<table>
<thead>
<tr>
<th>MARK SCHEME</th>
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<tbody>
<tr>
<td>MAXIMUM MARK: 40</td>
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<tr>
<td>SYLLABUS/COMPONENT: 9700/01</td>
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<tr>
<td>BIOLOGY</td>
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<tr>
<td>Paper 1 (Multiple Choice)</td>
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<tr>
<td>Question Number</td>
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TOTAL 40
KEY

a semi colon ; indicates a separation of marking points

an oblique line / indicates alternative wording or acceptable alternative

R means reject

A means accept

AW means 'alternative wording'

underlined with a straight line accept this word only, no alternative word is acceptable

D represents quality mark(s) awarded for diagrams, as indicated on the Mark Scheme

L represents mark(s) awarded for labels on diagrams, as indicated on the Mark Scheme

Q represents quality of expression and is used for marks awarded on free-response questions
2 (a) Award one mark per column. No penalisation for complete lack of all crosses (or all ticks) unless mixture of x and ✓ missing as agreed

<table>
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<tr>
<th>statement</th>
<th>emphysema</th>
<th>tuberculosis</th>
<th>obesity</th>
<th>rickets</th>
<th>smallpox</th>
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<td>eliminated by vaccination</td>
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<td>✓</td>
<td>✓ or x</td>
<td>x</td>
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[Total 5]
3 (a) Correct letter order on Question Paper:

A - nucleus;
C - mitochondria; B - RER;
D - Golgi apparatus;
E - cell surface membrane;

R. process statements instead of letters

(b) secrete/release/produce/make antibodies;
A. immunoglobulins
R. memory cells unless linked to antibody production

(c) nucleus/nuclear envelope/nuclear membranes/nucleolus;
no cell wall;
have organelles/named visible organelles; (golgi/mitochondrion/ RER) R. more organelles
larger (cell);
fixed ribosomes/ribosomes attached to E.R./no free ribosomes;

[Total 7]

4 (a) (i) shade in xylem; (complete xylem star must be shaded)

(ii) shade in phloem; (A. shading of just one phloem group)

(b) ref to bending/provide support/strength; R. lignin unqualified
R. prevents collapsing

(c) osmosis/diffusion;
down water potential gradient/from high/less negative to low/more negative water potential/AW; (R. osmotic potential/conc. gradients/ less or more) through partially/selectively/differentially permeable membrane; R. semi-permeable

(d) transpiration pull/cohesion-tension/cohesion-adhesion/
mass flow in xylem;
into spongy mesophyll (cells);
many cell walls/surfaces/large surface area; evaporation of water (from damp walls); into (substomatal/intercellular) air spaces; diffusion of water vapour/water as a gas/described; (e.g. movement of water vapour from high to low conc.) through stomata/cuticle (to air/ atmosphere);

(ignore ref. to apoplast, symplast, vacuolar pathways)

[Total 9]
5 (a) (i) haem; R. incorrect spelling combines/binds with/carries/holds/takes up/transports oxygen; 2

(ii) soluble/polar/hydrophobic (on outside)/compact/spherical/curled/coiled/folded (into a ball)/metabolically active;
. 4 polypeptides; 2

(b) iron needed for haem/haem contains iron;
less haemoglobin (made); R. less RBCs
less oxygen transported/supplied/delivered (to cells/tissues);
less respiration/respiration rate decreased;
R.respiration less efficient/effective  max 3

(c) muscle; A. cardiac/skeletal/involuntary muscle 1
R. named muscle, e.g. biceps muscle

(d) (i) 90%; 25%; A. within range 23-25% R. 23-26%, 22-25%
(N.B. Both % need to be correct for one mark) 1

(ii) haemoglobin unloads/releases oxygen/dissociates,
easily/readily/at higher ppO\textsubscript{2} (in tissues/cells);
(whilst) myoglobin holds on to oxygen/is very stable/does not dissociate easily/has a higher affinity for oxygen;
(so) providing a store/reservoir/reserve of oxygen;
(so will not) release oxygen until the pp/conc./tension of oxygen is low/during strenuous exercise;
so delaying anaerobic respiration; max 3

(e) S-shaped curve to the right of H;
(N.B. curve should be S-shaped, start at 0, plateau out at between 90-98% saturation, show 50% plus saturation at pp of 6kpa) 1

[Total 13]

6 (a) Two correct letters required for a mark for each column if list given; mark first 2 letters.

