CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the May/June 2015 series

9700 BIOLOGY

9700/41 Paper 4 (A2 Structured Questions), maximum raw mark 100

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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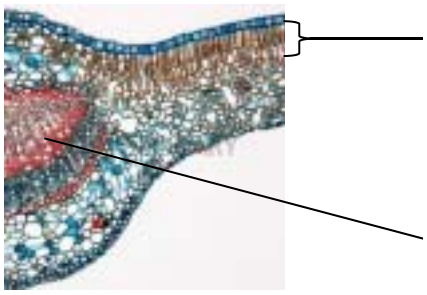
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1 (a)



P / palisade mesophyll (tissue) ;

X / xylem (tissue) ;

[2]

(b) *large surface area*
(to get) more, light / carbon dioxide ; **A** gas exchange **I** oxygen

thinness
small(er) / short(er) / reduced, diffusion distance for gases **OR**
fast(er) diffusion of gases ; **A** named gas, either CO_2 or O_2

1 mark only if both points made but not related to features in italics [2]

(c) (i) have chloroplasts / varying thickness of (cell) walls / no plasmodesmata ; [1]

(ii) water potential / Ψ, of (guard) cell(s), increases / becomes less negative ;

water leaves cell(s) ;

(by) osmosis / down a water potential gradient ; **I** diffuses

(guard cell) becomes, flaccid / less turgid / AW ; [max 3]

[Total: 8]

2 (a) has more than one polypeptide ; **A** FSH has 2 / α and β, polypeptides **R** has four

has, prosthetic group / non-protein part / carbohydrate / sugar ; [max 1]

(b) 1 produce / make, monoclonal antibodies specific to (u-h)FSH / anti(u-h)FSH monoclonal antibodies ;

2 ref. to column / framework, for, attachment / immobilisation ; **R** test strip

3 urine, added to / flows past / passed over, antibodies ;

4 (so) allowing, hormone / (h)FSH, to bind (to monoclonal antibodies) ;

5 treatment needed to release, hormone / (h)FSH (from monoclonal antibodies) ; **I** filtering
[max 3]

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(c) 1 sugars need to be added / glycosylation **;** **A** bacteria cannot modify protein

2 needs, Golgi body / rough endoplasmic reticulum **;** **A** bacteria lack, Golgi / rough endoplasmic reticulum

3 ref. to problems in bacteria with, introns / wrong promoter / secretion / **ora** **;** [max 1]

(d) *labels to correct recognisable structures*

(secondary) oocyte **;** **R** ovum

zona pellucida **;**

corona radiata / cumulus oophorus **;**

fluid-(filled space) / antrum **;**

granulosa / follicle / follicular, cells **;**

theca **;** [max 3]

(e) **(i)** *comparison*

1 more mature follicles with r-hFSH **;** **ora**

2 oestrogen (concentration), higher with r-hFSH **;** **ora**

3 comparative data quote **;** e.g. 13 v 8 mature follicles
OR 6.55 v 3.95 nmol dm^{-3} oestrogen concentration
OR manipulated figures
e.g. difference of 5 / 2.6 nmol dm^{-3} /
62.5% increase (r) follicles / 65.8% (r) oestrogen

explanation

4 (because) r-hFSH, purer / more concentrated / **ora**
OR
(some) u-hFSH, damaged by extraction technique / degraded **;** [max 4]

(ii) 1 difference / difference described, is significant **;**

2 not due to chance **;** **A** due to something other than chance

3 smaller than, critical value / value for significance of, 0.05 / 5% **;** [max 2]

[Total: 14]

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3 (a) *self-pollination* ***ora*** *for cross-pollination*

1 gametes / alleles / genes / DNA, come(s) from one parent ;

2 gives, less genetic variation / more genetic uniformity ;

3 results in inbreeding ;

4 increases homozygosity / decreases heterozygosity ; [max 3]

(b) anthers and stigma / stamens and carpels, closer together ; [1]

(c) 1 range of flower size in original population ;

2 genetic variation (affecting flower size) in original population ; **I** mutation

3 change in environment / selection pressure,
is absence of, bees / insect pollination (in greenhouse) ;

