CAMBRIDGE INTERNATIONAL AS & A LEVEL BIOLOGY · 9700

BIOLOGY



MARK SCHEME

19 GENETIC TECHNOLOGY

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Paper 1 Multiple Choice Answers: Genetic Technology

Question	Paper	Q. No.	Answer
1621	9700_w15_qp_11	40	A

Q1.

3 (a) (i)

bacterial strain	A	B	
diameter (d) / mm	24	16 ;	
area / mm^2	452 - 453	201 – 201.2 ;	**A** ecf
ratio of area A : area B	2.25 : 1	**A** 9:4	**A** ecf

[3]

(ii) 1. penicillin kills more of strain A than strain B or C / AW ;
2. ref. different active or binding sites ;
3. A produces less penicillinase than B or C ;
4. C is resistant (to penicillin) ;
5. C has mutation ;
6. penicillin cannot bind to enzymes ;
7. penicillin inactivated by C / C produces much penicillinase ;
8. AVP ; e.g. B is evolving into a more resistant strain / variation in carriers across membrane [4 max]

(iii) 1. antibiotic, is selective agent / provides selective pressure ;
2. resistant survive / susceptible die ;
3. ref. reproduction ;
4. resistants pass on, mutation / allele ; **R** gene
5. ref. <u>vertical transmission</u> ;
6. increases frequency of allele in population ;
7. may pass advantageous mutation to other species / ref. plasmid transfer ;
8. ref. <u>horizontal transmission</u> ; [4 max]

accept reference to strains A, B and C in correct context for points 2, 3 and 4

(b) 1. competitive inhibitors (of transpeptidase) ;
2. binds to enzyme ;
3. blocks active site ;
4. crosslnks in peptidoglycan wall cannot form ;
5. weakens cell wall ;
6. lysis / cell bursts ;
7. ref. high internal pressure of bacterial cell ; [4 max]

[Total: 15]

Q2.

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5 (a) 1 bacterium obtains energy ;

2 for synthesis of materials ;

3 for, growth / division ;

4 does not need to use carbon compounds for energy ; **A** named carbon compound

[2 max]

(b) 1 takes up large area ;

2 unsightly ;

3 requires, lot of water / continuous water supply ;

4 contamination of water / pollution due to acid ;

5 Cu / Fe, toxic to plants ; [2 max]

(c) *bioleaching (accept ora for mining)*

1 low level technology / no sophisticated machinery / requires less maintenance ;

2 low energy consumption / less fossil fuels used ;

3 few safety hazards / safer ; **R** no hazards

4 organism easy to, obtain / culture ;

5 self replicating ;

6 waste less hazardous ;

7 disposal of waste, costs less / is easier ;

8 ref. low grade ores / scrap iron ;

9 less workers needed ;

10 ref. use in situ ; [4 max]

[Total:8]

Q3.

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5 **(a)** *marking points refer to batch culture*

1 (penicillin) is a secondary, metabolite / product ; **R** *Penicillium*

2 more penicillin is produced (per unit time) ; **A** higher yield *comparative statement*

3 in the later stages of growth (of the culture) / after main growth phase is over ;

4 (penicillin produced when, fungus / *Penicillium*,) is short of nutrients ; **R** no nutrients left

alternative points for 2 and 3 for continuous culture (ora)

2a less penicillin is produced (per unit time) ; *comparative statement*

3a continuous culture remains in, exponential / active growth, phase ; [3 max]

(b) *description*

when pH is controlled (blue unbroken line)

1 penicillin is produced throughout the time period ;

when pH not controlled (blue dotted line)

2 penicillin production increases to a maximum and then decreases ;

3 2 penicillin figs plus 2 time figs (to support 1 or 2) ; *ignore pH figs*

explanation

4 (pH affects) enzymes (involved in penicillin production) ;

when pH is controlled

5 optimum pH for enzymes is at approx pH 7 ;

when pH not controlled

6 pH, high / above 7, decreases / stops, penicillin production ;

7 (pH, high / above 7), causes change in active site of enzymes / AW ; [4 max]

(c) 1 penicillin affects (bacterial) cell wall production ; **A** affects cross-linkages

2 inhibits, glycoprotein peptidases / enzymes involved with constructing (bacterial) cell wall ;

3 viruses do not have cell walls ; [2 max]

[Total: 9]

Q4.

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2 **(a)** 1 hamster injected with, antigen/CD40 ;

2 B cells/plasma cells, with ability to make antibody taken ;

3 from spleen ;

4 (B cells/plasma cells) fused with, tumour/cancer/myeloma, cell ;

5 use of, fusogen/PEG ;

6 (hybrid) cells cultured/AW ; **R** use of fermenter

7 check cells for mAb production ;

8 (antibody making) cells mass produced/AW ; **A** use of fermenter [4 max]

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(b) **(i)** *accept mouse survival for heart survival*

1 in **A**, 100% hearts survive 10 days **or** no heart survives 20 days ;

2 in **D**, 100% hearts survive, 80 days/to end of investigation ;

3 in **B**, 100% hearts survive 30 days **or** 10% hearts survive, 80 days/to end of investigation ;

4 in **C**, 100% hearts survive 30 days **or** 75% hearts survive, 80 days/to end of investigation ;

penalise once for no mention of percentage in mps 2, 3 and 4 [4]

(ii) 1 in **D**, both pathways/CD28 and CD40, blocked ;

2 so T-cells cannot be cloned/no immune response ;

3 in **B**, CD40 pathway is not blocked/only CD28 is blocked ;

4 so T cells can still be cloned/immune response triggered ; [2 max]

(c) 1 carry blood to, cardiac/heart, muscle/tissue/cells ;

2 supply oxygen ;

3 supply, nutrient/named nutrient ;

4 for, energy release/respiration ; **R** produce energy [3 max]

(d) *two of the following:*

1 diagnosis of, disease/named disease ; e.g. gonorrhoea/HIV

2 treatment of disease ; e.g. directing drugs to cancerous cells **A** autoimmune disease but **not** tissue or blood typing

3 pregnancy testing/drug testing ;

4 (passive) vaccine production ; [2 max]

[Total: 15]

Q5.

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3 **(a)** 1 penicillin inhibits enzyme ; *ignore name of enzyme*

2 peptidoglycan chains cannot link up/stops cross-links forming ;

3 cell wall becomes weaker/AW ;

4 turgor of cell not resisted (by cell wall)/AW ;

5 cell/wall, bursts ; [3 max]

(b) **(i)** **B** has, an outer membrane/channel proteins ;
B has thinner (peptidoglycan) wall ; *accept* ***ora*** *for* ***A*** [2]

(ii) 1 penicillin V can reach the, wall/(cell surface) membrane, of **A** ; **ora**

2 outer membrane of **B** stops penicillin V getting through ; **ora**

3 penicillin V cannot get through pores of outer membrane of **B** ; [2 max]

(iii) can penetrate outer membrane ;
through pores/directly through as non-polar ; [2]

(c) *batch culture*

1 set up and allowed to proceed ;

2 nutrients not added or products removed, (during fermentation) ;

3 air allowed in/waste gas allowed out ;

4 at end of each process, product harvested/fermenter cleaned out ; *max 2*

continuous culture

5 nutrients added (all the time) ;

6 products removed (all the time) ;

7 no down time/AW ; *max 2* [3 max]

(d) 1 *(Penicillium*/fungus), does not make penicillin all the time/penicillin is made in the later stages of growth ;

2 when beginning to run out of nutrients ;

3 (penicillin) is a secondary metabolite ;

4 continuous culture has no yield of penicillin ;

5 continuous culture, never reaches stationary phase of growth/always exponential growth ;
[3 max]

[Total: 15]

Q6.

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2 **(a)** **(i)** *any one from* ;
hot springs
sulphur springs
geysers
geothermals
marine vent
volcanic area
hot desert [1]

(ii) 1. each bacterium grows at a different temperature (range) ;
2. (the heap) heats up ;
3. idea of when temperature kills one species of bacterium others are still active
or
as temperature increases process can continue ;
4. increased oxidation of heap ;
5. more productive / enables increased yield of gold ; [3 max]

(b) **(i)** 1. *A. ferrooxidans* increases, oxidation of the ore / production of Fe^{3+} ;
2. little difference in effect 0–5 days ;
3. greatest effect after 15 days ;
4. comparative figs for with and without *A. ferrooxidans* on a single day ; [3 max]

(ii) 1. cheaper (than other methods) ;
2. does not require energy input ;
3. does not require other chemicals to be purchased ;
4. does not require specialist equipment ;
5. can be done *in situ* ;
6. less labour needed ;
7. bacteria are self-replicating / AW ;
8. more environmentally friendly than other methods / no harmful emissions / AW ;
9. useful for extraction from, low grade ores / waste ; [3 max]

(c) *must have at least one D mark to score 4 marks*
D1 both strains give similar rate with and without arsenic ions ;
D2 both strains are arsenic-resistant ;
D3 strain 2, more active / higher oxidation rate, (than strain 1) ;
E4 arsenic acts as a selective, agent / pressure ;
E5 mutation / AW, produces resistant bacteria ;
E6 resistant bacteria survive / **ora** ;
E7 resistant allele passed on ;
E8 frequency of allele increases (in population) ; [4 max]

[Total: 14]

Q7.

