

1. (i) plasmid cut by restriction enzyme;
at specific sequence;
same enzyme as used to cut (insulin) gene;
sticky ends / described;
ref. complementary sticky ends;
ligase seals (sugar-phosphate) backbone / AW; max 4
- (ii) *credit any two from the following:*
- 1 antibiotic resistance (gene) introduced and survivors have plasmid;
 - 2 fluorescent marker (gene) introduced and glowing bacteria have plasmid;
 - 3 identify bacteria producing insulin using antibodies; 2
- [6]**
2. *referring to pig insulin:*
ethical / religious, reasons;
incompatibility / lack of tolerance / immune response; ora
not exactly the same as / less effective than, human insulin; ora
- referring to human insulin from bacteria:*
engineered insulin is cheaper; ora
greater supply of engineered insulin; ora 1
- [1]**
3. (i) **R questions**
embryo, potential human/member of society/right to life/killed/AW;
may be from abortion;
scientist making decision for use of embryo/consent may not be required;
parents may not know fate;
religious objection;
may involve cloning;
some stem cells can be obtained instead from umbilical cord;
AVP; 1 max
- (ii) treat/cure for, anaemia/sickle cell anaemia/named blood disease;
blood, for transfusion/to replace loss;
treat, immune disorders/SCID/lupus;
treat, non-Hodgkins lymphoma/some types of cancer/leukaemia;
treat/cure for, Alzheimer's disease;
treat/cure for, Parkinson's disease;
treat paraplegics/repair injury to, nerves/spinal cord;
treat, genetic disorders affecting nerves/Huntington's/Tay Sachs/Lou
Gehrig's;
treat multiple sclerosis/motor neurone disease;
AVP; eg. stroke/brain damage/retinal repair
AVP; *must be relevant to use of blood cells or neurones* 2 max
- [3]**

4. (i) endonuclease;
cuts DNA;
with sticky or blunt ends;
at, palindromic/AW/specific/4 to 6 base pair/restriction, site;
from bacteria;
for cutting 'phage DNA;

max 3

(ii) 2 sources DNA;
ref. sticky ends;
complementary binding;
H-bonds between bases;
A to T and C to G;
nicks in sugar-phosphate backbone sealed/AW;
by ligase;

max 4

[7]

5. (a) (i) two recessive alleles/homozygous recessive/two of allele 2;
no, normal dominant/allele 1;
homozygous same allele as affected child;

2

(ii) deletion removes base pairs;
shorter/lighter, pieces of DNA move further in electrophoresis;
towards anode;
so allele 2, shorter/lighter, than allele 1;

max 3

(b) 0.25/25%/1 in 4;

1

[6]

6. ***max 7 for the process of genetic engineering***
max 2 for the advantages

1 identify / find, gene (for insulin) / length of DNA coding for insulin;

2 obtain / isolate / extract,
gene / length of DNA (for insulin); obtain / isolate / extract,
mRNA (for insulin);

3 restriction enzyme / named e.g.; reverse transcriptase;

4 cut plasmid; cut plasmid;

5 use same restriction enzyme; use restriction enzyme / named e.g.;

- 6 ref to, complementary ends / sticky ends / described;
- 7 insert, gene / AW, into plasmid;
- 8 recombinant DNA;
- 9 plasmid uptake by bacteria;
- 10 identify those bacteria that have taken up the plasmid;
- 11 provide with, raw materials / nutrients;
- 12 fermenter / bioreactor;
- 13 bacteria produce insulin;
- 14 extract and purify / downstream processing;
- 15 AVP; e.g.. detail of uptake by bacteria
method of identifying those that took up plasmid
PCR
ligase 7 max
- 16 advantage 1; e.g. more reliable supply
- 17 advantage 2; greater / faster, production
overcomes ethical problem described
less risk of disease
less risk of, rejection / side effects
human insulin so more effective 8 max

QWC – clear, well organised using specialist terms;

award QWC mark if four of the following are used

1

gene	plasmid
restriction enzyme	complementary
named e.g. of a restriction enzyme	sticky end
reverse transcriptase	recombinant DNA
fermenter / bioreactor	

[9]

7. (i) 4 - 6 base pairs;
palindromic / AW;
specific sequence; max 2
- (ii) yes, same sticky ends / sticky ends shown; GATC / CTAG
complementary (bases);
hydrogen bond;
A with T;
C with G; max 3

(iii) two correct cuts;

G | A T T C A G A A T T T C G | A A T C
 C T A A | G T C T T A A A G C T T A | G

1

[6]