4 plants with small, flowers / petals, are,
selected for / reproduce / at a selective advantage ; **ora**

5 <u>alleles</u> for small size passed to offspring ; **ora I** gene

6 frequency of, advantageous / smallness, allele increases ; **ora**

7 directional selection ;

8 temperature / irrigation / space / competition, different in field and glasshouse ;

9 small size explanation linked to factor in mp8 ; [max 5]

[Total: 9]

4 (a) (i) 1 habitat loss / urbanisation / roads / agriculture ; **R** deforestation

2 human damage (to plants) ; e.g. trampling / camping / picking

3 climate change ; e.g. drought / storms

4 soil erosion ;

5 loss of pollinators ;

6 use of herbicides ;

7 competition with / eaten by, introduced species ;

8 pollution ; [max 2]

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(ii) 1 to maintain biodiversity **;**

2 to maintain, food chains / food webs / stability of ecosystems **;**

3 to maintain, genetic diversity / genetic variation / gene pool **;**

4 resources (for humans) **;** e.g. biofuel / food / medicines / wood

5 aesthetic reasons / (eco)tourism **;**

6 to maintain, nutrient cycle / soil structure / climate stability **;**

7 *idea of* ethical duty **;** [max 3]

(b) 1 gibberellin moves (from embryo) to aleurone layer **;**

2 gene, switched on / transcribed / used to make mRNA **;**

3 amylase produced **; I** released / stimulated

4 (amylase), hydrolyses / digests, starch to maltose **; I** breaks down / converts **/** glucose

5 for, respiration / ATP / energy **;**

6 for, growth / development / cell division / mitosis, in embryo **;**

7 AVP **;** e.g. role of, DELLA / PIF [max 4]

(c) (i) *survival:*

1 less risk of extinction (for high seed survival compared with low survival) **;**

germination percentage:
for low survival:

2 as % germination increases, risk of extinction decreases **;**

for high survival:

3 as % germination increases risk of extinction decreases until,
30–36 % germination, then risk of extinction increases **;**

4 use of paired figures **;** e.g. quote % germination and risk of extinction for each of:
high v low [mp1]
2 points on low survival line [mp2]
2 points on high survival line [mp3]
allow ± one grid square for figures [max 3]

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(ii) *yes*

1 (scraping) increases germination **;**

2 more germination lowers risk of extinction **; ora**

3 if seeds don't survive long / for low survival value seeds, scraping is good **;**

no

4 if seeds do survive long-term / for high survival value seeds, a store of seeds remains in soil **;**

5 (avoid risk of) all germinating at once and perhaps all dying **;** [max 3]

[Total:15]

5 (a) 1 two (complete) sets of chromosomes / diploid / 2n **;**

2 one of each chromosome, from each parent / maternal and paternal **;**

3 to allow (homologous) pairs to form during, meiosis / prophase 1 / reduction division **;** [max 2]

(b) most / high % / more than 70%, of females in **three** populations prefer calls from their own population **;**

less than half / 44%, of females in, **one** population / population 60, prefer calls from their own population **; ora** [2]

(c) *yes*

1 different chromosome numbers **;**

2 cannot interbreed to form fertile offspring / hybrids infertile **;**

3 (because) not all chromosomes will be able to pair in meiosis **;**

4 live in different, habitats / climatic regions
OR
geographical isolation **;**

5 (so) unlikely to interbreed / reproductively isolated **;**

6 most females prefer males from their own population **; ora**

7 differences in mating, call / behaviour **;**

no

8 some females, willing to mate with / prefer, males from other populations **;**

9 phenotypically / morphologically, similar **;** [max 4]

[Total: 8]

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6 (a) *toxin may*

1 bind to receptors on postsynaptic (membrane) **;**

2 (so) stops ACh binding / inhibits depolarisation / no action potentials / Na^+ ion channels stay shut **;**

3 (so) stimulates ACh receptors / causes (continuous) depolarisation / causes action potentials / opens Na^+ ion channels **;**

4 reduces / stops, release / recycling, of ACh (by presynaptic neurone) **;**

5 inhibits acetyl cholinesterase / AW **; R** denatures [max 3]

