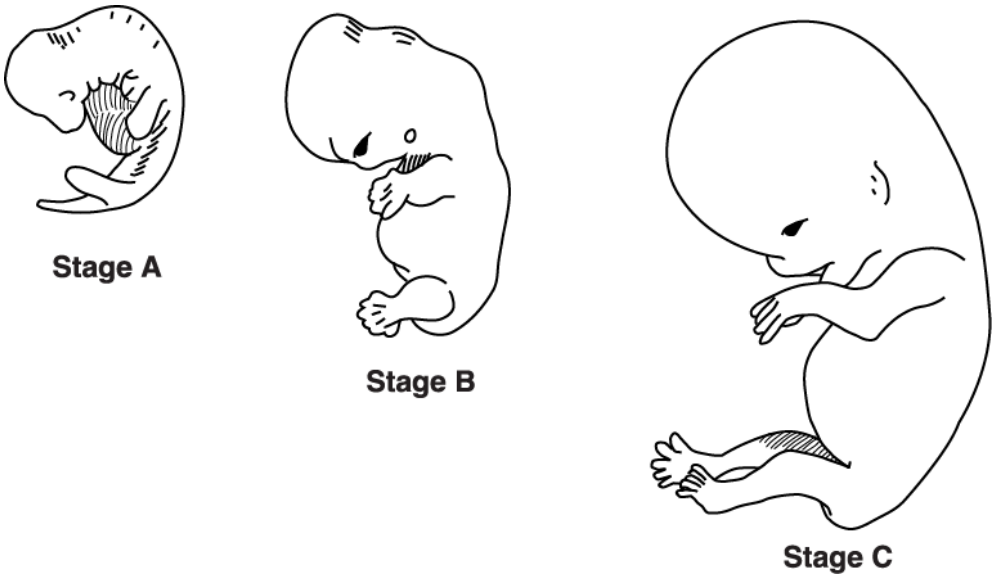
7. This question is about genetic control and selective breeding.

Genetic control is also achieved by genes switching on and off. There is a highly conserved set of genes called homeobox genes that control the development of body plans.

(i) Name **all** the **kingdoms** of living organisms that use homeobox genes to control the development of body plans.

_____ **[1]**

This figure shows a human embryo during the second month of development.



(ii) How can the control of development by homeobox genes be seen in **Stage A** in the figure?

_____

_____

_____ **[1]**

(iii) Describe how the process of apoptosis can be seen between **Stages A** and **B**, and between **Stages B** and **C**, in the figure.

Stages A to **B** _____

_____

Stages B to **C** ____

____

[2]

8. Discuss the ways in which genetic variation is produced, including the role of nuclear division.

In your answer you should link the processes to the ways in which the genetic variation is produced.

[9]

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9(a). Gene sequencing is an important technique in molecular biology.

Fig. 3.1 shows part of a computerised graph obtained from an automated gene sequencing machine.