<table>
<thead>
<tr>
<th>Alcohol</th>
<th>Caffeine</th>
<th>Nicotine</th>
<th>Heroin</th>
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</tbody>
</table>
(b) decrease in response to drug/effect of drug becomes less (intense);
decrease in sensitivity of receptors/more receptors are made;
drug is metabolised/becomes part of body’s metabolism; more drug necessary to achieve the same effect/sensation/euphoria; max 2

(c) award marks from any annotated diagrams
Either
inhibitor fits site other than active site/allosteric site; tertiary/3D structure or shape changes/any two bonds mentioned break;
(ionic, van der Waals, hydrophobic, hydrogen, disulphide, covalent)
active site changes shape;
substrate no longer fits/binds/active site no longer complementary to substrate/E.S. complex not formed;
or
inhibitor fits permanently/irreversibly into active site;
substrate can no longer bind/substrate blocked/no E.S. complex formed;
increasing substrate has no effect; max 3

Either mark scheme as appropriate – do not mix marking points from both mark schemes

[Total 9]

Total mark for paper = 50
<table>
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<tr>
<td>Question</td>
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</table>
(b) 4 from:
Procedure explained;
Random sample;
Repeat 3 or more times;
Calculate means;
Ratio calculated between 1:4 and 1:20; Max 4

(10)

Paper Total 25
1 (a) top half of leaf/just below (upper) epidermis; packed (densely); long axis in line with incident light/AW; 2 max

(b) contain large numbers of chloroplasts/large amount of chlorophyll; large vacuole; (only give if linked to next point) chloroplasts (in cytoplasm) close to cell wall/cell membrane; short diffusion pathway; (cell) elongated/arranged to intercept (maximum) light; thin (cell) wall; ref. movement of chloroplasts; 3 max

(c) contains photosystems/PS1 and PS2/chlorophyll and accessory pigments/ reaction centres; maintain carriers/receptors in position; site of photophosphorylation/light reaction; site of ETC; ref. proton pumping/proton gradient; large surface area; produce ATP/ref. ATP synthase; produce reduced NADP; 4 max

(d) ref. to Rubisco; carbon dioxide combines with RuBP; driven/powered by ATP; and reduced NADP; forms PGA; 2 max

Total: 11

2 (a) provides energy; suitable examples; e.g. muscle contraction, protein synthesis, DNA replication, cell movement, active transport 3

(b) substrate level phosphorylation cytoplasm (in glycolysis); oxidative phosphorylation matrix of mitochondria (in Krebs cycle); inner membrane of mitochondria/cristae; 2 max

(c) oxidative phosphorylation more than substrate level phosphorylation; ref. to quantity, e.g. 32/34 vs. 4/6 per glucose; 2
(d) requires proton gradient produced by ETC; with no oxygen ETC does not occur/no electron flow; NAD cannot be reformed/NADH cannot be oxidised; oxygen combines with electron/proton/oxygen final acceptor in ETC; 3 max

Total: 10

3 (a) A vesicles containing transmitter/acetylcholine/synaptic vesicle; B presynaptic membrane; C synaptic cleft/gap; D post synaptic membrane; E receptor/protein/Na\(^+\) gate;

(b) arrow pointing down; 5

(c) ref. low Ca\(^{2+}\) in synaptic knob/high Ca\(^{2+}\) outside knob; action potential/depolarization causes opening of Ca\(^{2+}\) channels; Ca\(^{2+}\) into synaptic knob; causes vesicles to move towards presynaptic membrane; causes vesicles to fuse with presynaptic membrane; vesicle contents/transmitter/exocytosis into synaptic cleft/gap; 3 max