8. 1 restriction enzyme to cut gene from genome;
 2 and, plasmid / artificial chromosome / DNA of vector;
 3 same restriction enzyme;
 4 if cut with sticky ends then join;
 5 if cut with blunt ends then, sticky ends / nucleotides, added; **R** bases
 6 with C bases one end and G bases other;
 7 requires terminal transferase;
 8 (DNA) ligase needed to seal nicks in DNA backbone;
 9 ref to join phosphate - sugar / adds phosphate;
 10 DNA may be produced by reverse transcriptase;
 11 from mRNA;
 12 single strand made double stranded by DNA polymerase;
 13 wanted DNA replicated by polymerase chain reaction (PCR);
 14 using, DNA polymerase with high optimum temperature / *Taq* polymerase;
 15 AVP;

max 8

QWC - clear, well-organised answer using specialist terms;

1

award QWC mark if three of the following are used

endonuclease
 terminal transferase
 reverse transcriptase
 (DNA) ligase
 DNA polymerase
 PCR
 correct use of nucleotide and base
 sticky ends
 blunt ends

[9]

9. insulin is, polypeptide / protein;
 (promoter), switches on transcription *or* makes gene produce, mRNA /
 insulin;
 as blood glucose rises insulin production increases;
 ref to figures with units;
 only produced when needed;
 ref to, homeostasis / negative feedback;

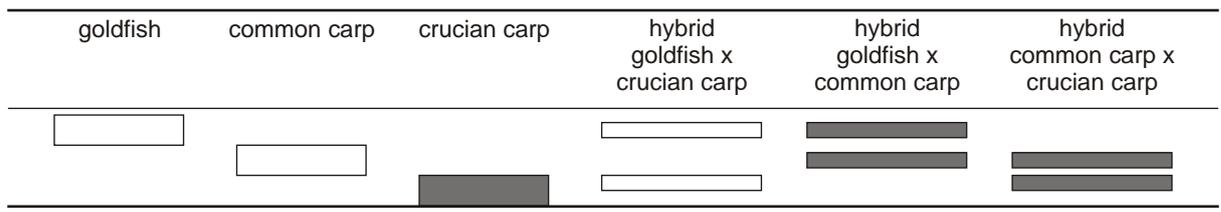
max 3

[3]

10. *benefits*
 avoids injections / pain of injections / children's fear of injections;
 mimics normal pancreatic behaviour;
 more stable homeostasis / reduced highs and lows in blood sugar;
 less chance, hypoglycaemia / hyperglycaemia;
 less restriction on lifestyle;
 no need to measure blood sugar;
 AVP; max 3
- problems*
 rejection;
 cells could lodge elsewhere;
 may take longer to act;
 AVP; e.g. rat data may not be applicable to humans,
 transgene may have unforeseen effect max 3 max 4
- [4]**
11. humans are eukaryotes / *Escherichia coli* is a prokaryote;
humans / eukaryotes have (accept ora)
 larger, proteins / genes;
 introns;
 'junk' DNA / non-coding DNA;
 repeating sequences;
 centromeres / telomeres;
 fossil genes;
E. coli cell much smaller; *ora*
 selection for, less waste of space / more compact genome; 2 max
- [2]**
12. (i) restriction (enzyme) / endonuclease; **A** named e.g. 1
 (ii) (DNA) ligase; 1
- [2]**

13. (a)
- 1 gene bank ;
 - 2 ref to wild type ;
 - 3 maintain genetic diversity ;
 - 4 ref to, loss of alleles / genetic erosion ;
 - 5 may have appropriate trait for breeding ;
 - 6 for future use ;
 - 7 requirements of breeders change ;
 - 8 in case, climate change / different conditions ;
 - 9 ref to, temperature / global warming ;
 - 10 ref to, pH tolerance / acid rain ;
 - 11 as yet unknown traits may be useful ;
 - 12 in case other named change ;
 - 13 may lose trait if interbred ;
 - 14 may form part of, food web / community ;
 - 15 that cannot be replaced ;
 - 16 adapted for, habitat / niche ;
 - 17 hybrids less well adapted ;
 - 18 ref to extinction ;
 - 19 AVP ; e.g. need to maintain population for leisure fishing
 - 20 AVP ;
- 8 max
- QWC – legible text with accurate spelling, punctuation and grammar;**
- 1

- (b) (i) enzyme from bacterium ;
 break down DNA of invading (bacterio)phages ;
 ref to specific site of DNA ;
 detail of site (4 - 6 bp / palindromic) ;
 cut DNA ;
 leaving blunt ends ;
 or sticky ends ;
- 3 max
- (ii) *crucian carp* 1 (thick) band in correct position (*see diagram*) ;
hybrid goldfish x common carp 2 (thin) bands in correct position ;
hybrid common carp x crucian carp 2 (thin) bands in correct position ;
- 3



