CAMBRIDGE
INTERNATIONAL EXAMINATIONS

June 2003

GCE A AND AS LEVEL

MARK SCHEME

MAXIMUM MARK: 40

SYLLABUS/COMPONENT: 9700/01

BIOLOGY
Paper 1 (Multiple Choice)

Question Number	Key	*Question Number*	*Key*
1	**D**	21	**D**
2	**A**	22	**B**
3	**C**	23	**B**
4	**C**	24	**A**
5	**A**	25	**C**
6	**C**	26	**C**
7	**D**	27	**B**
8	**A**	28	**B**
9	**B**	29	**C**
10	**A**	30	**D**
11	**B**	31	**A**
12	**C**	32	**C**
13	**B**	33	**C**
14	**C**	34	**D**
15	**D**	35	**B**
16	**A**	36	**B**
17	**D**	37	**D**
18	**A**	38	**B**
19	**C**	39	**B**
20	**C**	40	**C**

TOTAL 40

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MARK SCHEME

MAXIMUM MARK: 50

SYLLABUS/COMPONENT: 9700/02

BIOLOGY
Paper 2 (Theory 1)

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

Question	Expected Answers	Marks
1 (a)	C, E, D, B;	1
(b)	centromeres have divided/duplicated; R. split R. replicated (sister) chromatids/(daughter) chromosomes pulled/moved/ separate/migrate to (opposite) poles; ref. to the spindle/microtubules/spindle fibres; R. fibres	max 2
(c)	replication/DNA synthesis; assembly of nucleotides/polynucleotide (chain) formed; (alongside) old/original/both strands, act as template; by base/complementary pairing/ A-T and G-C; quantity of DNA doubles/two new double helices formed;	max 3
(d)	production of genetically identical cells/genetically uniform cells/ identical DNA/maintains genetic stability/same number and kind of c-somes/no genetic variation;	1

[Total 7]

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*

statement	emphysema	tuberculosis	obesity	rickets	smallpox
eliminated by vaccination	x	x	x	x	✓
a worldwide infectious disease	x	✓	x	x	✓ or x
a form of malnutrition	x	x	✓	✓	x
a deficiency disease	x	x	x	✓	x
involves degeneration of lung tissue	✓	✓ or x	x	x	x

[Total 5]

3 (a) Correct letter order **on** Question Paper:

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

max 4

R. process statements instead of letters

(b) secrete/release/produce/make antibodies; **1**
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; **max 2**

[Total 7]

4 (a) **(i)** shade in xylem; (complete xylem star must be shaded) **1**

(ii) shade in phloem; (A. shading of just one phloem group) **1**

(b) ref to bending/provide support/strength; R. lignin unqualified **1**
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 **max 2**

(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); **max 4**

(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/hydrophilic (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_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.*

Alcohol	Caffeine	Nicotine	Heroin
U V Y Z	S T Z	S T W X Z	U Y W

4

(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

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GCE A AND AS LEVEL

MARK SCHEME

MAXIMUM MARK: 25

SYLLABUS/COMPONENT: 9700/03

BIOLOGY
Paper 3 (Practical 1)

Question	Expected Answers	Mark	Additional Guidanc
1 (a) (i)-(iii)	T1 > T2; T1 results have increased; 35-40 means correct; 45-50 means correct;	1 1 1 1	
(b)	Allow the yeast to get to the correct temperature; Allow the gas to expand and vent/ contract and suck back;	1 1	
(c)	Correct ref. to results e.g. T1 higher; Increased kinetic energy of molecules/move faster; More collisions; Rate of diffusion of glucose into yeast;	1 1 1 1	REJECT unqualified rates of reaction. If T1 lower then ecf, i.e. accept correct ref. to table and denaturisation i.e. max 2
(d)	Two from: Explanation of control, i.e. yeast or no yeast/enzyme; eliminate effects of gas expansion due to temp fluctuations; Number of bubbles produced by T2 deducted from totals for T1;	Max 2	IGNORE for better comparison/control/fair test
(e)	Three from: Not alternate counting; Keep at constant temperature; Take more readings; Control pH; Measure volume of gas;	Max 3	Allow reduce volume of reagents if qualified
		(15)	
2 (a)	Clear single lines (quality); 3 arms to drawing; Nuclei drawn; Red blood cells smaller than nuclei; Wall of alveoli not more than 3 diameters of nuclei; 3 correct labels from: air space/alveolus; nucleus; cytoplasm; cell membrane; red blood cells; epi/endothelium; alveolus wall;	1 1 1 1 1 3 Max 6	

(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

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GCE A LEVEL

MARK SCHEME

MAXIMUM MARK: 50

SYLLABUS/COMPONENT: 9700/04

BIOLOGY
Paper 4 (Theory 2 (A2 Core))

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); matrix of mitochondria (in Krebs cycle);
oxidative phosphorylation	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;

5

(b) arrow pointing down;

1

(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;
choromatids (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

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GCE A LEVEL

MARK SCHEME

MAXIMUM MARK: 30

SYLLABUS/COMPONENT: 9700/05

BIOLOGY
Paper 5 (Practical 2 (A2))

Question	Expected Answers	Marks	Additional Guidance
1 (a) (i)	F1 does not change/∞; F2 changes quickest/F3 2nd to change;	1 1	
(ii)	Blue;	1	
(iii)	F1 renal vein (plasma); F2 urine; F3 renal artery (plasma);	Max 2	ENSURE ecf from (a) (i) 3 = 2 2 = 1
	1 mark for each correct explanation, i.e. F1 urea removed by kidney; F2 high concentration of urea; F3 low concentration of urea;	 1 1 1	
(b)	Two from: start all three at same time; replication; means of more precise pH measurement	Max 2	
		(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	Max 4	3 correct labels = 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	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

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GCE A LEVEL

MARK SCHEME

MAXIMUM MARK: 50

SYLLABUS/COMPONENT: 9700/06

BIOLOGY
Paper 6 (Options (A2))

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;
bacteria/*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 **6**

(ii) *(e.g. 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/potantial/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; **max 3**

(ii) attentuated/weakened organism can survive attentuation/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; **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; **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); **max 2**

(ii) better vaccine/AW;
more people vaccinated/AW;
better antibiotics/treatment;
cheaper antibiotics/treatment;
better public awareness;
AVP. **max 2**

[15]

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^+/Ca^{2+} 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/AW;
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;

detail (e.g. by enzyme action/cellulases/pectinases);
(culture of) single/naked cells;
liquid medium
detail (e.g. with same water potential as cells);
use (e.g. physiology/genetic investigation/making hybrids
detail (e.g. ref. specific investigation heterokaryon);
AVP;
AVP;

max 6

[20]

(b) (i) uses *Saccharomyces;*
cerevisiae/*carlsbergensis*;
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 CO_2 and alcohol;

max 8

(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;

max 6

(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^{o}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 *half marks rounded up;* **2**

(ii) **A** allows attachment to receptors in zona pellucida;
fuses with oocyte membrane; **max 1**

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/(d*m*/d*t*) 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 (d*m*/d*t*. 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; **max 6**

Total: 20

(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) **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 charcteristics 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; **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; **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; **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

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;

(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