(b) 1 enter, presynaptic neurone / AW **;**

2 causes vesicles (containing ACh) **;**

3 to, move to / fuse with, (presynaptic) membrane **;**

4 (so) ACh released (into synaptic cleft) / exocytosis **;** [max 3]

(c) 1 ensure one-way transmission **;**

2 filter out infrequent impulses / temporal summation **; I** weak

3 allow, interconnection / integration, of, nerve (cell) pathways / many neurones **;**
OR
spatial summation / convergence of impulses / divergence of impulses **;**

4 ref. memory / learning **;**

5 idea of inhibitory effect **;** [max 2]

[Total:8]

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7 (a) 1 glucose phosphorylated by ATP **;**

2 (forms) hexose / fructose, bisphosphate **;**

3 raises energy level of / activates, glucose / sugar
OR
lowers activation energy of reaction **;**

4 breaks down to **two** TP **;**

5 6C → 2 × 3C **;**

6 hydrogen (atoms) removed / dehydrogenated / oxidised **;**

7 2 reduced NAD formed **; A** NADH / $NADH_2$

8 ref. to 4 ATP produced / net gain of 2 ATP **;**

9 pyruvate produced **;**

10 AVP **;** e.g. ref. to substrate level phosphorylation / dehydrogenase / phosphofructokinase / hexokinase [max 6]

(b)

	substrate level phosphorylation	oxidative phosphorylation	
enzymes are involved	✓	✓	
occurs in cytoplasm	✓	×	;
occurs in mitochondria	✓	✓	;
channel proteins are involved	×	✓	;

[3]

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(c) *seeds soaked in water*

1 little / no, oxygen (in water) **;**

2 (mostly) anaerobic respiration **;**

seeds after 12 hours in the soil

3 (more) aerobic respiration / less anaerobic respiration **;**

4 mixture of substrates **;** e.g. 2 of carbohydrates, proteins and lipids

seedlings after 21 days

5 aerobic respiration **;**

6 substrate is, glucose / carbohydrate **;**

7 ref. to presence of leaves / photosynthesis **;** [max 6]

[Total:15]

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8 (a) gene mutation **;**

a change in the, base(s) / nucleotide(s) **;**
e.g. base, substitution / deletion / addition [2]

(b) *parental genotypes*
CC^aBb x C^hC^aBb ;

gametes
CB Cb C^aB C^ab x C^hB C^hb C^aB C^ab ; *allow on Punnett square*

offspring genotypes **; ;** *deduct one mark for each error*
max 1 ecf for offspring genotypes if only 4 given

offspring phenotypes **;**

phenotypes linked to genotypes **;**

	C^hB	**C^aB**	**C^hb**	**C^ab**
CB	**CC^hBB** full black	**CC^aBB** full black	**CC^hBb** full black	**CC^aBb** full black
Cb	**CC^hBb** full black	**CC^aBb** full black	**CC^hbb** full red	**CC^abb** full red
C^aB	**C^aC^hBB** Him black	**C^aC^aBB** albino black	**C^aC^hBb** Him black	**C^aC^aBb** albino black
C^ab	**C^aC^hBb** Him black	**C^aC^aBb** albino black	**C^aC^hbb** Him red	**C^aC^abb** albino red

[6]

[Total:8]

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9 (a) 1 obtain mRNA from β cells (of islets of Langerhans of pancreas) **;**

2 reverse transcriptase **;**

3 make (single-stranded) cDNA **;**

4 DNA polymerase used to make cDNA double stranded **;**

5 sticky ends created **; A** description

6 (obtain) plasmids **;**

7 cut with restriction, endonuclease / enzyme **; A** named e.g. EcoR1

8 ref. complementary sticky ends **;**

9 cDNA / insulin gene, mixed with plasmid **;**

10 DNA ligase **;**

11 seals nicks in sugar-phosphate backbone **; R** anneals [max 8]