Total: 9

4 (a) metaphase; II; (allow one mark for telophase and two marks for telophase 1) 2

(b) ref. spindles/microtubules shorten contract/pull/breakdown; centromeres divide; chromatids (pulled) apart; to opposite poles; chromosomes unwind/AW; nuclear membrane reforms; ref. cytokinesis/cleavage; 4 max

(c) independent/random assortment; of homologous chromosomes; different combinations of parental chromosomes; crossing over/chiasmata; between chromatids of homologous chromosomes/non-sister chromatids; breaks up linkage groups/mixes alleles from parents; R genes ref. to non-identical/genetically different gametes; 4 max

Total: 10
5 (a)  phenotype is the feature/characteristic;  
results from interaction of genotype and environment on organism/  
environment may alter the appearance of an organism;  
genotype unaffected by environment;  
genetic characteristics inherited/passed on to offspring/ora/represents alleles  
possessed;  

2 max

(b)  artificial selection carried out by humans;  
choose organisms with useful characteristics/benefit to humans;  
natural selection carried out by environment;  
ref. survival (to breed);  
ref. evolution;  

3 max

(c) (i)  length of DNA/sequence of bases/locus on a chromosome;  
coding for a characteristic/protein/polypeptide/enzyme;  

2

(ii)  alternative form of a gene;  
determining contrasting characters/controls one form of a character;  
occupies same locus;  
ref. sequence of bases;  
ref. dominance;  

3 max

Total: 10
1 (a) (i) F1 does not change/∞; F2 changes quickest/F3 2nd to change; 1

(ii) Blue; 1

(iii) F1 renal vein (plasma); F2 urine; F3 renal artery (plasma); 1 mark for each correct explanation, i.e.
F1 urea removed by kidney; 1
F2 high concentration of urea; 1
F3 low concentration of urea; 1

ENSURE ecf from (a) (i) 3 = 2  2 = 1

(b) Two from:
start all three at same time;
replication;
means of more precise pH measurement 1 mark 1 mark 1 mark

(10)

2 (a) 2 cells only drawn;
columnar;
cells tapering;
brush border drawn by single line;
large nuclei almost cell width;
3 correct labels from
brush border; nucleus; nuclear membrane; cell membrane;
cytoplasm;  max 1 1 mark

(b) Both circular/oval/angular/NOT columnar;
circular nucleus;
Nucleus proportionately smaller than (a);
Clear unbroken lines;
3 correct labels from:
nucleus; nuclear membrane;
chondrocyte; lacuna; intercellular matrix; cytoplasm; cell membrane;
max 1 1 mark

Max 4 3 correct labels = 1 mark

Max 4 3 correct labels = 1 mark
(c) Two from:
brush border: no brush border;
columnar: angular or circular;
nucleus oval: circular;
cells side by side: cells scattered;
no matrix: cells separated by matrix;  Max 2

(10)

3(a) Three from:
Ref to fan;
Ref to support;
Ref to under water;
Ref to acclimatisation;
Clip closed;
Capillary tube contains water;
Tight fit/no leaks;  Max 3

(b) Two from:
Light;
Temperature;
Humidity;  Max 2

(c) Three from:
Time measured;
Scale read;
Alter fan speed/change fan distance;
Replication;
Measure leaf area;
Ref to reset apparatus qualified;
Equilibrate if not given in (b);  Max 3

(d) \( \pi r^2 h = 2 \) marks;
Or length X;  1
Area of capillary;  1

(10)

Paper Total 30
Option 1 – Biodiversity

1 (a) (existence of many) different species; with (a wide range of) different, genes/alleles; (many) different, habitats/ecosystems; max 2

(b) has a very high, species diversity/biodiversity; is being lost rapidly; may be a carbon sink/ref. to global warming; loss may affect rainfall patterns; loss may affect, soil erosion/flooding; max 3