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2 **(a)** 1. (solutions of) alginate and enzyme mixed ;
2. droplets (of mixture) into calcium chloride (solution) ;
3. to produce beads ; [2 max]

(b) 1. idea of easier purification of product ;
2. enzyme, can be reused / is not lost / has longer shelf life ;
3. allows continuous culture ;
4. cheaper ; 2 max

(c) *description*
1. immobilised papain more active / papain in solution less active, at higher temperatures ;
2. idea of difference above 30°C ;
3. comparative figs ; e.g. values of activity for **both** at any **one** temperature above 30°C

explanation
4. (inert support) protects enzyme ; **A** beads
5. tertiary structure / 3D structure / active site, (of the enzyme) is stabilised ;
6. less denaturation ;
7. H bonds, vibrate less / less easily broken ;

accept ora for mp4–mp7 [4 max]

[Total: 8]

Q8.

5 **(a)** 1. higher yields / more crop survives ;
2. less need to use pesticides / crop pest-resistant ;
3. (reduced pesticide use) may benefit other organisms in the same environment ;
4. less risk of harm to humans, from spray drift / from pesticide residues on food ;

ignore refs to cost [2 max]

(b) (eating Bt maize) reduces growth rate ;
0.6 compared to 0.7 / difference of 0.1 ; [2]

(c) 1. experiments done in laboratory and not in the ecosystem / AW ;
2. predicts what could happen if Bt toxin conc. increases in the future ;
3. may not (normally) feed on pollen ; [2 max]

(d) 1. such results likely to have a negative effect on public perception (of GM crops) / AW ;
2. might reduce work for researchers in this area ;
3. might reduce income of companies (producing GM crops) ;
4. increased use of pesticides ; [1 max]

Q9.

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2 (a) (i) 1. ref. antigen presenting cells ;

2. (antigen) A recognised as, non-self / AW ;

3. by B lymphocytes;

4. with appropriate, receptor / antibody / immunoglobulin ;

5. ref. clonal selection ;

6. (B lymphocytes) clonal expansion / mitosis / cell division ;

7. T-helper cells to stimulate B-cell (response) ;

8. release cytokine;

9. (B lymphocytes) mature into plasma cells ;

10. (plasma cells) secrete (anti-A) antibody ; [4 max]

(ii) plasma cell fused with, myeloma / cancerous / malignant, cell ; [1]

(iii) 1. B cells / plasma cells, will not grow in culture / cannot divide (AW) / short-lived ;

2. cancerous / malignant / myeloma, cells divide, indefinitely / continuously
or
hybridoma divides (AW) indefinitely ;

3. AVP ; e.g. to obtain, genetic material / genes / genomes, from both cells [2 max]

(iv) use of marker described (attached to, antigen A / specific mAB against mouse antibody); [1]

(b) (i) 1. all infliximab treatments reduce percentage with increased joint damage ;

2. (general trend) high dosage / more infliximab, percentage with increased joint damage lower
or
low dosage / less infliximab, percentage with increased joint damage higher ;

3. both increasing dosage & decreasing time intervals have an effect;

4. at high dosage increasing time interval shows, percentage with increased joint damage is similar / AW ;

5. at low dosage increasing time interval shows, the percentage with increased joint damage is less / AW;

6. 30.5% with no infliximab to 0.5 – 1.0% with most infliximab / 30% decrease ;

7. other comparative data ; [3 max]

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(ii) because small numbers involved / AW ; [1]

(c) *N.B. diagnosis not treatment*

1. quick diagnosis;
2. than having to culture pathogen ;
3. (quicker diagnosis) so quicker treatment ;
4. less labour intensive (than culturing) ;
5. not all pathogens can be cultured ;
6. microscopic identification difficult ;
7. viruses difficult to identify ;
8. AVP ; e.g. ref. specificity / ref. non-pathogenic diseases [3 max]

[Total: 15]

Q10.

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2 **(a)** 1. *idea of* wait for / time needed for, immune response to occur ;

2. ref. B lymphocytes mature to, plasma cells / effector B cells ;

3. plasma / effector B, cells secrete antibodies ;

4. plasma / effector B, cells extracted from (mouse) spleen ;

5. fused with, myeloma / cancerous / malignant, cells ;

6. (hybridoma cells) cultured ; ***A*** *before or after mp7*

7. identify cells secreting antibody (specific / against *T. pallidum*); *ignore 'containing'*

8. AVP ; e.g. use of fusogen [4 max]

(b) 1. (solution of) H9-1 / antibody added ; *ignore injecting*

2. given time for binding (then washed off) ;

3. examined with microscope ;

4. using, UV light ; **A** laser

5. fluorescent / yellow, treponemes are *T. pallidum* ; [3 max]

(c) *dark-field microscopy*

1. not enough treponemes (*T.pallidum*) present ;

2. *(idea of)* not noticed among other treponemes ;

blood test

3. not enough antibodies present to measure (in plasma) ; *ignore absent*

4. in host cells but not in blood / takes time to reach blood stream from point of entry ;

5. ref. time for immune response to occur / immunocompromised people ; [2 max]

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(d) (i) 1. H9-1, more accurate than other tests / correct in all cases ;

2. small number of false results from other tests ;

3. blood test least accurate ;

4. comparative figures ; (dark-field microscopy v. blood test)

e.g. of acceptable figures:-
(dark-field microscopy) 1 false negative and 2 false positives / ~ 5% / 3 errors out of 61 / 3.33% false negatives
(blood test) 3 false negatives and 2 false positives / ~ 8% / 5 errors out of 61/ 10% false negatives

5. comment re: small numbers ; [3 max]

(ii) 1. had infection before / antibodies already present ;

2. (have antibodies to) other treponemes that share an antigen with *T. pallidum* ; [1 max]

(e) *N.B.* ***treatment*** *not diagnosis*

1. *idea of* (monoclonal) recognise, specific antigen / cancer cell ;

2. (monoclonal) carries, drug / radioactive molecule / coloured molecule ;
ignore magic bullet alone

3. how this leads to treatment ; e.g. *cytotoxicity / effect radiation / effect laser*

4. as passive vaccine ;

5. (monoclonal) injected directly into, blood / body, to attack a particular pathogen ; [2 max]

[Total: 15]

Q11.

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3 **(a)** 1. nutrients added **and** product removed at a steady rate/AW;

2. (so) volume kept constant;

3. organism kept at, exponential/log, phase of growth; [max 2]

(b) 1. (branched fungus tangles together in clumps so) too heavy for bubbles to, lift/stir
OR ref. to blocking;

2. difficult to, harvest/get desired texture;

3. mutant may be, harmful when eaten/toxic/allergenic;

4. mutant may produce, distasteful/coloured, substance;

5. mutant may be less productive;

6. mutant may have high concentration of RNA (which is difficult to lower);

7. approval for sale only applies to original strain; [max 4]

(c) 864 kg; [1]

[Total: 7]

Q12.

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3 **(a)** 1. nutrients added **and** product removed at a steady rate / AW;

2. (so) volume / named condition, kept, constant / at an optimum;

3. organism kept at, exponential / log, phase of growth; [2 max]

(b) **(i)** 1. at, low / 7.0, (carbon concentration) higher temperature causes increases in, growth / dry mass;

2. at, high / 14.0, (carbon concentration) higher temperature causes little or no change in, growth / dry mass;

3. comparative figures plus units; [3]

(ii) *carbon or nitrogen source*

1. to produce, amino acids / proteins / enzymes;

2. to produce, nucleic acids / nucleotides / ATP / purines / pyrimidines / named N-base;

3. chitin / building block, for cell wall;

carbon only

4. used in respiration;

5. to produce, carbohydrates / sugar / polysaccharide / glycogen / lipids; [3 max]

[Total: 8]

Q13.

4 **(a)** 1 (mouse) injected with antigen ; **A** protein / red cells

2 spleen / plasma / B, cell ;

3 with ability to make antibody ; *linked to 2*

4 fused with, tumour / myeloma / cancerous, cell ;

5 cells cultured ;

6 cells checked for antibody production ;

7 cells cloned ; [4 max]

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(b) **(i)** 1. Herceptin / X-ray, induces (slightly) more cell death than control ;
A more effective

2. X-rays induce more cell death than Herceptin ; **A** more effective

3. comparative figures supporting 1 or 2 ; e.g. 0.6 or 0.75 v 0.5

4. Herceptin and X-rays induce much more cell death (than either treatment alone) ; **A** highest / most / greatest, effect

5. comparative figures supporting 4 ; e.g. 2.0 v 0.6 or 0.75 [3 max]

(ii) $\frac{2.0 - 0.6}{0.6} \times 100\ \%$

= 233 % ;; *award 2 marks for correct answer* *ignore decimal places*

allow 1 mark for valid working if answer incorrect [2]

(c) **(i)** 1. increase in dose of X-ray causes, decrease in % cells surviving / more cell death ;

2. increase in X-ray dose plus Herceptin causes greater, decrease in % cells surviving / cell death ;

3. difference greatest above 2 ($J\ kg^{-1}$) ; **R** ref to time or rate [3]

(ii) identifies cancer cells ;
immune response triggered ;

enters cancer cell ;
kills it ;

Herceptin enhances effect of X-ray ; [2 max]

[Total: 14]

Q14.

