

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.

- (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.

- 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 cm³ ;
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]

- (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]

- 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.

- 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.

- 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.

- 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]

- (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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Page 8	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9700	42

- (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.

- 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); [max 2]
R ref. to larvae breeding
- (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;

- (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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Page 5	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9700	41

- (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.

- 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]

- (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.

- (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	possibility 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]

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]

- (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 because insulin conc. rises ;
this subsumes marking point 1
 3 glucose conc. falls lower because insulin conc. is higher ;
this subsumes marking point 1
 4 (later) glucose rises higher because 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 one time
 or
 one glucose conc. linked to an insulin conc. at one 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]**

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]**

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 / <i>E. coli</i> / <i>bacteria</i> ;	to obtain transformed host <i>E. coli</i> 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.

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.

- 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]

- (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]

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.

- 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]

- (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]

- (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.

- 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.

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.

- 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.

- 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]