(c) (i) more variety of plants in system A than (B, C or) D; ref. to different levels of vegetation in original forest (canopy, understory); therefore greater variety of habitats for birds; greater variety of food sources for birds; ref. pesticides; max 2

(ii) more coffee trees grown in a (unit) area; no competition with other trees; better availability of light; loss of habitats for pests; increased use of fertilisers; increased use of pesticides; max 2

(iii) populations of pests (on coffee trees) can become very high in D; plentiful food source for them; fewer bird species to predate them/fewer predators; max 2

(d) nitrogen fixation; bacterial/Rhizobium/root nodules, provide nitrate/ammonium; 2

(e) pay premium for coffee grown, in system A/in sustainable way; provide, grants/subsidies, to coffee farmers to use system A; encourage/educate/inform, consumers to encourage them to buy coffee grown in system A; find uses for the non-coffee trees in system A; max 2

[Total 15]

2 (a) A operculum; B gill bar; 2

(b) (each gill arch has) many (gill) filaments; each filament has many (gill) lamellae; which provides large surface area; distance between water and blood very small; filaments interlocked/packed closely, to slow water flow; max 3

(c) counter-current; partial pressure/concentration, of oxygen in blood always lower than in water next to it or always a diffusion gradient between water and blood; water progressively loses oxygen as it passes through the gills;
if both flowed in the same direction then blood could only become as saturated as outflowing water; this arrangement takes more oxygen from the water; increases length/surface area over which exchange occurs; max 3

(d) (i) volume of, buccal cavity/mouth, increased; by lowering, jaw/floor of mouth; while operculum is closed; this reduces pressure (below that of surrounding water) so water flows in; mouth closed and, jaw/floor of mouth, raised; increases pressure in mouth; operculum open; so water pushed out through the gills; max 4

(ii) as swimming speed increases, rate of pumping increases; because more oxygen required; for (aerobic) respiration in (swimming) muscles; rate of pumping, decreases/remains constant, between 0.4 and 0.6 ms\(^{-1}\); stops completely at 0.75 ms\(^{-1}\)/just before 0.8 ms\(^{-1}\); because (only) ram ventilation used now/water flowing over gills as a result of swimming; max 3

[Total 15]

3 (a) (i) named virus + appropriate structure for it; (core of) RNA/DNA/nucleic acid; surrounded by, capsid/capsomeres; (capsid contains) protein; size between 10nm to 300nm; detail for named virus; for example
\(T_2\) – tail fibres/baseplate/other
HIV – reverse transcriptase
herpes – envelope/lipoprotein covering

(ii) \((e.g. \text{ bacteriophage, adenovirus})\)
1 cell recognition/interaction between viral protein and component of host cell membrane;
2 virus/nucleic acid/DNA, enters cell;
3 normal cell activities stopped;
4 host cell DNA broken down (by viral enzymes);
5 viral DNA used, for transcription/to form mRNA;
6 viral proteins made;
7 viral DNA replicates;
8 new viruses assembled;
9 viruses burst from cell/cell lysis;
(e.g. HIV, other retrovirus)
1 cell recognition/interaction between viral protein and component of host cell membrane;
2 RNA and reverse transcriptase enter cell;
3 viral DNA made using viral RNA as template;
4 viral DNA incorporated into host DNA;
5 viral DNA used, for transcription/to form mRNA;
6 viral proteins made;
7 viral DNA used to produce RNA component of virus;
8 new viruses assembled;
9 viruses burst from cell/cell lysis;  

max 7

(iii) virus acellular/bacterium is a cell;
virus, has no cell surface membrane or may have envelope/bacterium (always) has cell surface membrane;
virus has no cell wall/bacterium does;
virus is (much) smaller than bacterium;
virus has either DNA or RNA/bacterium has both;
viral, DNA/RNA, may be single stranded or is linear/bacterial DNA is double-stranded or circular;
virus has no ribosomes/bacterium does;
virus does not, respire/feed/grow/excrete/have metabolic reactions, (while outside host cell);
virus can only reproduce inside host cell;  

max 7

[Total 20]