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3	(a)	(i)	so that, the bacteria were not killed / enzymes not denatured ;	[1]
		(ii)	1. bacteria put into (solution of) sodium alginate ; 2. place mixture in syringe ; 3. add drops of mixture to calcium chloride solution ; 4. calcium ions replace sodium ions (to form beads) ; 5. bacteria trapped in beads ;	[3 max]
	(b)	(i)	*note comparison between blue line and black line* *ignore references to red line - agar* 1. both increase up to, 18 / 24, hours ; 2. both similar, initially / up to 18 hours ; 3. biggest difference at 24 hours / rate of increase for immobilised cells greater than free cells between 18 and 24 hours ; 4. after 24 hours immobilised cells rate decreases while free cells rate continues to increase or after 39 hours free cells rate is greater than immobilised cells rate ; 5. free cells final concentration is still lower than highest value attained by immobilised cells ; 6. use of comparative figures ;	[4 max]
		(ii)	1. (could be) less surface area (to volume ratio) in cubes than beads ; 2. (could be) a greater diffusion distance to centre of cubes than beads ; 3. agar may be less permeable (to substrate) than alginate ; 4. something in agar may inhibit bacterial enzymes ; 5. some protease adsorbed by agar ;	[2 max]

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	(c)	(i)	82.14 / 82.1 / 82 (%) ; ; *allow one mark for suitable working if incorrect answer*	[2]
		(ii)	1. can use alginate (beads) many times ; 2. (reduces cost of), materials / energy / labour ; 3. fewer bacterial cultures needed / less time spent immobilising bacteria ; 4. more protease produced (per hour) (using alginate) ; 5. can run fermentation for longer time ; 6. less time wasted between fermentations ; *answers must imply comparison*	[3 max]
				[Total:15]

Q15.

3	(a)	(i)	condensation ;	[1]
		(ii)	1. autolysins ; 2. make holes in cell walls ; 3. in, growing / developing, bacteria ; 4. (antibiotic), inhibits / acts on, (another) enzyme ; 5. so peptidoglycan chains cannot link up / stops cross-links forming ; 6. cell wall becomes weaker / AW ; 7. turgor of cell not resisted (by cell wall) / AW ; 8. cell bursts ;	[4 max]
		(iii)	(glycoprotein) peptidase ; R other peptidase	[1]
	(b)		viruses have no cell wall ;	[1]
	(c)		*assume gram+ unless otherwise stated*	
		1	(gram+) penicillin can reach, cell wall / peptidoglycan, directly /AW / (gram-) ora ;	
		2	(gram-) outer membrane provides protection (from penicillin) / (gram+) ora ;	
		3	(gram+) more % peptidoglycan in wall (so greater effect from penicillin) / (gram-) ora ;	[2 max]

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	(d)		*accept antibiotic for penicillin and bacteria for S. pneumoniae throughout*	
		1	increase in resistance (throughout time period) ;	
		2	paired figs + units ;	
		3	overuse / misuse, of penicillin ;	
		4	some *S. pneumoniae* survive ;	
		5	mutation (in *S. pneumoniae)* ;	
		6	resistance, gene / allele ;	
		7	resistance passed to other bacteria ; e.g. plasmid transfer	
		8	resistant strain, multiplies ; *idea of many produced*	
		9	beta – lactamase produced ;	
		10	breaks down penicillin ;	
			point 7 accept vertical or horizontal transfer *point 8 accept vertical transfer only*	[5 max]
				[Total: 14]

Q16.

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2 (a) (i) 1 penicillin inhibits enzyme / peptidase ;

2 blocks / alters shape of, active site ;

3 peptidoglycan chains cannot link up / stops cross-links forming ;

4 cell wall weaker / AW ;

5 turgor of cell not resisted (by cell wall) / AW ;

6 cell / wall / bacterium, bursts ; [3 max]

(ii) *any two from*

1 viruses do not have cell wall ;

2 viruses do not have cytoplasm ;

3 viruses do not have peptidoglycan ;

4 viruses do not have peptidase ; [2 max]

(b) *without antibiotic*

1 numbers of both wild-type and mutant strains, increase / hardly changes ;

with antibiotic

2 numbers of both wild-type and mutant strains decrease ;

3 mutant strains decrease more than wild-type ; **A** faster
this subsumes marking point 2

4 after 24h, wild-type plateaus and mutant strain continues to decrease ;

5 ref. comparative figures at any one time ; *ignore units for bacteria*
blue with blue
red with red
red with blue – with antibiotic [4 max]

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(c) **(i)** 1 changes in, base / nucleotide, sequence ; **A** named change e.g. substitution

2 alters, triplet code / codon ;

3 enzyme has different, primary structure / amino acid sequence ;

4 enzyme has different, 3D structure / tertiary structure / active site ; [2 max]

(ii) *red and blue with antibiotic*

1 wild-type bacteria can produce glucans **or** mutant bacteria produce less glucans ;

2 glucans bind with antibiotic ;

3 wild-type more resistant to antibiotic **or** mutant bacteria less resistant to antibiotic ; [2 max]

(d) 1 antibiotic, is selective agent / provides selective pressure ;

2 resistant bacteria, survive / reproduce ;

3 pass allele for resistance to offspring ;

4 frequency of allele in population increases ; [3 max]

[Total: 16]

Q17.

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3	(a)	(i)	hybridoma ;		[1]
		(ii)	1 identical (antibodies) **or** produced by cloning ;		
			2 variable regions / antigen binding sites, all identical **or** (antibodies) are specific to one antigen ;		[2]
		(iii)	*Mark text first*		
			1 (four) polypeptides ;	*plural*	
			2 two heavy **and** two light chains ;	**A** long and short	
			3 ref. disulphide, bridges / bonds ;		
			4 ref. variable regions / binding sites ;		[3 max]
	(b)	(i)	1 HAT cannot be metabolised / AW ;		
			2 HAT inhibits mutant myeloma cells / AW ;		[2]
		(ii)	1 mouse spleen cells can metabolise HAT / AW ;		
			2 because they have suitable enzyme ;		[2]
		(iii)	1 so that only fused cells survive **or** unfused myeloma cells die ;		
			2 identifies, cells to be cloned / fused cells ;		[2]
	(c)		1 can be done at home / easy to use / non-invasive ;		
			2 cheap ;		
			3 result produced quickly ;		
			4 result likely to be accurate ;		
			5 can be done early in pregnancy ;		
			6 safe to use ;		[4 max]
					[Total: 16]

Q18.

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2 **(a)** 1. allele for lactase deficiency is recessive ; **A** allele for lactose intolerance
2. parents, heterozygous / carriers ;
3. child homozygous recessive ; [2 max]

(b) **(i)** 1. at low temperatures activity of, immobilised lactase is lower (than free lactase) / free lactase is higher (than immobilised lactase) ;
2. ref 42–43 °C as changeover point ;
3. maximum activity of immobilised lactase is lower (than free lactase) / **ora** ;
4. *idea of* optimum temperature of immobilised lactase 40–45 °C and optimum for free lactase is 35 °C ;
5. comparative figures at any one temperature ; *(units required for temperature only)* [3 max]

(ii) *assume immobilised accept ora*
1. harder for substrate to reach enzyme ;
2. harder for product to pass out of bead ;
3. accumulation of product leads to product inhibition ;
4. *idea of* enzyme less able to move leading to fewer ES complexes / AW ; [2 max]

(c) 1. can re-use enzyme / enzyme not lost / AW ;
2. ref. cost effective ;
3. *idea of,* easier to purify product / less contamination of product ;
4. greater stability at higher temperatures / thermostable ;
5. *idea of,* copes with any pH / pH stable ; [3 max]

[Total: 10]

Q19.

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2 **(a)** 1. 6 penicillin inhibits, enzyme / peptidase ;
2. blocks / alters shape of, active site ;
3. peptidoglycan chains cannot link up / stops cross-links forming ;
4. (so) cell wall weak(er) ;
5. turgor of cell not resisted (by cell wall) /
idea of inability to withstand increased internal pressure ;
6. cell / wall / bacterium, bursts ; *ignore 'dies' as in question* [4 max]

(b) 1. mRNA produced by transcription ;
2. *idea of* triplet code ;
3. translated (at ribosome) ;
4. correct ref. to function of tRNA ; e.g. anticodon / carries amino acid
5. formation of polypeptide ;
6. AVP ; e.g. ref. tertiary structure / 3D shape / ref. bonds [3 max]

(c) **(i)** *mutant strain 1*
1. very low resistance **or** affected by low concentration of antibiotic ; **A** less resistant
2. gene (for efflux pump) not properly, expressed / switched on ;
3. (so) few pumps (produced) **or** pumps out less antibiotic ;
A pumps not working well [2 max]

mutant strain 2
4. more / x4, resistant **or** tolerates high concentration of antibiotic ;
5. gene (for efflux pump fully), expressed / switched on ;
6. (so) many pumps available **or** pumps out more antibiotic ; [2 max]

(ii) 1. natural selection ;
2. antibiotic provides selection pressure ;
3. mutant **2** has selective advantage ;
4. in presence of >64 **and** <256 $\mu g cm^{-3}$ antibiotic ;
5. **R** dies / mutant strain **2** survives ;
6. mutant **2**, reproduces / increases in number ;
7. (so) passes, resistance / mutation, (to offspring) ; *ignore allele / gene* [4 max]

[Total: 15]

Q20.