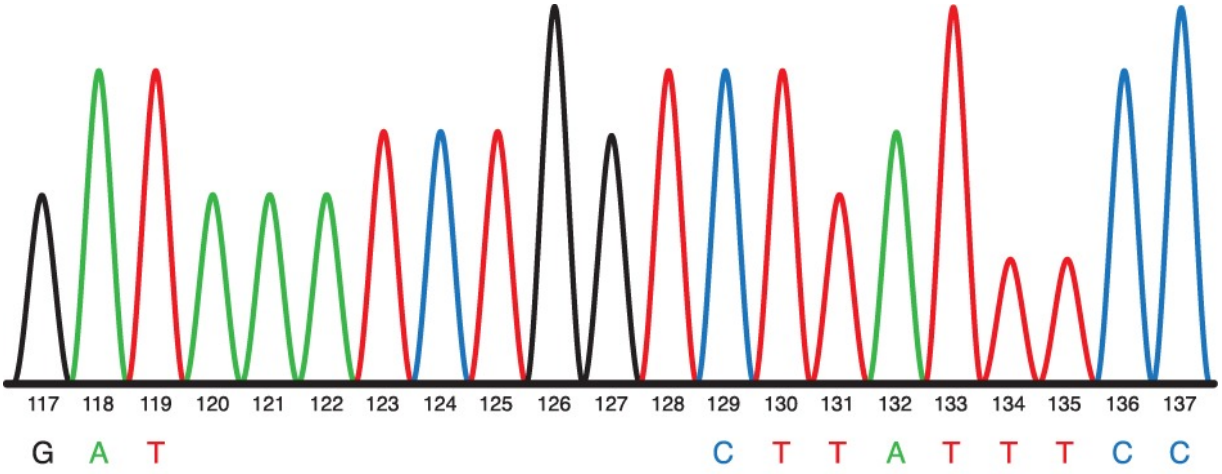


Fig. 3.1

- The section of the DNA molecule represented in Fig. 3.1 is from base position 117 (on the left of the graph) to base position 137 (on the right of the graph).
- The bases in the DNA sequence are labelled with four different coloured fluorescent dyes.
- The identities of some of the bases (117 to 119 inclusive and 129 to 137 inclusive) are indicated below the graph.

Use Fig. 3.1 to identify the order of bases from positions 120 to 128.

.....	.....	.....	.....	.....	.....	.....	.....	.....
120	121	122	123	124	125	126	127	128

[1]

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(b). To produce the type of graph shown in Fig. 3.1, the automated gene sequencing machine needs to be loaded with the following:

- the DNA to be sequenced
- short primer sequences specific to the DNA to be sequenced
- many normal DNA nucleotides
- some chain-terminating DNA nucleotides labelled with coloured dyes
- the enzyme *Taq* polymerase.

A regular cycle of temperature changes allows many DNA fragments of different lengths to be built up by the polymerase chain reaction (PCR).

Fig. 3.2 shows the end parts of the sequences of seven of these different length fragments, labelled 1 to 7. The end parts of the sequences for fragments 1 to 4 are complete but those for fragments 5 to 7 are not.
These seven fragments correspond to the **last seven peaks** on the right hand side of the graph in Fig. 3.1.

The letters in boxes represent labelled chain-terminating DNA nucleotides.
The letters not in boxes represent normal DNA nucleotides.

(i) Use the information in Fig. 3.1 to fill in the missing nucleotide bases on fragments 5 to 7 on Fig. 3.2.

You should distinguish between the normal and labelled nucleotides in the sequence for each fragment.

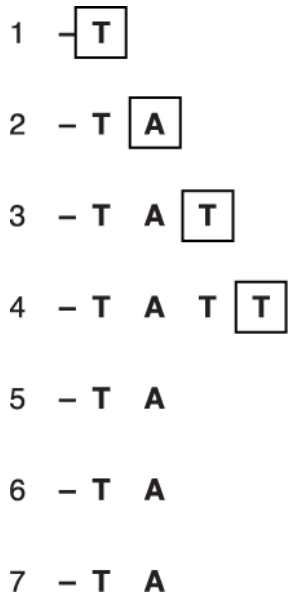


Fig. 3.2

[2]

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(ii) Explain how the automated sequencing machine orders the DNA fragments from the PCR reaction into the size order shown in Fig. 3.2.

---**[3]**

(c). Asthma in children may be treated with drugs. One of the most commonly used drugs is salmeterol.

Salmeterol acts by binding to protein receptors in the lining of the bronchioles. However, in approximately 14% of children with asthma, salmeterol is not very effective. This is thought to be the result of a genetic mutation in these children.

Suggest why this mutation reduces the effectiveness of salmeterol.

---**[3]**

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(d). In a recent medical trial, 62 children with this genetic mutation were studied.

- Their asthma was not controlled well by salmeterol.
- 31 children continued using salmeterol and the remaining 31 were given an alternative drug, montelukast.
- Montelukast is not routinely prescribed because salmeterol is far more effective for most children with asthma.

(i) After one year, the children taking montelukast had better control of their asthma and were able to reduce their use of montelukast.

Suggest why these children responded better to montelukast than to salmeterol.

---**[2]**

(ii) Comment on the reliability of the results of this medical trial.

---**[1]**

(iii) It is proposed that a simple saliva test could identify those children who have the mutation.

What would be the source of the genetic material used in this test?