14. (a) mRNA and its complementary RNA bind together ;
hydrogen bonding ;
A to U and C to G ; **R** 'T'
double stranded RNA / duplex RNA ;
cannot bind to ribosome ;
tRNA cannot bind ;
cannot be translated / AW ;
ref to, RNA interference / RNAi ; 4 max
- (b) (i) theobromine content, reduced / approximately halved ;
no significant difference between short and long lengths of RNA ;
caffeine content reduced ;
to half by short lengths of RNA ; **A** figures
to about a third by long lengths of RNA ; **A** figures 3 max
- (ii) (re caffeine) greater chance of pairing longer length with mRNA ;
AVP ; 1
- (iii) explant of meristematic / cambium / totipotent / pluripotent, cells
/ tissue ;
explant (surface) sterilised / sterile nutrient ;
appropriate hormone to stimulate, mitosis / division ;
callus formed ;
subdivided ;
appropriate hormone to stimulate differentiation ;
plantlet formed ;
hardening medium / sterile soil 4 max
- (iv) genetically identical ;
genotype does not affect result ;
easily genetically engineered ;
plants derived from it identically genetically engineered / AW ;
large numbers easily obtained ;
early stages compact ; 3 max
so easily kept in identical conditions ;
15. (a) rDNA = DNA from two sources ;
both DNAs cut with, restriction enzyme / named restriction enzyme ;
giving sticky ends ;
or giving blunt ends to which sticky ends added ;
complementary binding of sticky ends ;
H bonds / e.g. A to T / e.g. C to G ;
nicks in (sugar-phosphate) backbone sealed by ligase ; 3 max

[15]

- (b) percentage / proportion, of, muscle fibres with central nuclei / dying muscle fibres, increases in control with time ;
percentage / proportion, of, muscle fibres with central nuclei / dying muscle fibres, reduced by treatment ;
ref to comparative figures with percentages and day ; 3

(c) *advantages*

- 1 can identify presence of disorder ;
- 2 removes uncertainty ;
- 3 allows early treatment ;
- 4 which may improve, life expectancy / quality of life ; **A** avoid unnecessary suffering
- 5 allows, informed choice about having children / planning healthy family ;
- 6 allows IVF and, embryo screening / preimplantation genetic diagnosis (PGD) ;
- 7 allows fetal testing and termination ;
- 8 choice, re donation / adoption ;
- 9 AVP ; e.g. detail of donation: AI(D) / egg donation / embryo donation

maximum 5 on advantages

disadvantages

- 10 false, positives / negatives ;
- 11 may not be test for all mutations ;
- 12 only small number tests available / not available for all conditions ;
- 13 simple presence may not result in condition ;
- 14 confirmed presence gives stress / fear ;
- 15 problem *re*, telling / testing, rest of family ;
- 16 discrimination by, employers / insurers ;
- 17 ethics of termination ;
- 18 AVP ; e.g. detail of problem of test, risk of test procedure, diagnosis and elimination rather than treatment, increase in, intolerance / discrimination, of disabled, 'designer' problem

maximum 5 on disadvantages

8 max

QWC – clear well organised using specialist terms;

1

must include both advantages and disadvantages and two terms

such as

life expectancy, quality of life,
IVF, PGD, PGH, AI(D),
amniocentesis,
CVS, karyotype,
false positive, false negative

[15]

16. *answers referring to insulin production can also be credited in mp 2,3,4*
- 1 *Escherichia coli* ; **A** *E. coli*
- genetic engineering* 3 max
- 2 amino acid sequence (of HGH), known / analysed ;
- 3 gene coding for HGH synthesised ;
- 4 using, triplet code / genetic code ;
- OR*
- 5 mRNA (coding for insulin) from beta cells ;
- 6 use reverse transcriptase ;
- 7 synthesise cDNA ;
- 5 plasmid (vector) ;
- 6 cut using restriction (endonuclease) enzyme ;
- 7 ref to gene and plasmid mixed with (DNA) ligase ;
- 8 (recombinant) plasmid introduced into, bacterium / bacteria ; **AW**
- large scale production* 4 max
- 9 genetically engineered / recombinant bacteria ;
- 10 grown in fermenter / fermentation, qualified ;
- 11 reproduce / replicate / multiply / undergo binary fission / form a clone
/ large numbers / millions of bacteria / gene cloning ;
- 12 idea of gene expression / transcription and translation, for HGH,
synthesis / production ; **A** *insulin when relevant*
- 13 downstream processing ;
- 14 separation / purification, of growth hormone ; **A** *insulin when relevant*
- 15 AVP ; e.g. ref to screening using antibiotic resistance markers
- 16 AVP ; scaling up to determine optimum operating conditions
bacteria killed and separated (from proteins)
by centrifugation
growth hormone separated from other, proteins / molecules
(product separated by) large scale chromatography / ultrafiltration
other detail of fermentation e.g. pH 5.5 – 8.0, temperature
20 – 45 °C, aeration, glucose
doubling time 20 minutes 6 max
- QWC – clear, well organised with specialist terms ;** 1
- any three, used in context, from*
amino acid sequence (beta cells for insulin) / triplet (mRNA for insulin) /
genetic code (reverse transcriptase for insulin), plasmid, vector, restriction
enzyme, ligase, recombinant, genetically engineered, binary fission, clone,
transcription, translation, downstream processing, screening, antibiotic
resistance markers, centrifugation