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3 (a) 1 globular ;
2 ref. tertiary structure / 3D shape ;
3 active site (because enzyme) ;
4 outer amino acids with hydrophobic R groups (because in membrane) / AW ; [2 max]

(b) 1 (penicillin) binds, rarely / briefly, with PBP2a ;
ignore doesn't bind well
2 (so) most PBP2a molecules not blocked ;
3 (so) cell wall / cross links, can still be made (in presence of penicillin) ;
4 penicillin is competitive inhibitor (of PBP) ;
5 (so) reduces PBP enzyme activity ; [3 max]

(c) 1 viruses have no (peptidoglycan) wall ;
2 viruses have no, transpeptidase / glycoprotein peptidase ;
3 viruses, have no cell structure / are not cells ;
4 viruses have no metabolism ; [2 max]

[Total: 7]

Q21.

2 (a) *prevents*
1 growth of new blood vessels (to tumour) ;

2 supply of (more), oxygen / nutrient ; **A** named nutrient

3 more routes for metastasis / AW ; [max 2]

(b) (i) VEGF ; [1]

(ii) cell formed by fusion of a plasma cell **and** a cancer cell ;
A B-lymphocyte, B cell, splenocyte **and** myeloma cell [1]

(c) 1 does not act as foreign antigen / AW ;

2 (so) does not cause, immune response / rejection ;

3 avoids, allergic reactions / side effects / anaphylactic shock ;

4 allows more than one treatment ;

5 remains in body for longer (so more effective) ; [max 3]

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(d) *drawing IgG*
ignore labels

four polypeptide chains shown ; *in correct positions*
(disulfide) bridges shown to link chains ;



[2]

[Total: 9]

Q22.

5 **(a)** **(i)** 1 performed in an open fermenter / nutrients added at a steady rate throughout ;

2 products harvested throughout ;

3 pH / temp / oxygen concentration, controlled throughout ;

4 *ref. to* input = output / constant volume ; [max 2]

(ii) 1 organisms maintained in exponential phase ;

2 faster rate of enzyme production ;

3 no build-up of toxins ;

4 no down time / AW ;

5 small vessels can be used ;

6 cost effective ; [max 3]

(b) **(i)** 1 percentage breakdown (of azo-dye) increased, between 7 and 10 days / after 10 days ;

after 7 days

2 percentage breakdown (of azo-dye) increased with increasing concentration of azo-dye, up to 150 mg dm^{-3} / except for 200 mg dm^{-3} ;

3 two breakdown percentages at two dye concentrations to support mp2 ;

after 10 days

4 percentage breakdown (of azo-dye) decreased with increasing concentration of azo-dye ;

5 two breakdown percentages at two dye concentrations to support mp4 ; [max 4]

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(ii) 1 time is not taken for enzymes to leave white-rot fungal cells ; **ora**

2 lower concentration of enzymes from white-rot cells ; **ora**

3 AVP ; e.g. possible inhibitory effect of azo-dye on white-rot cells/ ESCs formed more quickly [max 2]

(c) 1 enzyme can be, re-used/ recovered after use ;

2 enzyme does not contaminate water/ no purification needed ;

3 *idea of* enzymes being thermostable ;

4 *idea that* enzymes able to withstand pH changes ;

5 *ref. to* increased shelf-life of enzyme ; [max 3]

[Total: 14]

Q23.

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1 (a)	use of living organisms/biological agents/animals/plants/cells/ microorganisms; to, produce useful products/produce foods/produce medicines/ produce chemicals/process other materials/treat waste; in fermenter/culture vessel/AW;	**max 2**
(b)	ref. availability of information; ref. public knowledge/understanding/awareness (of information); ref. complexity of issues; ref. actual/potential benefits importance; ref. actual/potential risks; ref. perceptions of benefit/risk; ref. political/commercial pressures; ref. misinformation/AW;	**max 4**
(c) (i)	initial levels, normal higher than GM/ora; normal has a more rapid rise from 0-4 days/ora; normal reaches much higher level at 4/8 days/ora; normal stays same level from (approx.) 4-8 days/while GM rises slightly; normal drops again after 7/8 days/GM continues to rise after 7/8 days;	**max 3**
(ii)	idea of – start later; idea of – happen slower;	**2**
(iii)	not ripe/green when picked; long shelf life/AW; will not over-ripen; do not ripen too quickly; do not become squashy/firmer; AVP;	**max 2**
(iv)	ref. moral principles/personal choice/values of society/AW; ref. to actual/potential/perceived advantages/named advantage; ref. to actual/potantial/perceived risks/hazards/named risk/hazard; AVP.	**max 2**
		[15]

Q24.

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2. (a) (i) no moving parts;
continuous circulation;
maintained using difference in specific gravity;
of rising aerated culture and air-depleted culture;
heat exchange removes heat;
produced from respiration; 3 max

(ii) C source / glucose ;
N source / ammonia;
growth factor / choline ;
minerals / ammonium sulphate / zinc sulphate / copper sulphate / iron sulphate; 3 max

(b) coloured;
flavoured;
fibres pressed to form pieces / ref texture;
reduction of RNA; 2 max

Total 8

Section_B

1.

9 (a) 1. DNA not surrounded by nuclear membrane / no nucleus;

2. (prokaryote) DNA is circular;

3. DNA not associated with histones; **A** naked DNA

4. plasmids (may) be present;

5. no (double) membrane-bound organelles; **A** no, mitochondria / chloroplasts

6. no, ER / Golgi; **A** ribosomes not attached to membranes

7. ribosomes,70S / 18 nm / smaller (than eukaryotic cells);

8. cell wall made of, peptidoglycan / murein / amino sugars / AW;

9. (usually) unicellular;

10. 0.5 to 5.0 μm diameter; **A** any value between 0.5 and 5.0 as long as μm is used

11. AVP; (may) have, flagella / pili / capsule / slime layer [8 max

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(b) 12. ores (may) contain metal sulfides;

13. example; e.g. iron / copper / zinc / cobalt / lead

14. insoluble in water so difficult to extract;

15. bacteria oxidise metal sulfide;

16. to soluble sulfate;

17. bioleaching;

18. example of bacteria; e.g. *A.ferrooxidans*

19. bacteria need to survive in acidic conditions;

20. mixture of bacteria required (in bioheap);

21. (in order to) survive a wide range of temperatures / range of bacteria with different temperature optima;

22. advantage;

23 e.g. low grade ores / spoil heaps, can be exploited
can get metal from industrial waste
does not produce sulfur dioxide
can be done in situ
low energy demand
less (heavy) machinery
not labour intensive
relatively cheaper (than other mining methods)

24. AVP; e.g. ref. gold / uranium [7 max]

[Total: 15]

2.

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10 (a) 1. regulatory gene codes for repressor protein ;
2. (repressor protein) binds to operator region ;
3. (repressor protein) blocks promoter region ;
4. lactose binds to repressor protein which changes shape ;
5. (repressor protein with bound lactose) breaks away from operator region ;
6. promoter region now unblocked, so RNA polymerase binds to promoter region ;
7. structural genes transcribed ;
8. and translated ;
9. enzymes formed ;
10. ref. lactose permease and uptake of lactose from medium ;
11. ref. β-galactosidase and breakdown of lactose ;
12. into, glucose / galactose ; [max 9]

(b) 1. DELLA proteins inhibit germination ;
2. seed absorbs water ;
3. stimulates production of gibberellin ;
4. by embryo ;
5. gibberellin causes breakdown of DELLA proteins ;
6. leads to transcription of mRNA coding for amylase ;
7. in aleurone layer ;
8. (amylase) hydrolyses starch to maltose ;
9. ref. maltose converted to glucose ;
10. glucose respired by embryo during germination ; [max 6]

[Total: 15]

3.

10 (a) bacteria walls made of peptidoglycans ;

bacteria secrete autolysins ;

make holes in cell wall/ **AW** ;

to allow wall to stretch during growth / **AW** ;

(glycoprotein) peptidases form cross-links (between peptidoglycans) ;

(penicillin) inhibits (glycoprotein) peptidases ;

cross-links (between peptidoglycans) do not form ;

cell wall weakened ;

bacteria take in water by osmosis ;

increased turgor pressure causes cell to burst ; **AW**

AVP ; e.g. competitive inhibition [max 8]

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(b) ref. bioleaching ;

Acidithiobacillus/A. ferrooxidans ; **A** *Thiobacillus/T. ferrooxidans*

low grade ores/(mine) waste ;

two metals ; e.g. copper, zinc, cobalt, uranium, lead, nickel, gold, silver **I** iron

insoluble ore turned into soluble products ;

ore piled up ;

acidic conditions created/pH low(ered)/pH 1.5 – 3 ;

different bacteria at different temperatures ;

chemoautotrophic ; **A** description

oxidation (reactions) ;

sulfide/S^{2-} to sulfate/SO_4^{2-} ; (direct oxidation of ore)

Fe^{2+}/ferrous → Fe^{3+}/ferric ;

Fe^{3+} oxidise other ores ;

product, drains/leaches/is washed, into pool ;

metal displaced by adding scrap iron ; [max 7]

[Total:15]

4.