(b) (i) Absence of features can be implied
chordates have notochord (at some stage), arthropods do not;
chordates have, gill/pharyngeal, slits (at some stage), arthropods do not;
chordates have hollow nerve cord, arthropods have solid nerve cord;
chordates have dorsal nerve cord, arthropods have ventral nerve cord;
chordates have closed blood system, arthropods have, open system/haemocoel;
chordates have endoskeleton, arthropods have exoskeleton;
chordates have postanal tail, arthropods do not;

max 6

(ii) three body layers;
ectoderm on outside, mesoderm, endoderm on inside;
coelom is cavity; within mesoderm;
somatic mesoderm on outside and splanchnic mesoderm inside;
coelom is filled with fluid;
coelom is lined by peritoneum (in vertebrates);
mesentery connects, peritoneum/the two layers of mesoderm;  

max 7
(iii) isolates muscles of gut from muscles of body wall; which provides advantages in, locomotion/digestion; provides space for development of organs; example; (not heart or lungs) can provide specialised cavities (such as pleural/pericardial/abdominal); within which fluid composition can be regulated; (fluid within coelom) can act as a hydrostatic skeleton; by providing incompressible material against which muscles can act; detail of role of coelom in annelid locomotion; (fluid within it) can be used as a transport system; fluid moved by cilia; provides fluid for excretion (of metabolic waste); (in e.g. annelids) provides a site for gamete maturation; and for embryo development; max 7

[Total 20]
Option 2 – Biotechnology

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/potential/perceived risks/hazards/named risk/hazard;
AVP. max 2

[15]
2 (a) (i) stimulates immune system;
without causing (severe) infection;
made from, killed organisms/fragments of organisms;
made from, weakened/attenuated organism;
with antigens; \hspace{5cm} \text{max 3}

(ii) attenuated/weakened organism can survive attenuation/still have
ability to cause disease;
or regain pathogenicity/regain ability to cause disease;
very rare/AW;
ref. allergy to vaccine/hypersensitivity;
ref. side effects;
named side effect linked to appropriate vaccine;
chance of serious injury or death;
but chance of dying of disease much greater; \hspace{5cm} \text{max 4}

(iii) virus grown in living cells;
e.g. animal/named animal/hen embryo;
attenuated/weakened;
by, treatment with chemicals/high temperatures/alien conditions for
growth/AW;
subcultured many times/AW;
ref. harvest;
ref. purification; \hspace{5cm} \text{max 4}

(b) (i) vaccination/immunisation;
for (almost) all children;
detail (e.g. type of vaccine/introduced before 1980);

OR

better treatment;
details (e.g. isolation/antibiotics); \hspace{5cm} \text{max 2}

(ii) better vaccine/AW;
more people vaccinated/AW;
better antibiotics/treatment;
cheaper antibiotics/treatment;
better public awareness;
AVP. \hspace{5cm} \text{max 2}
3 (a) (i) hydroponics;
  plant roots grown in/in contact with water;
  not usually submerged;
  will tolerate almost freezing;

  aeroponics;
  misting plant roots/AW;
  ref. cycles/continuous;
  run off collected/reused;

  ref. nutrient solution;
  grown indoors/AW;
  use virus tested cuttings AW;
  ref. artificial light;
  soil based media must be washed off/clean plants;
  ref. optimum temperature (15º-18º C);
  ref. effects of low temperatures (e.g. flowers liable to split/weaker
  flower stems/slower growth);
  ref. effect of higher temperatures (e.g. denaturation of enzymes);
  requires Na⁺/Ca²⁺ levels to be high to establish plants;