---**[1]**

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10. In 1958, scientists made a breakthrough in artificial reproductive cloning by successfully cloning a vertebrate species. The species cloned was the African clawed frog, *Xenopus laevis*.

Fig. 1.1, shows the cloned offspring produced, labelled **D**, as well as the three adult frogs (**A**, **B** and **C**) that were used to create them.

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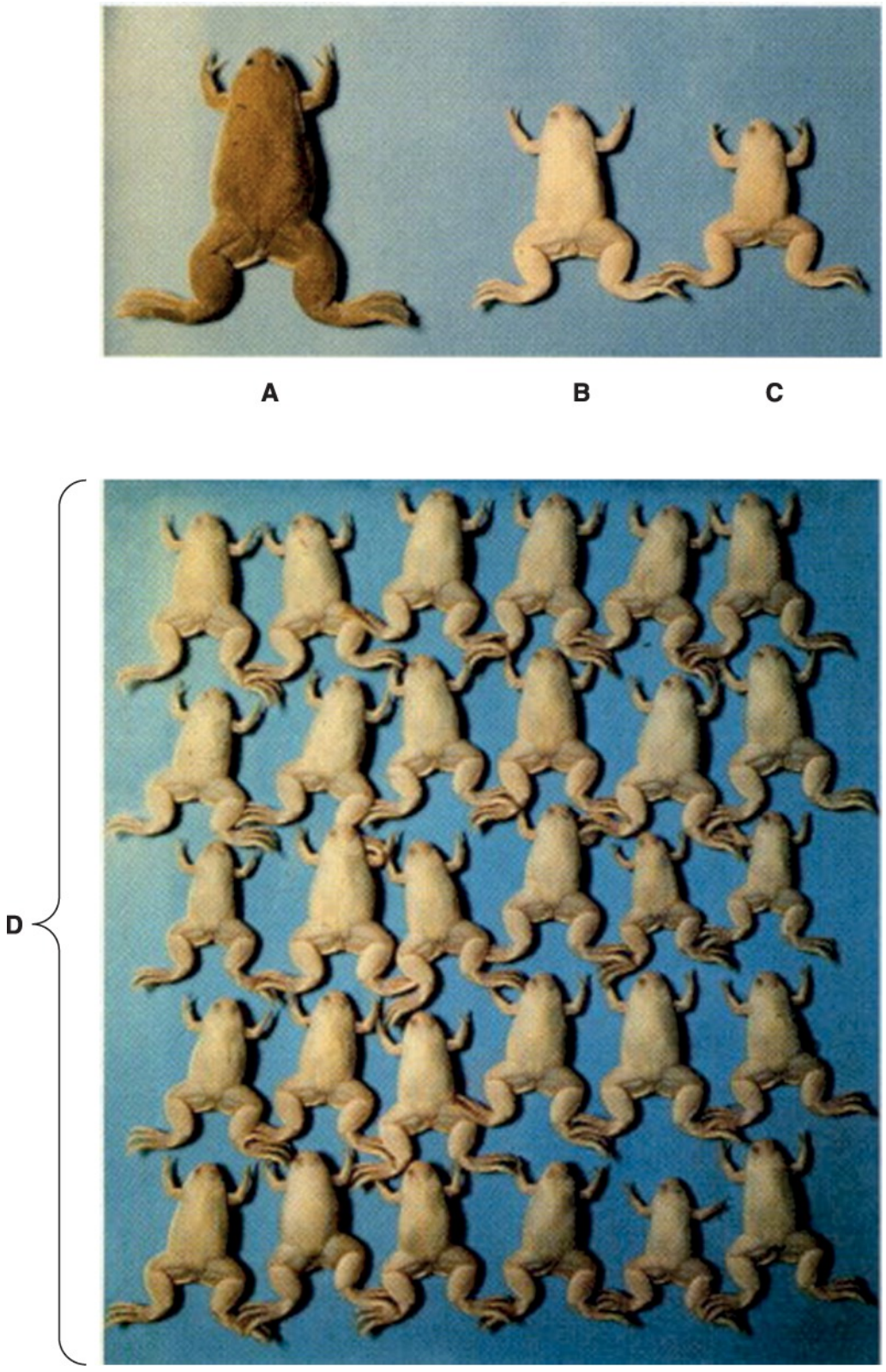


Fig. 1.1

- frog **A**, a brown-coloured female frog, laid eggs, which then had their nuclei removed.
- frog **B**, an albino (white-coloured) female, laid eggs that were fertilised by sperm from **C**.