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10 (a) use *Penicillium* (in batch fermenter) ;

(main) nutrients added at start ;

penicillin only produced, after growth phase/ when running out of nutrients ;

(penicillin) is a secondary metabolite ;

fermentation is stopped ;

penicillin is harvested ;

fermenter is cleaned out/ ref. sterility ;

new culture of *Penicillium* is put in and started again ;

ref. fed batch culture ;

carbohydrate / named nutrient, added regularly ;

keeps fermentation going longer / produces more penicillin ;

detail of fermenter ;; e.g. paddle to mix nutrients / sterilising steam inlet / set at pH 6.5 / aeration / kept at 27 °C [max 8]

(b) *batch*
easy to set up culture ;

can continue with minimal attention / AW ;

environmental conditions easy to control ;

fermenter can be used for different process afterwards ;

only waste one batch if contaminated ;

less chance of blockage in fermenter ;

continuous
no / less, down time / AW ;

small vessels can be used ;

productivity high ;

cost effective ;

downstream processing easier ;

good for using immobilised enzymes ; [max 7]

[Total:15]

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Q1.

Question 1

(a) peptide bonds between amino acids ;
primary structure / amino acid sequence determines folding sites ;
hydrogen bonds maintain (secondary structure) ;
ref. beta pleated sheet / alpha helix ;
ref. folding to form tertiary structure / globular shape ;
sulphur bridges / ionic bonds / Van de Waals forces / hydrophobic interactions ;

3 max

(b) reverse transcriptase / synthesise DNA from mRNA ;
restriction endonuclease / enzyme ;
produces sticky ends ;
plasmid cut by restriction enzyme ;
recombinant DNA formed ;
DNA ligase (correct ref) ;
DNA inserted into host e.g. Hamster kidney / ovary cells ;
Detail of insertion e.g. electric shock / calcium ions.

4 max

(c) no contamination / ref. named infection HIV / reduced rate of infection / greater production rate ;

1

(d) ref. to introns and exons / only mammalian cells have Golgi / enzymes (for post translational modification) ;

1

Total: 9

Q2.

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(b) *reverse transcriptase*
makes, cDNA / single strand of DNA ;
from (human) mRNA ;
DNA polymerase
produces, second strand of DNA / double stranded DNA ;
ref. links nucleotides (in context of backbone formation) ;
ref. semiconservative replication / ref. complementary base pairing ; *[max 2]*
restriction enzymes
cut DNA / cut plasmid ; **R** cuts gene **A** cuts out gene
at specific sites / at palindromic sites ;
to give sticky ends ; **A** blunt ends *[max 2]*
DNA ligase
seals nicks in sugar-phosphate backbone ;
forms rDNA ;
by adding phosphate group ; *[max 2]* [6 max]

Q3.

(b) (i) 1 cut DNA (into fragments) ;
2 by, restriction enzymes / named enzyme ;
3 place on (agarose) gel ;
4 apply, current / p.d. / electricity ;
5 fragments travel towards anode ;
6 short fragments travel, further / faster, than long ones ; **A** mass of fragments
7 visualise DNA with UV light / other means of visualisation ;
8 AVP ; e.g. Southern blotting / described [4 max]

(ii) 1 change to, primary structure / secondary structure / tertiary structure / folding / 3D shape ;
2 protein / enzyme, cannot carry out its normal function ;
3 (could be an enzyme) that is essential for a metabolic pathway ;
4 (could) control the expression of another gene / series of genes ; [2 max]

(iii) 1 (only) one base / base pair / triplet, needs to change (for teosinte to become maize) ;
2 idea that this could occur in a natural population of teosinte / mutation ;
3 variant, looks different / easy to spot ;
4 early farmers could have selected it to breed from ;
5 no need for complex breeding programme ; [3 max]

Q4.

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6 **(a)** 1 increases, cellular uptake of glucose (from blood) / membrane permeability to glucose ;

2 (by), liver / muscle / adipose, cells ;

3 increased, respiration / metabolism, of glucose ; **A** increased glycolysis

4 causes conversion of glucose to, glycogen / fat ; **A** inhibits glycogenolysis

5 (blood glucose concentration maintained between) 80–120 mg per 100 cm^3 ;
A single value between 80–120 [3 max]

(b) 1 it is identical to human insulin / ora ;

2 (more) rapid response ;

3 no / fewer, rejection problems / side effects / allergic reactions ;

4 ref. to ethical / moral / religious, issues ;

5 cheaper to produce in large volume / unlimited availability ; **R** cheap to produce

6 less risk of, transmitting disease / infection ;

7 good for people who have developed tolerance to animal insulin ; [2 max]

(c) **(i)** 1 single target site will be in correct resistance gene ;

2 (gene to be inserted has) complementary sticky ends to target site sticky ends ;

3 more cuts would fragment plasmid ; [2 max]

(ii)

circle of DNA taken up by bacteria	bacteria resistant to ampicillin	bacteria resistant to tetracycline
unaltered plasmids	✓	✓ ;
recombinant plasmids that have taken up the wanted gene	✓	× ;
circles of the wanted gene	×	× ;

[3]

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(d) (i) 1 risk spread of resistance to other bacteria ;

2 spread of resistance makes the use of antibiotics less effective / AW ;

3 via, conjugation / transformation / uptake of plasmids ; **A** description

4 via, 'phage / transduction ; **A** description

5 ref. R plasmid multiple resistance (MDR) / extreme resistance (XDR) ; [3 max]

(ii) 1 gene for fluorescent substance ;

2 source of gene ; e.g. from jellyfish

3 substance fluoresces when exposed to appropriate light ;

or

4 lacZ gene / gene for β-galactosidase ;

5 splits non-blue substrate ;

6 product is blue ; [2 max]

[Total: 15]

Q5.

8 (a) (i) 1 parents, heterozygous/carriers ;

2 CF allele recessive ;

3 CF child homozygous recessive ; [2 max]

(ii) 1 thick/sticky/dehydrated, mucus produced ;

2 mucus not moved effectively by cilia/mucus accumulates ; **R** mucus blocks airway

3 reduced gaseous exchange/longer diffusion pathway ;

4 difficulty in breathing/AW ;

5 infections/(mucus) traps bacteria ;

6 lungs are scarred ; [2 max]

(b) (i) 1 alters genotype ;

2 insert, dominant/normal, allele ; **R** gene

3 into, affected/appropriate, cells ;

4 use of vector/named vector ;

5 ref. recombinant DNA ; [2 max]

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(ii) *advantage*

1 treats cause not symptoms ;

2 no, physiotherapy/antibiotics/etc, needed ;

3 less time consuming than others treatments ; max 1

disadvantage

4 effects only last for a few days (at present)/low uptake by target cells ;

5 only target lung cells (at present) ;

6 side effects ; max 1 [2 max]

[Total: 8]

Q6.

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8	(a)	(i)	1	change in, genetic material/DNA, (in cell) ;	
			2	(therefore) change product of cell ;	
			3	during protein synthesis ;	[2 max]
		(ii)	1	identification of transformed, cells/organisms ;	
			2	avoid use of antibiotics ;	
			3	easy to detect ;	
			4	no known ill effect on GM organism ;	[2 max]
	(b)	(i)	1	reduces deficiency disease/AW ;	
			2	better quality food ;	
			3	assistance to developing nations/AW ;	
			4	cheap seed ; e.g. for golden rice	[2 max]
		(ii)	1	high cost of GM seed ;	
			2	too much power held by multinational companies ;	
			3	change to ecosystem ; e.g. hybridisation	
			4	GM crops may be difficult to sell ;	
			5	GM plant varieties may be genetically unstable ;	
			6	no long term studies done on effects on human health ;	
			7	reduction in biodiversity/outcompetes natural variety or species ;	[2 max]
					[Total: 8]

Q7.

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3 **(a)** 1. VNTRs with more repeats are, longer / greater mass ; **ora**

2. phosphate groups (of DNA) give negative charge ;

3. fragments / DNA, attracted to, anode / positive electrode ;

4. Shorter / lower mass / fewer repeat, pieces move, faster / further in unit time; **ora**

5. ref. impedance of gel / AW ; [3 max]

(b) *N.B. answer on Fig 3.2*
one band in exactly same place as given band ; *may be drawn thinner*

second band above the first ; [2]

(c) *to identify*
1. a carrier / heterozygote, before marriage ;

2. a carrier / heterozygote, before conceiving child ;

3. HbS HbS child *in utero* re: termination ;

4. HbS HbS child at birth re: treatment ;

5. ref. genetic counselling ; [3 max]

[Total: 8]

Q8.