N supplied as, nitrate/not ammonium salts;
  ref. pH around 6/below 7;
  ref. low humidity/need for ventilation;
  AVP (e.g. CaNO₄ requirements decrease during flowering/wider
  spacing between cuttings reduces disease); max 8

(ii) (indoor culture so)
  not ruined by pests/easier pest control;
  no pesticides;
  no bad weather/AW;
  can be grown in adverse climates/AW;
  avoids poor soil/variability of soil;
  no weeds/no herbicides needed;
  avoids, poor drainage of soils/over watering/AW;
  higher oxygen levels around roots/AW;
  can be grown out of season/any time of year/when profit is
  biggest/AW;
  grown where land is in short supply/maximises land use/AW;
  ref. potential for lower labour costs;
  AVP (e.g. can easily supply more carbon dioxide/maximise
  photosynthesis/optimise conditions); max 6
(iii) Callus culture:

named specific example of source;
aseptic transfer;
ref. sterile medium/conditions;
with named plant growth regulator;
ref. cell division/mitosis;
including cells that may not normally divide;
each (callus/sample/cell) capable of forming a new plant;
genetically identical to/clone of;
the source material/each other;
section cut;
detail (e.g. from suitable part of plant, e.g. hypocotyl/surface sterilised);
callus is mass of undifferentiated cells/aggregate of cells;
solid medium;
detail (e.g. agar);
use (e.g. propagation);
detail (e.g. of cheap/virus free/GM/ cloned plants;
AVP;
AVP;

Suspension culture:

named specific example of source;
aseptic transfer;
ref. sterile medium/conditions;
with named plant growth regulator;
ref. cell division/mitosis;
including cells that may not normally divide;
each (callus/sample/cell) capable of forming a new plant;
genetically identical to/clone of;
the source material/each other;
separation/dispersal of cells;
detail (e.g. gentle shaking/cellulase);
(culture of) single cells/small clumps of cells;
liquid medium;
detail (e.g. medium is entirely synthetic/complex);
use (e.g. production);
detail (e.g. of metabolites/GM proteins/AG;
AVP;
AVP;

Protoplast culture:

named specific example of source;
aseptic transfer;
ref. sterile medium/conditions;
with named plant growth regulator;
ref. cell division/mitosis;
including cells that may not normally divide;
each (callus/sample/cell) capable of forming a new plant;
genetically identical to/clone of;
the source material/each other;
cell walls removed;
(b) (i) uses *Saccharomyces*; 
*ceresiaecarlsbergensis*;
malting barley; grapes;
under moist conditions/soaked; crushed;
causes germination of grain; to extract sugars;
enzymes/amylases hydrolyse starch; etc. for wine;
dry in kiln;
crush dried grain/milling/grist;
mashing/mix crush grain with water;
allow further breakdown of starch;
add hops;
for flavour;
and sterilise wort;
add yeast;
fermentation;
produce CO₂ and alcohol;

(ii) new strains of yeast;
by genetic engineering/named process;
Improved yield/tolerate higher alcohol content;
top and bottom fermenters;
add amylases/gibberellins;
reduces time to convert starch to sugars;
produce low carbohydrate beers;
unmalted barley and amylases/glucanases/proteases replace malt;
marking points for wine;
(iii) use *Fusarium*;
grown on flour waste/named medium;
other nutrient sources, e.g. glucose/minerals/ammonia;
continuous aseptic culture;
air lift fermenter;
heat exchanger;
mycelium harvested;
centrifuged;
water content reduced;
RNA reduced;
by ribonucleases/heating to 60-70°C;
pressed/processed;
flavour added;
colour added;
high protein content;
no cholesterol.

max 6

[20]
Option 3 – Growth, Development and Reproduction

1 (a) (i) A plasma membrane/cell surface membrane  
B acrosome  
C nucleus  
D mitochondrion  

(ii) A allows attachment to receptors in zona pellucida; fuses with oocyte membrane;  