(b) 1 (recombinant) plasmids mixed with bacteria **;**

2 (some) bacteria, take up plasmids / transformed **;**

3 heat shock / calcium chloride solution / Ca^{2+} ions / electroporation **;**

to identify bacteria containing plasmids

4 grow on, agar / medium, containing antibiotic (A) **; A** ampicillin

5 plasmid contains, antibiotic (A) / ampicillin, resistance gene(s) **;**

6 bacteria with plasmid survive **; ora**

to identify recombinant bacteria

7 replica plate **; A** description e.g. sponge / velvet pad / absorbent paper

8 (onto) agar / medium, containing second antibiotic (B) **; A** tetracycline

9 *(tet*^{R} / B / 2nd) resistance gene inactivated (by insertion of new, DNA / gene) / AW **;**

10 (ID) colonies from, 1st / ampicillin, plate that do not grow on, 2nd / tetracycline, plate **;** [max 7]

[Total:15]

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10 (a) *batch / penicillin*

1 nutrients, decrease / run out ;

2 so, secondary metabolite / penicillin, made ;

3 fermenters can be used (after cleaning) for different process ;

4 if problem occurs only one batch affected ;

5 needs little, monitoring / attention (once set up) ;

continuous / mycoprotein

6 (fungus) kept in, exponential / log, phase (of growth) ;

7 (so) high, biomass / yield / production rate ;

8 little / no, downtime ;

9 small, vessels / space, required;

10 cost-effective ; [max 8]

(b) 1 mouse is injected with an antigen ;

2 wait for immune response to occur ;

3 clonal selection ; **A** description e.g. antigen binds to, specific / virgin, B cell

4 clonal expansion ; **A** description e.g. mitosis / division / cloning of B cells

5 B-lymphocytes / plasma cells, are extracted ;

6 from the mouse's spleen ;

7 fused with, cancer / myeloma / tumour, cells ;

8 hybridoma cells formed ;

9 hybridoma cells producing antibodies are identified ;

10 cultured on a large scale (to secrete monoclonal antibodies) ; [max 7]

[Total:15]

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1 **(a)** label **L** to any thylakoid membrane **;**

label **R** to stroma **;** [2]

(b) to absorb, more / maximum, light **;**

to avoid damage by high light <u>intensities</u> **;** [2]

(c) 1 carbon dioxide **;** **A** CO_2

2 ATP **;**

3 reduced NADP **;**
mp 2 and mp3 in either order

4 acetyl CoA **;** [4]

[Total: 8]

2 **(a)** defective development / increased risk of miscarriage / mutation **;** [1]

(b) 1 *idea of* switch on gene / transcription **;**

2 detail of positional problem **;**
e.g. gene may insert in any of the chromosomes
e.g. gene may be within an, intron / non-coding DNA
e.g. gene may share promoter with host gene that does not get switched on in this cell [2]

(c) *assume metaphase I unless otherwise stated*

	metaphase I		metaphase II	
1	bivalents / homologous pairs, (line up)	**or**	single chromosomes (line up)	**;**
2	chiasmata	**or**	no chiasmata	**;**
3	46 / 2n / diploid (number of, chromosomes)	**or**	23 / n / haploid (number of, chromosomes)	**;**
4	undivided centromeres	**or**	dividing centromeres	**;**

accept from labelled diagram [max 3]

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(d) *comparison - max 2*

1 greater total number of oocytes with r-hFSH **;**

2 greater number of, oocytes in metaphase II / secondary oocytes, with r-hFSH **;**

3 comparative figures **;** e.g. 763 v 407 / 634 v 323 / 83% v. 79%

explanation

4 r-hFSH purer / more concentrated **ora**
or
u-hFSH may have degraded **;** **ora** [max 3]

(e) (i) 1 results same for first three days **;**

2 higher concentration with r-hFSH from day 3 **;**

3 greatest difference is at day 12 **;**

4 highest concentration of u-hFSH at 3 nmol dm^{-3} **and** r-hFSH at 9 nmol dm^{-3}
or
r-hFSH highest concentration × 3 u-hFSH **;** [max 3]

(ii) 1 thickening of, endometrium / lining of uterus **;**

2 development of blood capillaries in, endometrium / lining of uterus
or
endometrium / lining of uterus, becomes more vascular **;**

3 inhibition of FSH, production / release / secretion **;** [max 2]

[Total: 14]

3 (a) 1 lots of pollen grains made
so more chance of pollination **;**

2 pollen grains, light / smooth / aerodynamic,
so easily transported **;**

3 no / small, petals / corolla / perianth,
so stamens / anthers / stigma, outside of flower **;**