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3 **(a)** 1. sequence of, bases / nucleotides, in the original DNA strand(s) ;

2. complementary base-pairing ;

3. A with T and C with G ;

4. purine with pyrimidine ;

5. 2 H-bonds and 3 H-bonds ; *allow marks from annotated diagram* [2 max]

(b) chance / random ;
only present in low concentration ; [2]

(c) **(i)** ATCGAT / in order of size starting with shortest ; [1]

(ii) 1. fragments are separated according to, length / mass ;

2. phosphate groups (of DNA) give negative charge ;

3. fragments move to, anode / positive electrode ;

4. short / light, fragments move, faster / further in unit time / **ora** ;
must be comparative

5. ref. impedance of gel / AW ; [3 max]

[Total: 8]

Q9.

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4 **(a)** 1. ref. to vitamin A deficiency in, developing countries / named part of the world ;

2. rice, is a staple food / forms a major part of diet (in those countries) ;

3. increases vitamin A (in diet) ;

4. ref. prevention of blindness or reduces susceptibility to, diarrhoea, respiratory infections, measles ; **ora** [2 max]

(b) (desaturases, are not limiting production because) phytoene does not accumulate ;

(so) desaturases are, functioning normally / converting phytoene to other compounds ;

or

GGDP, present in large amounts / accumulates / remains high ;

(so) phytoene synthase is, limiting / reducing conversion to phytoene ; [2]

(c) **(i)** restriction (enzymes) ; [1]

(ii) 1. (promoter required) to ensure expression of the (introduced) genes / AW ;

2. (suitable promoter) might not be present in the rice cells ;

3. (suitable promoter) might not be in the correct position relative to the introduced genes ; [2 max]

(iii) *yes (no mark)*

1. all rice cells contain the same *crtI* genes ;

2. only difference was the source of the *psy* genes ;

3. if *crtI* limiting there would be no difference in the carotene in each group ; [2 max]

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(d) 1. different base sequences (in the *psy* genes from different sources) ;

2. so different amino acid sequences, in the enzyme / in phytoene synthase ;

3. so different tertiary structure ;

4. could affect interaction with other components, e.g. cofactors ;

5. AVP ; *e.g. refs to different protein synthesising machinery in the cells*

ignore refs to active site and ability to bind with GGDP – must be able to do that as it does it in daffodils [2 max]

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(e) 1. GM seed could be difficult for farmers in developing countries to obtain ;

2. high cost of buying (new) GM seed / cannot use own seed ;

3. may not grow well in all conditions (as other traits not selected for) ;

4. too expensive for, people to buy / farmers to sell ;

5. might reduce efforts to relieve poverty ; [3 max]

[Total: 14]

Q10.

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2 (a) male mosquitoes do not, bite humans/feed on blood transmit disease
OR
only females, bite humans/feed on blood/transmit disease;

I GM male mosquitoes are not infected with the disease [1]

(b) 1. easier to, identify/screen;

2. more economical/time saving/labour saving;

3. resistance gene(s) can be passed to other bacteria;

4. idea of antibiotics no longer effective
OR requiring development of new, antibiotics/treatments; [max 2]

(c) (i) production of tTA causes production of **more** tTA/AW; [1]

(ii) 1. promoter, initiates transcription/switches on gene/causes gene expression/AW;

2. ref. binding of, RNA polymerase/transcription factors;

3. otherwise gene has to be inserted near an existing promoter;

4. this is difficult to do/this may disrupt expression of existing gene;

5. in eukaryotes precise position of promoter important; [max 3]

(iii) 1. GM larvae do not die immediately;

2. so gives longer time for tTA, production/build up;

3. so tTA gets into environment (when GM larvae die) and kills non-GM larvae;

4. so (longer-lived larvae) compete with non-GM larvae (for, food/space);

R ref. to larvae breeding [max 2]

(d) (i) 1. chemical **A** has, similar shape to tTA/complementary shape to binding site;

2. so chemical **A** binds to, DNA/binding site, **AND** prevents tTA from binding;

3. chemical **A**, binds to/changes shape of, tTA
AND so prevents tTA binding to, DNA/binding site;

4. stops positive feedback/small quantity of tTA does not kill; [max 2]

5. chemical **A**, binds to/changes shape of/breaks down, tTA, so no longer toxic;

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(ii) 1. GM males, mated/bred;
R with GM females

2. mosquitoes fed chemical **A**;

3. males, identified/separated;

4. ref. cloning; [max 2]

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(iii) 1. GM males die if they cannot get chemical **A**;

2. (if males mate), their offspring die;

3. only mate with, other *A. aegypti*/their own species; [max 2]

[Total: 15]

Q11.

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2 (a) (i) 1. easier to, identify / screen;

2. more economical / time saving / labour saving / harmless;

3. resistance gene(s) can be passed to other bacteria;

4. idea of antibiotics no longer effective
or
requiring development of new antibiotics; [2 max]

(ii) 1. promoter, initiates transcription / switches on gene /causes gene expression / AW;

2. ref. binding of, RNA polymerase / transcription factors;

3. otherwise gene has to be inserted near an existing promoter;

4. this is difficult to do / this may disrupt expression of existing gene;

5. in eukaryotes precise position of promoter important;

6. idea that you need a coral promoter to switch on a coral gene; [3 max]

(b) (i) 1. DNA fragmented by, restriction enzyme(s) / endonuclease(s);

2. loaded (into wells) at, negative end / cathode end, (of gel);

3. ref. buffer / electrolyte;

4. phosphate groups of DNA give negative charge;

5. (negatively charged) DNA attracted to, anode / positive electrode;

6. separation due to, electric field / PD / potential difference;

7. short pieces / smaller mass, move further (in unit time) / move faster; **ora**

8. ref. impedance of gel / AW; [4 max]

(ii) 1. idea of comparison of position with reference DNA;

2. ref. staining / fluorescence in UV;

3. by use of DNA probe;

4. ref. single-stranded / complementary base pairing; [2 max]

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(c) 1. allows estimate of numbers of each type;

2. to check success (of release of sterile males);

3. if sterile males wrongly identified as wild;

4. there will be a waste of resources, e.g. pesticides;

5. if wild males wrongly identified as sterile males;

6. a potential infestation may be missed;

7. AVP; e.g. to determine which moths to (re)release [2 max]

(d) 1. that DsRed is not toxic to predators of the moth;

2. that DsRed does not persist in the environment;

3. that the gene cannot pass to other organisms;

4. does not alter, food web / ecosystem, (in harmful way); [2 max]

[Total: 15]

Q12.

Question 5

(a) restriction (endonuclease) enzyme ;
named example e.g. EcoR1 ;
specific sequence of bases ;
ref. to sticky ends / exposed bases ; **[3 max]**

(b) ref. to complimentary base pairing ;
of sticky ends ;
ligase ;
formation of phosphodiester bond ; **[3 max]**

(c) identical to human insulin (ref. to bovine / porcine insulin used previously) ;
ref. to possible immune response ;
easier to extract ;
pure / uncontaminated ;
regular production not dependent on livestock ; **[2 max]**

Total [8]

Q13.

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2 (a) (i) acts as chloride channel ; **A** Cl^- **R** chlorine

Cl^- moves out (of cell) ;

active transport / binding site for ATP ; [2 max]

(ii) **E** on diagram / upper face, because this is where, oligosaccharides / glycocalyx / carbohydrate chains, are present ;
A glycoprotein **R** glycolipid [1]

(b) (i) form / variety / version, of a gene ;

only affects phenotype when dominant allele not present / AW ; [2]

(ii) 1. thick / sticky / dehydrated, mucus produced ;

2. mucus not moved effectively by cilia / mucus accumulates ;

3. reduced gaseous exchange / longer diffusion pathway ;

4. difficulty in breathing ;

5. more infections / (mucus) traps bacteria ;

6. lungs are scarred ; [3 max]

(c) viral DNA carries normal (CFTR), allele / gene ;
R RNA **A** recombinant DNA

virus binds (with lung cells) ;

viral DNA put into, (lung) cells / host DNA ; [2 max]

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(d) **(i)** 1. translation will not occur normally ;

2. no amino acid added to chain when stop codon reached ;

3. protein chain not completed / protein only partially made ;

[2 max]

(ii)

PTC124		gene therapy
1. can be taken orally	**or**	delivered (by vector) into respiratory tract ;
2. self administered	**or**	requires medical treatment ;
3. is readily taken up by cells	**or**	poor take up by cells ;
4. no vectors needed / fewer or no side effects	**or**	possibilty of side effects (from vectors) / named side effect ;
5. only needs to enter cytoplasm	**or**	difficulty in inserting gene into host DNA ;
6. no need to switch on gene	**or**	difficulty in switching on gene ;

[3 max]

[Total:15]

Q14.

6	**(a)**	**(i)**	same band of DNA as, first / affected, child ;	[1]
		(ii)	1. father and mother, have normal and mutant alleles / are heterozygous ; 2. mutant / CF, DNA is, shorter / lighter ; 3. therefore travels further ;	[2 max]
	(b)	1	outcome of test needs explanation / counsellor gives advice on options ;	
		2	already have one affected child to care for or problems / cost, of care ;	
		3	ref. termination ;	
		4	life expectancy increasing with improved drugs ;	
		5	gene therapy, not as yet successful / likely to be temporary ;	
		6	possibility of, pre-implantation genetic diagnosis (PGD) / artificial insemination by donor sperm (AID), on another occasion ;	[4 max]
				[Total: 7]

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Q15.