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- frog **C**, an albino male, produced sperm that fertilised the eggs of **B**.

One of the fertilised eggs from **B** was allowed to divide. Nuclei were extracted from the resulting cells and placed into the eggs from frog **A**. These eggs developed into the frogs labelled **D** in Fig. 1.1.

(i) The frogs in Fig. 1.1 show discontinuous variation in colour.

Using your knowledge of discontinuous and continuous variation, and the information given, suggest:

one other phenotypic characteristic in which the frogs show a discontinuous pattern of variation

---

one phenotypic characteristic in which they show a continuous pattern of variation.

---**[2]**

(ii) State the extent to which the environment is likely to affect each of the phenotypic characteristics that you have suggested in **(i)**.

---**[2]**

(iii) Suggest why albino frogs were used to produce the nuclei for transfer.

---**[2]**

11. A mixture of three sugars is added to batch fermenter at the beginning of the process:

- the monosaccharide glucose, which the yeast uses up first, during days 0 to 2
- the disaccharide maltose, which is used during days 1 to 5
- the trisaccharide maltotriose, which is used during days 4 to 6.

Suggest why the yeast uses the sugars in this order.

---

[3]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			C	1	
			Total	**1**	
2			(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**	
3			sequence / order, of amino acids	1	**ALLOW** primary structure.
			Total	**1**	
4			B	1	
			Total	**1**	
5			D	1	
			Total	**1**	
6	a	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
	b	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	

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Question			Answer/Indicative content	Marks	Guidance
	c		hox gene does not produce transcription factor / transcription factor not activated (1) molecules signalling apoptosis not produced (1) apoptosis (to separate fingers) does not occur (1)	3	
	d		primary mRNA is modified (1) removal of introns to produce mature mRNA (1) Alternative splicing can produce different versions of mRNA (1) protein must be activated by cAMP / phosphorylation (1) binding (of cAMP) alters shape of protein (1)	3	
			Total	**14**	

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Question			Answer/Indicative content	Marks	Guidance
7		i	animal **and** plant **and** fungi;	1	any order **DO NOT CREDIT** other kingdoms **Examiner's Comments** The mark for (i) was rarely awarded. The most common mistake seen was to write animal and plant, but then miss out the fungi kingdom. Some answers incorrectly included protoctista and quite a few answers listed domains or classes instead of kingdoms.
		ii	head-tail orientation / anterior-posterior axis; position / development, of limbs; (traces of) segmentation; position / development, of eyes;	1 max	**IGNORE** dorso-ventral orientation / head, thorax, abdomen / polarity unqualified **ACCEPT** head at one end, tail at the other **ACCEPT** has limbs **DO NOT CREDIT** head segment / thorax segment / abdomen segment **Examiner's Comments** The majority of candidates got this correct, noting the head-tail orientation or position / development of limbs and segmentation. Very rarely was the development of an eye seen. A common error was to mention head at one end and legs at the other, instead of head and tail orientation. Some candidates just mentioned polarity but didn't qualify their answer and vague answers often included references to changes to the body plan, whilst a few misinterpreted the question and talked about genes switching on at different times (this cannot be seen so gained no mark).

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Question			Answer/Indicative content	Marks	Guidance
		iii	(**A** to **B**) disappearance of tail / AW; (**B** to **C**) webbing / tissues /cells, removed between fingers / toes;	2	**(B** to **C) ACCEPT** fingers / toes / digits, become more defined / separate / form individual digits **IGNORE** fingers / toes / digits, forming / developing **Examiner's Comments** For stages A to B, few candidates indicated that the tail disappeared, instead mentioning other body structures. Candidates often incorrectly wrote about the head becoming detached from the body or about the eyes opening, which gained no credit. For stages B to C, most candidates got the idea of the webbing being removed from between fingers and toes but some did not phrase it accurately enough, instead talking about apoptosis and not what apoptosis meant, or only going so far as to mention the formation/development of digits, which actually occurs in stage B.
			Total	**4**	