B enzyme digests path between follicle cells; enzyme digests zona pellucida;  

max 1

(b) (i) fresh/not frozen maximum/peak/80% at 24 hours; at 24h 80% v. 26%;  
 frozen highest/c. 58% at 0 hours and falls with time; after 48h fresh still penetrate 40% of oocytes v. frozen only 10%;  
A any valid figures of comparison  
max 2

(ii) need time for capacitation; removal of, glycoprotein/plasma protein; accounts for increase in ability to penetrate oocytes between 0 and 24 hours; decrease in ability 24-48 hours from lack of, nutrients/energy;  
max 3

(iii) non-lethal/slight, damage; during, freezing/thawing; alters membrane/speeds up capacitation; ref. to capacitation having already occurred; during time delay between ejaculation and freezing;  
max 2

(c) increase in, enzyme/nitric oxide synthase, activity in sperm; on contact with zona pellucida; enzyme active after sperm penetrates oocyte; results in increase in nitric oxide concentration in oocyte; leads to increase in calcium ion concentration in oocyte;  
max 4

Total: 15

2 (a) Any three of the following:  
petals, absent/small/inconspicuous/green/dull-coloured;  
stamens, flexible filament/hang outside flower/anthers versatile;  
 stigma, feathery/hangs outside flower;  
pollen, much/small/light/smooth (non-sticky);  
no credit for structures that are not present such as ‘no nectary’  
max 3
(b)  (pericarp) becomes, more fleshy/other possible change; growth/swells; colour change; increase in, attractants/sugars/scent; max 3

(c)  needs knowledge of: undifferentiated/meristematic, cells in, cutting/other propagule; stimulated by plant growth substances/plant growth regulators; auxin/cytokinin; form adventitious roots; ref. tissue culture; max 3

(d)  asexual reproduction; genetically identical/clone; original susceptible so all susceptible to same pathogen; only change via mutation; max 3

(e)  meiosis fails; in pollen mother cell/embryo sac mother cell; problem, in synapsis/when homologous chromosomes pair; in prophase 1; crossing over between, three chromosomes/six chromatids, results in tangle; max 3

Total: 15

3  (a) (i)  absolute growth rate: also called actual growth rate; measure of how rate of growth varies with time; plot of increase in parameter in unit time against time; e.g. kg per year plotted against year/(dm/dt) against (t)/other e.g.; useful for showing, when growth is most rapid/how rate changes with time;

relative growth rate: also called specific growth rate; takes into account existing growth; absolute growth rate divided by parameter; e.g. change in mass in one year divided by mass at beginning of year (dm/dt. 1/m); shows growth rate relative to size of organism; max 6

(ii)  suitable example: (that will allow for samples over time)
large number of organisms; in identical conditions; e.g. of condition (e.g. temperature/water supply/humidity/nutrients); second e.g. of condition; samples taken at regular intervals; randomly; organism separated from medium; dried in oven/other suitable conditions; cooled in desiccator; repeat to constant mass; average dry mass; max 8
(iii) problem of allometry;
  single dimension may not reflect growth in different dimension;
  e.g. may be long but thin/other e.g.;
  problem instars;

  fresh mass/wet mass easily altered;
  (plants) by water supply/transpiration/environmental conditions;
  (animals) by ingestion/egestion/excretion;
  such gains/losses not true growth;   \[\text{max 6}\]

(b) (i) link between nervous system and endocrine system;
  stimulates pituitary gland;
  to release specific hormones;
  via releasing factors;
  small peptides;
  travel in, blood/portal vessels;
  e.g. GnRF for pituitary to release, FSH/LH;
  e.g. TRH for pituitary to release TSH;
  involved in negative feedback;
  e.g. negative feedback; (oestrogen/progesterone/thyroxine)   \[\text{max 6}\]