4 **(a)** 1 binds to receptors (on liver cell membranes) ;

2 conversion of glucose to glycogen / glycogenesis ;

3 (because) insulin activates enzyme ; e.g. glucokinase / phosphofructokinase / glycogen synthase

4 increased use of glucose in respiration ;

5 increased uptake of glucose / increased permeability to glucose (of liver cells) ; [3 max]

(b) **(i)** 1 mRNA (found in β cells) is only from gene coding for insulin / AW ;

2 large numbers (of mRNA coding for insulin) ;

3 (whereas) DNA has all genes ;

4 (so) restriction enzymes needed ; [2 max]

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(ii) 1 cut plasmid (DNA) ;

2 at specific, base sequence / site ;

3 leaving sticky ends (that will join with insulin gene) ; [2 max]

(c) **(i)** *all statements must be comparative*
inhaled (accept ora for injected)
1 insulin concentration rises more rapidly when inhaled ;

2 higher peak ;

3 falls, more rapidly / earlier ;

4 (after 150 mins) lower (than injected) ;

5 use of comparative figures ; *figures for both at one time* [3 max]

(ii) 1 glucose conc. is linked to insulin conc. ;

inhaled (accept ora for injected)
2 (initially) glucose falls <u>because</u> insulin conc. rises ;
this subsumes marking point 1

3 glucose conc. falls lower <u>because</u> insulin conc. is higher ;
this subsumes marking point 1

4 (later) glucose rises higher <u>because</u> insulin conc. is lower ;
this subsumes marking point 1

5 use of figures ;
e.g. one glucose conc. for inhaled and one for injected at <u>one</u> time
or
one glucose conc. linked to an insulin conc. at <u>one</u> time
(either inhaled or injected) [3 max]

(iii) *advantages:*

1 faster response time ;

2 less chance of, infection / contamination ;

3 good for people with needle phobia ; *max 1*

disadvantages :

4 could cause larger swings in blood glucose concentration ;

5 may need to taken more often / not long lasting ;

6 possible variability of dose / AW ; *max 1* [2 max]

[Total: 15]

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Q16.

5 (a) 1 AAV2.5T infects more cells than AAV / AW ;

2 both increase until 20 days ;

3 AAV2.5T falls after 20 days but AAV remains steady ;

4 figures ; *two intensities on a single day* [2 max]

(b) 1 infected cells fluoresce (when luciferin added) ;

2 able to identify infected cells ; [2]

(c) 1 correct form of (CFTR) protein made ;

2 delivered to / inserted into, membrane ;

3 acts as chloride channel ;

4 chloride ions leave cell ;

5 water leaves cell ;

6 normal / less viscous, mucus formed ;

7 give credit to mention of one symptom reversed ;
e.g. no blockage of airways / less chance of infections [4 max]

[Total: 8]

Q17.

5 (a) 1. caused by a single gene ;
2. caused by a recessive allele ;
3. delivery of, correct / dominant / normal, allele (could correct the condition) ;
4. only need to get allele into a few cells ;
5. ease of access to affected area ;
6. serious so worth the risk ;
7. AVP ; e.g. only targets eye / no surgery needed [3 max]

(b) 1. virus no longer able to cause infections ;
2. correct / dominant / normal, allele (of *RPE65*) added ;
3. promoter added ; [2 max]

(c) 1. ref. to safety / not known if the technique might have side effects ;
2. rare condition ;
3. expense ;
4. AVP ; e.g. trial to see if delivery method works [2 max]

[Total: 7]

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Q18.

7

step	reason for step
obtain copies of gene with sticky ends	the gene codes for the synthesis of insulin
plasmid (used) ;	acts as a vector for the transfer of the gene into the host
use restriction endonuclease enzyme	to produce 'sticky ends' **or** cut at specific, site / sequence ;
mix vector and gene	gene inserts into, vector / plasmid **or** forms recombinant DNA / AW ; **A** detail of complementary base pairing
(use DNA) ligase ;	to seal the sugar-phosphate backbone
insert, plasmid / vector, into host / *E. coli* / *bacteria* ;	to obtain transformed host *E. coli* cells
screen for, and obtain, successfully transformed cells	so only recombinant host cells cultured / AW;
ref. batch / continuous, culture **or** fermenter **or** bacterial cloning / population growth ;	to obtain large amounts of insulin for extraction and purification

[7]

[Total: 7]

Q19.

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5 (a) (i)

correct order	letter of step
1	C
2	**H**
3	**F**
4	**A**
5	D
6	**B**
7	**E**
8	**G**

H F A all above **D** ;
H F A in correct order ;

B E G all below **D** ;
B E G in correct order ; [4]

(ii) **A** – (DNA) ligase ;
H – reverse transcriptase ; [2]

(b) 1. it is identical to human insulin / **ora** ;
2. (more) rapid response ;
3. no / fewer, rejection problems / side effects / allergic reactions ; **R** immune response
4. ref. to ethical / moral / religious, issues ;
5. cheaper to produce in large volume / unlimited availability ; **R** cheap to produce
6. less risk of, transmitting disease / infection ;
7. good for people who have developed tolerance to animal insulin ; [2 max]

[Total: 8]

Q20.

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3 (a) (i) 1. gene isolated ;
2. inserted into plasmid / AW ;
3. correct ref. sticky ends ;
4. plasmid taken up by, *E. coli* / bacterium ; **R** plasmid inserted into bacterium
5. detail ; e.g. use of restriction enzyme / cDNA produced [3 max]

(ii) 1. marker gene linked to gene for wanted protein ;
2. with promoter ;
3. GFP gene is, transcribed / expressed ;
4. producing GFP which fluoresces ; [3 max]

(b) *disadvantage*
1. may not fluoresce very brightly / may be difficult to detect ;

explanation
2. only a few molecules of GFP produced ;
3. each enzyme molecule produces more fluorescent substance / *idea of* enzymes can be re-used ; [2 max]

[Total: 8]

Q21.

2 (a) 1 ref. sticky ends ;
2 GATC and CTAG ;
3 complementary bases (pairing) ;
4 A to T **and** C to G ;
5 H-bonds (to sticky ends of plasmid) ;
6 (gaps in) sugar-phosphate backbones sealed by (DNA) ligase ;
7 AVP ; e.g. formation of phosphodiester bonds / ref. terminal transferase [4 max]

(b) (i) 1 *idea of* identifying bacteria that, are transformed / have taken up plasmid / have taken up ampicillin resistance gene ;
2 these bacteria have survived ;
3 these bacteria may contain pBR322 or recombinant plasmid / plasmids taken up may not contain human insulin gene ;
4 other bacteria have been killed ; [3 max]

(ii) 1 (*Bam*HI) breaks the tetracycline resistance gene ;
2 (inserting human insulin gene) makes tetracycline resistance gene inactive ;
3 colonies that are ampicillin-resistant but **not** tetracycline-resistant have taken up recombinant plasmid / insulin gene ;
4 colonies that survive on, tetracycline / both ampicillin and tetracycline / plate **T**, have not taken up the recombinant plasmid / insulin gene ; [3 max]

(iii) *Answer on Fig. 2.2*
left hand colony on plate **A** ; [1]

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(c) (i) 1 plasmids (easily) transferred between bacteria ;
2 (bacteria of), same species / different species ;
3 bacteria can acquire antibiotic resistance / renders antibiotic useless / AW ; [2 max]

(ii) *mark for gene and mark for how product detected*
1 gene for β galactosidase ;
2 blue colour from X-gal medium ;
or
3 gene for β glucuronidase (GUS) ;
4 produces product that is easily stained blue ;
or
5 gene for, GFP / other fluorescent product ;
R fluorescent / fluorescence, gene
6 fluorescence detected when present ;
or
7 other gene ;
8 how detected ; [2 max]

[Total: 15]

Q22.

2 (a) *idea of* cross-pollination involves two (parents)/ self-pollination one (parent) ;

ref. outbreeding/ inbreeding ;

(two parents) have different, genotypes/sets of alleles ;

idea of new combinations of alleles in offspring ; [max 3]

(b) (total) DNA/ genome, cut into fragments ;

by restriction enzymes ;

DNA, denatured/ made single stranded ;

ref. primers/(modified) PCR ;

ref. dideoxynucleotides/chain termination ;

DNA/Taq, polymerase ;

copies of different lengths produced ;

electrophoresis ; **A** description

detection, of fluorescence/by laser scanner ;

sequence of, bases/nucleotides, read (by computer) ; [max 4]

(c) cross(-pollinate) them ; **A** description

(if same species) offspring, are fertile/can themselves produce seeds; **ora** [2]

[Total: 9]

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Q23.