17. (a) *plasmid DNA* *protein*
- | | | |
|--|---|-------|
| nucleotides / sugar + phosphate + base ;
4 different subunits ;
phosphodiester bonds ; A phosphoester
contains P ;
double-stranded / double helix ;
circular ;

AVP ; e.g. role of H bonds | amino acids ;
20 different subunits ;
peptide bonds / polypeptide ;
contains S / disulphide bonds ;
may have 4 ^o structure ;
ref to, 2 ^o / 3 ^o , structure / AW ; | 3 max |
|--|---|-------|
- (b) (i) stimulates, immune response / production of antibodies / T or B cells ; 1
- (ii) stimulate, cell-mediated immunity / T cells ;
 antigen, remains in body longer / continuously produced ;
 antigens in blood only stimulate, humoral immune system / B cells ;
 antigens (in blood) lost in urine / broken down in liver ;
 ref to MHC ; 1 max
- (c) (i) binds RNA polymerase ;
 allows, transcription / production of mRNA ;
 switches gene on / allows gene expression ; 2 max
- (ii) (protect against) more than one, strain / disease / pathogen / AW ;
 stronger immune response ;
 less likely mutant form will escape immune response / AW ;
 AVP ; cheaper / reduces number of vaccinations 2 max
- (iii) Golgi modifies protein / polypeptide / AW ;
 forms glycoproteins / add sugars *or* carbohydrate ;
 Golgi forms vesicles ;
 incorporated into cell membrane ; **R** exocytosis
 AVP ; 2 max
- (d) *cells that take up DNA vaccine might*
- 1 function less well ;
 - 2 be killed by immune system / trigger auto-immune response ;
 - 3 have genes disrupted / mutation ;
 - 4 new gene might be inherited / AW ;
 - 5 plasmid could enter bacteria ;
 - 6 superbug / create new disease / AW ;
 - 7 effects unknown / new technology / no human trials ;
 - 8 AVP ; ref ethics, ref irreversible 3 max

18. increase in use of, GM crop / GE crop / Bt cotton;
no / less, insecticide needed;
reduced number of cases of pesticide poisoning;
ref to figures (e.g. by $\times 4.4$);
reduced cost (insecticide);
ref to figures (e.g. by $0.62 \text{ US\$ kg}^{-1} / \times 1.38$);
ref to limitations of survey;
AVP;
A reverse arguments max 4 [4]
19. (i) ref to, rDNA / recombinant DNA;
restriction enzyme(s);
cut DNA at specific site(s);
detail site(s);
ref to viral DNA and, human DNA / DNA of gene;
ref to sticky ends;
complementary binding;
detail of binding; $A = T / C \equiv G$ / hydrogen bonds
ligase to seal 'nicks' in (sugar-phosphate) backbone; max 4
- (ii) has effect when added to genome;
not masked;
no need to, remove / inactivate, recessive / mutant, allele; max 2 [6]
20. cheaper;
ref to compatibility / less chance of rejection / fewer side effects;
stated ethical issue; e.g. don't need to kill animals / removes religious objections
ref to contamination / easier to purify / ref to disease;
consistent quality;
more effective (as human in origin);
production level can meet demand / reliability of supply / faster production;
ignore greater production 2 max [2]