(ii) anterior lobe;
  growth hormone (GH)/somatotrophin, from anterior lobe;
  ref. somatomedin from liver;
  stimulates protein synthesis;
  important for growth of, long bones/arms and legs;
  TSH from anterior lobe;
  stimulates thyroxine secretion;
  FSH from anterior pituitary;
  stimulates development of ovarian follicle;
  stimulates secretion of oestrogen;
  ref. secondary sexual characteristics in female;
  stimulates spermatogenesis;
  LH (ICSH) from anterior pituitary;
  stimulates ovulation;
  stimulates formation of corpus luteum;
  stimulates secretion of progesterone;
  stimulates secretion of testosterone;
  ref. secondary sexual characteristics in male;
  FSH and LH control menstrual cycle;   \[\text{max 8}\]

(iii) secretes, thyroxine/\(T_4\);
  secretes, triiodothyronine/\(T_3\);
  target = respiring cells/increase in respiration rate;
  controls, basal metabolic rate/BMR;
  switches on transcription;
  stimulates protein synthesis;
  stimulates brain development;
  stimulates growth;
  especially of skeleton;
  ref. temperature regulation;   \[\text{max 6}\]

Total: 20
Option 4 – Applications of Genetics

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

(b) (i) 1430-1500;

(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) \( \eta = 1; \)

(ii) probability = > 0.1;

(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

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

3 (a) (i) to alter phenotype of domesticated animals or plants;
trait of, use/value, to man.

Allow following examples of use:
quantitative agricultural plant improvement;
quantitative agricultural animal improvement;
qualitative agricultural improvement (plant or animal);
ornamental example in plants;
ornamental example in animals;
other example; (i.e. sporting, etc.) max 6

(ii) plant without resistance crossed with resistant plant;
offspring 1 seeds sown;
offspring 1 plants challenged by disease/AW;
resistant offspring 1 interbred;
selection and interbreeding continued for many generations;
resistant offspring 1 backcrossed to parent;
for background genes;
for traits other than resistance;
selection and backcrossing continued for many generations;
resistant parent, same species/primary (or secondary) gene pool;
resistant parent, different species/tertiary gene pool;
practical detail 1;
practical detail 2; [male sterility/removal of anthers/bagging/pollination] gene bank/landrace/wild species; max 8

(iii) orthodox seeds;
seeds dehydrated;
stored at -20°C;
storage life doubled by 5°C (A approx.) reduction in temperature;
storage life doubled by 2% (A approx.) reduction in humidity;
germination tests every 5 years;
recommended threshold value = 85% germination;
then seeds grown and fresh seed collected;
recalcitrant seeds cannot be dried and frozen; max 6

Total: 20
(b) (i)  *linkage*
2 or more genes on same chromosome;
do not assort independently in meiosis;
inherited together;
number of linkage groups = number of pairs of homologous
chromosomes/haploid number of chromosomes;
genes closer together less likely to be separated by crossing-over;

*crossing-over*
prophase meiosis I;
during synapsis;
chromatids of a bivalent break;
rejoin with non-sister chromatid;
exchange between paternal and maternal chromatids;
of alleles;
diagram;
ref. chiasma;
ref. cross over value; [max 5 on c-o]
genes closer together less likely to be separated by crossing over;  max 8

(ii) six loci; [A 4 loci]
A, B, C, DP, DQ, DR; [A A, B, C, D]
tightly linked/rarely separated by crossing over;
inherited as a unit;
*haplotype*;
chromosome 6;
very large number of alleles;
hence very many different combinations in the population;
child receives one haplotype from mother and one from father;
probability of two siblings sharing one haplotype = 0.5;
probability of two siblings with identical haplotypes = 0.25;  max 6

(iii) HLA loci code for (glyco)proteins;
at cell surface/in plasma membrane;
recognition markers/self or not-self markers;
act as antigens;
transplant from unmatched donor rejected;
ref. immune system/immune reaction;
detail of immune system; [antibodies/T cells]
some HLA antigens induce a greater reaction than others;
ref. immunosuppression;
ref. ABO groups;
red cell antigens and plasma antibodies;
detail ABO mismatch;
ref. ‘universal donor’/’universal recipient’;  max 6

Total: 20