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Question	Answer/Indicative content	Marks	Guidance
8	**A1** independent assortment / random segregation, of (homologous) chromosomes / bivalents; **A2** in, metaphase **I** / meiosis **I**; **A3** *of* chromatids in, metaphase II / meiosis II; **A4** (so) homologous chromosomes, have different alleles / come from different parents; **A5** produces large number of allele combinations; **C1** crossing over / (formation of) chiasma(ta); **C2** in, prophase **I** / meiosis **I**; **C3** (so) chromatids will have new combination of alleles; **C4** amount of variation depends on distance between crossover points; **M1** mutation; **M2** changes the (DNA) nucleotide/ base, sequence; **M3** DNA checks (during duplication) did not recognise damage; **M4** *idea of* differences in (named) protein(s); **N1** non-disjunction; **N2** homologous chromosomes do not separate (in metaphase I); **N3** one, more / less, chromosome present;	8 max	**A1 ACCEPT** Random assortment / independent segregation **A2 / A3 DO NOT CREDIT** metaphase / meiosis, I **and** II **A2 / A3 ACCEPT** correct anaphase stage linked to segregation **A2** must be in context of independent assortment / random segregation **A4 / A5 DO NOT CREDIT** genes **A4 ACCEPT** pairs of chromosomes / maternal **and** paternal chromosomes, have different alleles / come from different parents **A5 ACCEPT** different combinations of, chromatids / chromosomes, in gametes **CREDIT** figures e.g. for humans 2^{23} possible combinations **C1 DO NOT CREDIT** between sister chromatids **C2 DO NOT CREDIT** prophase / meiosis, I **and** II **C2** must be in context of crossing over **C3 ACCEPT** shuffles / swaps / exchanges, alleles on chromatids **C4** e.g. more variation the further apart the crossovers occur **M2 IGNORE** 'pairs' **M2 CREDIT** deletion, / substitution / addition, of, base / nucleotide **M3 ACCEPT** proof reading did not recognise damage **M4** e.g. change in, amino acid sequence / primary structure **N1 CREDIT** inversion / translocation (chromosome mutation) **N2 CREDIT** description of inversion / translocation **N3 CREDIT** examples of chromosome changes e.g. Trisomy 21

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Question	Answer/Indicative content	Marks	Guidance
	F1 random, mating / fusion of gametes/ fertilisation; **F2** gametes are not genetically identical; **F3** produces large number of (allele) combinations; QWC;	1	**F2 ACCEPT** gametes are genetically different **F3 DO NOT CREDIT** produce large number of gene combinations **Awarded for one change and consequence of that change** **Award if ONE of the following has been awarded** mp **A1 or A2 or A3 <u>and</u>** mp **A4** or **A5** **OR** mp **C1 or C2 <u>and</u>** mp **C3 or C4** **OR** mp **M1 or M2 <u>and</u>** mp **M3 or M4** **OR** mp **N1 or N2 <u>and</u>** mp **N3** **OR** mp **F1 or F2 <u>and</u>** mp **F3** **Examiner's Comments** This question discriminated well across the mark range, with many candidates able to relate genetic variation to the stages of meiosis. Weaker candidates merely listed the events of each stage of meiosis, without linking them to the way in which genetic variation was achieved, gaining no credit. Candidates should be encouraged to read the question again after they have answered it to check they have followed the instructions correctly. The most common responses seen talked about independent assortment of chromosomes in metaphase I and chromatids in metaphase II,crossing over in prophase I, mutation and random fertilisation, all of which gained credit. However, some candidates confused the terms chromosomes and chromatids, for example talking about crossing over between sister chromatids, which lost the marking point. Other common errors were a lack of appropriate detail, for example fertilisation rather than random fertilisation,

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Question			Answer/Indicative content	Marks	Guidance
					daughter cells rather than gametes, which meant that the marking points F1 and F2 could not be awarded. Few candidates related the processes involved in creating genetic variation to the consequences of that process, i.e. the production of new combinations of alleles in the gametes, and so failed to gain the QWC mark.
			Total	**9**	