21. (i) restriction (enzyme) / endonuclease; 1
- (ii) *this may be answered in the context of inserting into a plasmid.*
 cut DNA with restriction enzyme;
 ref to sticky ends;
complementary;
 base pairs / CCC and GGG / C pairing with G / alternative;
 (DNA) ligase / ligation;
 ref to bonding / AW; e.g. hydrogen *or* phosphodiester / sugar-phosphate
 AVP; e.g. add sticky ends to blunt ends
 cut both at the same place 3 max
- (iii) codes for, protein / polypeptide / enzyme;
 A ref to, protein synthesis / transcription / translation
 (enzyme) catalyses / causes, condensation / formation of glycosidic
 bonds / reaction (between, mannose / sugars); 2
22. 1 genetic, testing / screening;
 2 for inherited disease / AW;
 3 (test to see if) individual is carrier;
 4 premarital testing / predict if (potential) offspring may inherit the disease;
 5 antenatal testing;
 6 ref to termination;
 7 embryo selection (to ensure embryo healthy); **R** selection of sex
 8 (test for genes that contribute to) diseases that develop later in life;
 9 those with genes given, advice to limit effects / counselling;
 10 faster / earlier, diagnosis;
 11 develop more, effective / efficient, drugs (to combat disease);
 12 drugs have direct effect, on genes / protein made from specific gene code;
 13 gene therapy / correct the base sequence of faulty gene;
 14 economic implications / AW;
 15 AVP; e.g. ref. to method used / use of gene probes / biopsy
 16 AVP; allows targeting of drug treatment 4 max

[6]

[4]

23. anxiety about (future) health / may not want to know / AW;
 many diseases we can test for have no treatments;
 discrimination by employers;
 discrimination by, insurance companies / banks;
 reliability of tests in question; **A** false, positive / negative, result
 example of disease given in context;
 cost to, NHS / government;
 rich people can benefit / poor will not benefit;
 AVP;; e.g. moral issues associated with embryo selection
 eugenics
 parents feelings towards child
 presence of allele may not cause disease / ref to multifactorial
 diseases
 ref to storage of data and freedom of information / invasion
 of privacy / question of paternity

R 'playing God' / cloning

4 max

[4]

24. (a) **1** prevent, self-pollination / unwanted pollination, of flowers;
2 detail of prevention;
3 cross-pollinate two varieties; **A** crossed / mated / hybridised
4 detail pollination;
5 isolate, plants / flowers;
6 collect seeds and sow;
7 in high salt concentration;
8 select plants, which survive / can tolerate, high concentration;
9 and have large, tasty tomatoes;
10 interbreed these plants;
11 repeat selection;
12 ref many generations;
13 cross with variety with large tomatoes to improve size;
14 cross with variety with good flavour to improve taste;
15 ref backcrossing with original variety for salt tolerance;
16 AVP;
17 AVP;

max 8

e.g. ref background genes / hybrid vigour / heritability /
 effect on vigour / ref setting up pure-breeding initial lines

**QWC – legible text with accurate spelling, punctuation
 and grammar;**

1

- (b) (i) active transport;
(energy from), ATP / respiration;
against concentration gradient;
ref binding site for ion / AW;
ref change of shape of protein; max 3
- (ii) GE quick(er) / SB slow(er);
(tolerance) in one generation (v. many generations);
ref one gene / rest of genome unaltered (v. hybridisation);
background genes intact (v. need for backcrossing);
different varieties engineered for different conditions;
no problem re interbreeding;
can select, transporter system / AW, / from, another species
/ named taxon;
can select, transporter system / AW, / for maximum efficiency;
AVP; max 3
- [15]
25. (i) DNA from two different sources;
combined / joined / AW; 2
- (ii) restriction enzymes cut DNA;
at specific sites;
detail of sites;
may give sticky ends;
complementary sticky ends join;
terminal transferase / enzyme, adds sticky ends;
ligase joins, gaps / nicks; max 3
- [5]
26. (i) fewer genetically engineered mosquitoes pass parasites across midgut
; **A** figures
fewer g e mosquitoes have parasites in salivary glands; **A** figures
fewer g e mosquitoes can infect (uninfected) mice; **A** figures
'less good as vectors' instead of all of first three points = 1 only
use of comparative figures; max 3
- (ii) *benefit* one of following;
reduce use of, insecticide / drug
safer than, insecticide / drug
AVP max 1
- hazard* one of following;
parasite may develop resistance
gene may pass to other species
AVP max 1
- [5]

27. AATCCC / adenine adenine thymine cytosine cytosine cytosine; (first 6)

[1]

28. can fix nitrogen;
does not deplete soil nitrogen / improves nitrogen content of soil (over time);
allows cultivation of poor soil;
reduces use of fertilisers;
higher yield;
AVP; e.g. reduce contamination of environment by fertilisers
qualified cost ref.
ref. leaching of nitrate

2 max

[2]