4 long filaments
so anthers outside of flower **;**

5 anthers outside of flower / versatile anthers,
so pollen released **;**

6 long style
so stigma outside of flower **;**

7 stigma outside of flower / stigma has large surface area,
so traps pollen **;** [max 5]

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(b) 1 not dependent on, external factors / wind **;**

2 other plants (for cross-pollination) may be at a distance **;**

3 maintains (hybrid) gene pool **;**

4 keeps advantageous (hybrid) characteristics in offspring **;** [max 3]

(c) can breed with parent species / not reproductively isolated from parent species **;** [1]

[Total: 9]

4 (a) 1 reduces likelihood of harmful recessive <u>alleles</u> coming together **;**

2 to prevent, inbreeding depression / reduced vigour **; ora**

3 increases ability (of population) to adapt to changing environment **; ora**

4 increases chances of survival when exposed to, pathogen / disease **; ora** [max 3]

(b) (i) *assume foothills unless otherwise stated*

1 frogs (in foothills) have low(er) body temperature **; ora**

2 (lower temperatures) slow down, metabolic / enzyme-catalysed, reactions **; ora**

3 because, kinetic energy / collision rate, is less
or
fewer ESCs **; ora** [max 2]

(ii) 1 *idea of* initially foothill populations have greater mass than lowland populations **;**

2 (foothill) max mass reached earlier **; ora**

3 (foothill) max mass greater **; ora**

4 paired comparative figures **;**
e.g. [mp2] 37 days v 45 days
[mp3] 420 mg v 375 mg
day 37 foothills 420 mg v lowland 370 mg

5 after day 37 foothills decreases and lowland continues to increase in mass **;** [max 3]

(iii) 1 kept in identical (environmental) conditions **;**

2 (so) genes must be / environment cannot be, causing the differences **;** [2]

(iv) 1 (foothill population) can cope with (the effect of) cool temperatures **;**

2 time period available for, growth / metamorphosis, shorter in the foothills **;**

3 more chance of metamorphosing before, autumn / cooler weather, arrives **;** [max 2]

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(c) 1 tadpoles / adults, from lowlands unlikely to survive in the foothills / AW ;

2 ref. to genetic differences (between the two populations) ; [2]

[Total: 14]

5 **(a)** arrow downwards from cell body into long axon ; [1]

(b) **(i)** 1 active transport ;

2 ref. to sodium potassium pump ;

3 sodium ions out **and** potassium ions in ;

4 against their, concentration / electrochemical, gradient ;

5 ref. to, ion diffusion / ion leakage ; [max 3]

(ii) 1 enter, presynaptic knob / AW ;

2 causes vesicles ;

3 to, move to / fuse with, presynaptic membrane ;

4 (so) neurotransmitter released (into synaptic cleft) / exocytosis ; [max 3]

(iii) 1 restoring Na^+ gradient / 34% energy, (only) in dendrites ;

2 recycling transmitter **and** setting up Ca^{2+} gradient / 6% energy, only in axons ;

3 so more mitochondria in dendrites as more energy required for processes ; **ora** [max 2]

[Total: 9]

6 **(a)** 1 humans (as selective agent) ;

2 shorthorn and Brahman bred together ;

3 offspring with ideal characteristics chosen to mate ;

4 repeated over many generations ;

5 allele frequency for ideal characteristics increases ;

6 directional selection ; [max 3]

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(b) *any two from*
docility / AW ;

ref. to milk production ;

high fertility ;

hornlessness ;

ref. to meat production ;

disease resistance ; [max 2]

(c) 1 inbreeding depression / lack of hybrid vigour ;

2 more chance that harmful recessive alleles may be expressed ;

3 decrease in heterozygosity / increase in homozygosity ;

4 less genetic variation ; [max 3]

[Total: 8]

7 **(a)** **(i)** adenine ; [1]

(ii) ribose ; [1]

(b) 1 loss of phosphate / hydrolysis, leads to energy release ;

2 small packets of energy ;

3 small / water-soluble, so can move around cell ;

4 immediate energy donor ;

5 link between energy-yielding and energy-requiring reactions / AW ;