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Question			Answer/Indicative content	Marks	Guidance
9	a		AAA TCT GGT;	1	**Examiner's Comments** The vast majority of candidates were able to identify the bases correctly from the automated sequencing graph, with base 6 labelled as A being the most common error.
	b	i	the correct bases inserted in **all** 3 rows before box; correctly identifying the last base in each sequence as the labelled base; 5 **T** **T** [**T**] 6 **T** **T** **T** [**C**] 7 **T** **T** **T** **C** [**C**]	2	**Examiner's Comments** This was also well answered by the majority of candidates, though some candidates failed to attempt the question. The most common error was a failure to inset the correct sequence of bases in all three rows, before putting in the labelled base.

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Question			Answer/Indicative content	Marks	Guidance
		ii	electrophoresis; (negatively-charged DNA) moves towards, positive electrode / anode; smallest/smaller (fragments) move, fastest / faster; **ora** resolution on gel sufficient to register 1, nucleotide / base;	3 max	 **ACCEPT** positive, end /terminal **IGNORE** ref to distance **ACCEPT** lightest / shortest **ACCEPT** description 'machine detects fragments to one base in length' **IGNORE** pair **Examiner's Comments** This question proved to be a good discriminator, with few candidates gaining full marks. Most candidates realised the question was asking them to explain the process of electrophoresis, though some explained the PCR process instead, or the process gene sequencing in general. Many explained that the DNA was negatively charged so moved towards the positive anode, but many then failed to get the third marking point as they stated that the smallest fragment moved further and failed to say that they moved fastest, possibly because this had been the correct marking point in a previous question. In this case the question was related to the use of electrophoresis in sequencing,rather than as a method of just separating fragments. A number of candidates lost a marking point for saying 'the fragments moved towards the positive cathode'.

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Question			Answer/Indicative content	Marks	Guidance
	c		(mutation) change in (DNA) nucleotide/ base, sequence; (mutation causes) change in, amino acid sequence / primary structure (of protein); change in, tertiary structure/ 3D shape / binding site, of <u>receptor</u>; salmeterol unable to bind; *idea that* no response triggered in cell / no second messenger system activated;	3 max	**IGNORE** triplet / codon / gene / frameshift **DO NOT CREDIT** active site **ACCEPT** salmetorol not complementary shape to <u>receptor</u> **ACCEPT** salmeterol cannot bind as easily e.g. adenyl cyclase not activated **IGNORE** 'has no effect' **Examiner's Comments** This question discriminated well, with many candidates gaining 3 marks, for correctly linking a change in nucleotide sequence to a change in primary and tertiary structure of the receptor, so that salmeterol was unable to bind. A common error was to talk about proteins in general, rather than receptors, or to not mention that a mutation leads to a change in base sequence. Weaker candidates related their answers to enzymes, and discussed changes to the shape of active sites which gained no credit.

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Question			Answer/Indicative content	Marks	Guidance
	d	i	(mutation resulted in) <u>receptor</u> having complementary shape to montelukast; montelukast able to bind; (whereas) salmeterol cannot; montelukast may have a different <u>receptor</u>;	2 max	**DO NOT CREDIT** active site **IGNORE** fit **ACCEPT** attach **ACCEPT** cannot bind as easily **ACCEPT** montelukast receptors not damaged **Examiner's Comments** Many candidates scored both marks on this question by applying their knowledge about receptors to this new situation, and suggesting that montelukast could bind to the mutated receptor due to it being complementary in shape, whilst salmeterol could not. Other acceptable suggestions included that montelukast had different receptors which were unaffected by the mutation or that the drug worked in a different way which did not involve the mutated receptors. A minority of candidates talked about building up a resistance to salmeterol or having no resistance to montelukast, which did not gain credit.
		ii	not reliable because, sample size **too** small / **only** 62 children in study; **or** could be reliable because 31 is quite a large sample;	1	**<u>Note</u>** *31 is a suitable number for a phase 1 trial* **Examiner's Comments** A surprisingly large number of candidates failed to get this mark, which asked about the reliability of this trial. Some candidates talked about the lack of a control group, length of study or age range of the group, rather than the fact that the sample size was too small to be reliable. Generalised statements such as 'if you increase the sample size then reliability will be increased' were not credited.