3 (a) (i) idea of sugars unable to pass through phospholipid bilayer ;

hydrophilic/polar/not lipid-soluble/water soluble ;

large ; [max 2]

(ii) forms bonds with hydrophilic heads (of phospholipids) ;

hydrophobic parts of SWEET ;

bond with, fatty acid chains/hydrophobic tails, (of phospholipids) ;

ref. hydrogen bonding/ionic bonds/hydrophobic interactions ; [max 3]

(b) (i) (SWEET) gene cannot be switched on ;

no SWEET (protein) produced ;

no, glucose/sugar, secreted (into intercellular spaces) ;

(so) Xoo/bacteria, do not multiply/numbers remain low ;

(small numbers of Xoo/bacteria) so no disease ; [max 3]

(ii) allele is recessive ;

idea of not expressed when dominant allele present ;

ref. promoter ; e.g. normal promoter must be inactivated or removed/must transfer mutated promoter [max 2]

(iii) prevents diffusion of air (from leaves to roots) ;

ref. aerenchyma ;

roots respire anaerobically ;

(so) less ATP produced (for growth) ;

bacteria use of oxygen ;

more ethanol produced may be beyond tolerance/**AW** ; [max 4]

[Total:14]

Q24.

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3 (a) (i) *reverse transcriptase*: produces (c)DNA from mRNA ;

DNA polymerase: produces double stranded DNA from, single stranded (DNA)/cDNA ;

restriction enzyme: cuts, DNA/plasmid ;

DNA ligase: joins (gaps in) the sugar-phosphate backbone (of DNA) ; [4]

(ii) 1 causes blood glucose concentration, to decrease/return to normal (from high) ;

2 (target cells are) liver/muscle ;

3 increased, absorption of glucose (from blood)/ permeability of cell surface membrane to glucose ;

4 increased (rate of) respiration of glucose ;

5 *idea of* increased conversion of glucose to glycogen ;

6 inhibits secretion of glucagon/decreased gluconeogenesis ; [max 3]

(ii) 1 identical to that produced by body ;
2 activity the same/ fast response/no immune response ;

3 no need for animal insulin/AW ;
4 for religious reasons/for ethical reasons/for e.g. vegetarian ;

5 uncontaminated/pure ;
6 so no risk of disease ;

7 production very efficient/always available ;
8 extraction from animals, costly/complex/limited by supply of animals ; [max 2]

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(b) (i) *insulin* ***X*** ***ora*** *throughout for human insulin*

1 greater initial increase in activity / AW ;

2 time of maximum activity / peak, earlier ; [1.9h v. 3h]

3 maximum activity / peak, greater ; [9.4 v 5.4 (a.u.)]

4 rate of decrease greater ;

5 activity always higher ;

6 comparative figures ; [see above] [max 4]

(ii) 1 changes, tertiary / 3D structure ;

2 affects binding to receptor (on cell surface membrane) ;

3 (this) affects production of second messenger ;

4 hydrophilic / hydrophobic, bonds different ;

5 AVP ; e.g. may affect, solubility in blood / transport in blood / rate at which broken down [max 2]

[Total: 15]

Q25.

3 **(a) (i)** **X** – reverse transcriptase ; **R** RNA

Y – DNA polymerase ; [2]

(ii) 1. large number of copies of mRNA readily available ;

2. *idea of* mRNA is only from gene coding for insulin (being expressed) ;

3. easier than, extracting / locating, gene from cell's DNA ;

4. AVP ; e.g. introns already removed / bacteria cannot remove introns [max 2]

(b) 1 in yeast cells promoters already present ;

2 have RER / Golgi body ;

3 so, insulin can be modified / insulin is in correct 3D conformation ;

4 AVP ; e.g. *ref. to* YAC holding more DNA than BAC [max 2]

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(c) 1 it is identical to human insulin/exact fit to receptor (cell surface membranes) ;

2 (more) rapid response ;

3 no/fewer, rejection problems/side effects/allergic reactions/ immune response ;

4 *ref. to* ethical/moral/religious, issues ;

5 cheaper to produce in large volume/unlimited availability ; **R** cheap to produce

6 less risk of, transmitting disease/infection ;

7 good for people who have developed tolerance to animal insulin ; [max 3]

[Total: 9]

Q26.

1 **(a)** reduces genetic diversity;
alleles lost;
increases homozygosity/decreases heterozygosity;
accumulation of deleterious recessive alleles; **max 3**

(b) (i) 1430-1500; **1**

(ii) neither A nor B can self-pollinate;
stigma not receptive when own pollen released;
stigma not in appropriate position when own pollen released;
neither can be pollinated by another plant of the same phenotype;
because behaviour synchronous;
A pollinates B in morning and B pollinates A in afternoon; **max 4**

(c) (i) $\eta = 1$; **1**

(ii) probability = > 0.1; **1**

(iii) difference from expectation is not significant;
because > than 0.05/1 in 20;
ratio of phenotypes is 1 : 1;
observed difference due to chance; **max 2**

(iv) unambiguous symbols identified;
Aa;
aa;
[A correct answer based on co – dominant situation] **max 3**

Total: 15

Q27.

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2 (a) (i) thick/dehydrated, mucus builds up in lungs;
and gut;
bacterial infections in lungs;
scar/damage, lungs;
mucus blocks secretion of digestive enzymes (from pancreas)/
impaired digestion;
infertility; **max 3**

(ii) recessive allele;
autosomal/chromosome 7;
homozygote recessive = sufferer;
heterozygote = carrier;
correct statement re inheritance;
[e.g. 1 in 4 chance from 2 carrier parents] **max 3**

(iii) large number of different mutations;
each test specific;
DNA has different, code/base sequence;
probe binds to specific/complementary sequence; **max 2**

(b) (i) study of ion transport through cell membrane;
if no CFTR/protein (produced and put into cell membrane) then no transport; **2**

(ii) inability to transport HCO_3^-;
change in transport ratio;
transport ratio < 0.1 : 1.0;
increase in acidity/decrease in pH;
ref. effect on mucus; **max 3**

(iii) poor digestion of protein;
lipid;
starch;
malnutrition;
ref. to effect on production of, insulin/glucagon; **max 2**

Total: 15

SECTION-B

1.

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7 *(a) Describe the use of recombinant DNA technology in the synthesis of human insulin by bacteria [9]*

(b) Explain the advantages of treating diabetics with human insulin produced by genetic engineering [6]

1 mRNA coding for insulin/isolate gene for human insulin;

2 from beta cells of islets of Langerhans/pancreas;

3 reference to reverse transcriptase;

4 to cDNA;

5 reference PCR/DNA polymerase/double strand;

6 reference sticky ends/AW;

7 use of vector/virus/plasmid;

8 reference endonuclease/restriction enzymes;

9 to cut plasmid;

10 reference DNA ligase to join DNA;

11 inserted into suitable host cell/E.coli/bacteria;

12 reference method of insertion;

13 identification of modified bacteria;

14 reference growth/culture of engineered bacteria in fermenters; **9 max**

(b) 15 constant/reliable supply all year round/unlimited supply;

16 less risk of contamination/infection;

17 identical to insulin produced in the body;

18 less/no risk of allergic reaction;

19 does not stimulate the immune system;

20 fewer side effects;

21 can be produced without the killing of animals/ethical reason;

22 cheaper/easier to extract and purify;

23 more available/large amount;

24 more rapid response; **6 max**

Total 15

2.

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10 (a) 1. chance / random / spontaneous ;

2. change in, base / nucleotide, sequence (in DNA) ;

3. during DNA replication ;

4. base substitution ;

5. often no effect / silent mutation / may code for same amino acid ;

6. base addition / base deletion ;

7. have great effect on phenotype ;

8. frame shifts ;

9. alters whole sequence of bases after mutation ;

10. may lead to stop codon ;

11. different / new, allele ;

12. protein, different shape / different function / not made ; [max 9]

(b) 1. no / no functional, channels for Cl^- ions ;

2. Cl^- ions do not move out ;

3. less water leaves cell ;

4. mucus (on cell surface membrane) stays, thick / sticky ;

5. *symptoms – any **4** from:*
mucus not moved effectively by cilia / mucus accumulates ;

6. reduced gaseous exchange / longer diffusion pathway ;

7. difficulty in breathing ;

8. more infections / (mucus) traps bacteria ;

9. lungs are scarred ;

10. blocked sperm ducts ;

11. blocked pancreatic duct ; [max.6]

[Total: 15]

3.

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10 (a) 1. (CF caused by) mutation ;

2. of CFTR gene ;

3. (CFTR) protein defective ;

4. (so) insert, normal / dominant, (CFTR) allele ;

5. into DNA ; **A** chromosome

6. in cells of respiratory system ; **A** named part of airway **Ignore** alveoli

7. ref. to vector ;

8. taken as spray / inhaled ;

9. use liposomes ;

10. use harmless virus ;

11. not all cells take up virus ;

12. may have unpleasant side-effects ;

13. effects are short-lived / treatment needs repeating ; [max 8]

(b) *counsellor:*

1. ref. to pedigree analysis ;

2. ref. to genetic screening / DNA analysis ;

3. detail of genetic screening ; e.g. tissue samples from adults / IVF and test embryos/ amniocentesis

4. explains results of tests / estimates chances of having affected child ;

5. (may discuss) termination ;

6. (may discuss) alternative, therapies / treatments ;

7. (may discuss) financial implications (of having affected child) ;

8. (may discuss) the effect of having affected child on existing siblings ;

9. (may discuss) ethical issues ; *max 6*

couple referred if:

10. either has genetic disease (in family) or are carriers ;

11. history of recurrent miscarriages ;

12. older woman ; [max 7]

[Total: 15]

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