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Question			Answer/Indicative content	Marks	Guidance
		iii	(epithelial) cells lining cheek;	1	**ACCEPT** (named) white blood cells in saliva / salivary gland cells **Examiner's Comments** It was surprising to many examiners that most candidates struggled to answer this question. Many candidates believed that genetic material can be found in proteins and enzymes, or just in saliva in general. Few candidates realised that cells from the cheek, white blood cells and salivary gland cells can be found in saliva, and that this can be used as a source of DNA.
			Total	**13**	

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Question			Answer/Indicative content	Marks	Guidance
10		i	*discontinuous* gender / male and female / eye colour; *continuous* size / length / mass;	2	**Mark the first answer on each prompt line.** If an additional answer is given that is incorrect or contradicts the correct answer, then = **0 marks** **Note:** Suggestions must relate to **visible** characteristics of the **frogs**, **ACCEPT** sex **IGNORE** skin colour (as stated in Q), **CREDIT** example of a ***measurable*** characteristic (e.g. leg length, surface area, height, weight) **Examiner's Comments** The majority of candidates could correctly identify a phenotypic characteristic which showed a continuous pattern of variation, but, surprisingly, many could not give an acceptable example of discontinuous variation. Some failed to use the information given, stating colour as an example, or blood group, neither of which were allowed.

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Question			Answer/Indicative content	Marks	Guidance
		ii	*idea of* 1 no / little, environmental effect for, (named example of) discontinuous variation / example given for discontinuous variation in **(i)** as ecf; 2 some / large, environmental effect for, (named example of) continuous variation / example given for continuous variation in **(i)** as ecf; 3 gender may be affected by, temperature / atrazine exposure;	2	**IGNORE** examples of environmental factors **ACCEPT** discontinuous variation is ***only,*** genetic / due to alleles present **Note:** A comparative statement (e.g. 'environment has a greater effect on continuous variation') = **2 marks** (mps 1 & 2) e.g. 'no environment effect for discontinuous variation but it does affect continuous variation' = **2 marks** (mps1 &2) **Examiner's Comments** Most candidates performed well. Others described factors that affected the type of variation and didn't write 'environmental' or address the question 'Discuss the extent to which' and so lost marks as a result.
		iii	1 *idea that* offspring visibly different from, A / egg donor; 2 to show that the offspring produced were clones; 3 to show / identify, (genetic) parents (of clone) / B and C;	2 max	**ACCEPT** brown frog for A **2** 'to show that cloning is successful' is **not** enough **Note:** 'To show that the offspring were clones as they are not the same as A.' = **2 marks** (mps 1 & 2) **Examiner's Comments** This was a challenging question, with many candidates suggesting that albino frogs were being used as they were endangered or possessed a desirable characteristic, rather than the idea that the offspring would be visibly different to the egg donor, but identical to the genetic parents or other clones.

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Question			Answer/Indicative content	Marks	Guidance
			Total	**6**	
11			**1** glucose can, be used / enters glycolysis, directly / without being broken down (first); **2** maltose, must, be hydrolysed / have glycosidic bonds broken; **3** enzyme / maltase, only made when, needed / maltose present / glucose running out; **4** enzyme induced / gene(s) switched on; **5** transcription and translation / protein synthesis, takes time; **6** maltotriose requires, more (2) hydrolysis (reactions) / breaking of more (2) glycosidic bonds **or** enzyme to break down maltotriose made last;	3 max	**ACCEPT** 'monosaccharide' for glucose and 'disaccharide' for maltose and 'trisaccharide' for maltotriose throughout **1 IGNORE** ref to glucose being used first / at start / immediately (as stated in Q) **Examiner's Comments** This was a challenging question, which few candidates grasped, often simply reciting the information given in the stem of the question. Many thought that glucose needed to be broken down before it could be used. There was a lot of reference to breaking the disaccharide or trisaccharide down before use, but many answers were vague and did not mention hydrolysis or glycosidic bonds, gaining no credit. Only a few candidates realised that enzymes would need to be produced to carry out the hydrolysis and that this would involve enzyme induction and protein synthesis.
			Total	**3**	

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