6 high turnover ; [max 3]

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(c)

stage	products
glycolysis	pyruvate reduced NAD
Krebs cycle	reduced NAD reduced FAD carbon dioxide / CO_2
oxidative phosphorylation	NAD FAD water / H_2O

;;;

6 correct = 3 marks
4/5 correct = 2 marks
2/3 correct = 1 mark [3]

(d) *lipids*

1 more C-H bonds / more reduced / more hydrogen ;

2 produces more reduced NAD ;

3 produces more ATP per, gram / unit mass ;

4 more, aerobic respiration / oxidative phosphorylation / chemiosmosis ;

5 fats **only** broken down aerobically ; [max 2]

(e) (i) CO_2 produced divided by O_2 consumed / ratio of CO_2 produced to O_2 consumed;

ref. to volume / number of molecules / moles, of, CO_2 / O_2 ;

in the same time / per unit time ; [max 2]

(ii) *carbohydrate* = 1.0 ;

lipid = 0.7 ; [2]

(iii) becomes greater than 1 ; [1]

[Total: 15]

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8 (a) (i) locus ; [1]

(ii) having two identical alleles (of a gene) ; [1]

(b) *parental genotypes*
1 C^BC^{CM} ;

2 $C^{CH}C^{CM}$;

parental gametes
3 C^B C^{CM} C^{CH} C^{CM} ;

offspring genotypes
4/5 C^BC^{CH} C^BC^{CM} $C^{CH}C^{CM}$ $C^{CM}C^{CM}$;; *deduct one mark for each error*

offspring phenotypes
6 black black chocolate cinnamon ; *must link phenotypes with genotypes*

penalise once for wrong symbol then ecf throughout [6]

[Total: 8]

9 (a) 1 ref. to VNTR (sequences) ;

2 quantity of DNA increased by PCR ;

3 DNA fragmented by, restriction enzyme(s) / endonuclease(s) ;

4 loaded (into wells) in agarose gel ;

5 (at) negative end / cathode end ;

6 ref. to buffer / electrolyte ;

7 direct current applied ;

8 phosphate groups of DNA give negative charge ;

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

10 short pieces / smaller mass, move further / move faster ; **ora**

11 (pieces) transferred to, membrane / nylon / nitrocellulose / absorbent paper
or
Southern blotting ;

12 heated to separate strands ;

13 probes / fluorescent dye, added ;

14 X-ray film / UV light / lasers ;

15 pattern of stripes / ref. banding pattern ; [max 9]

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

2 (more) rapid response ; **ora**

3 no / fewer, immune response / side effects / allergic reactions ; **ora**

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

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

6 less risk of, transmitting disease / infection ; **ora**

7 good for people who have developed tolerance to animal insulin ; **ora** [max 6]

[Total:15]

10 (a) *description*

1 enzyme mixed with sodium alginate (solution) ;

2 placed in syringe ;

3 added drop by drop ;

4 to (solution of) calcium chloride ;

5 beads (with enzyme) formed ;

6 beads separated from calcium chloride ;

7 wash with water ;

advantages

8 (enzyme) can be re-used ;

9 product, uncontaminated / enzyme-free ;

10 (so) purification not needed / less downstream processing ;

11 reduces cost ;

12 works at higher temperature / thermostable ;

13 works in changed pH ;

14 reaction, can be fast(er) / have high(er) yield ; [max 9]

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(b) 1 glucose oxidase immobilised **;**

2 stuck onto, pad / (dip)stick **;**

3 dip stick lowered into, body fluid / blood / urine **;**

4 oxidises glucose (in body fluid) **;**

5 (changes glucose to) gluconic acid **;** **A** gluconolactone

6 hydrogen peroxide produced **;**

7 (peroxide) reacts with chromogen (on pad) **;**

8 produces, colour / named colour **;**

9 darkness of colour / range of colours, is proportional to concentration of glucose **;**

10 AVP **;** e.g. peroxidases catalyse reaction / ref. to importance of fixed time to observe colour change [max 6]

[Total: 15]

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MARK SCHEME for the May/June 2015 series

9700 BIOLOGY

9700/43 Paper 4 (A2 Structured Questions), maximum raw mark 100

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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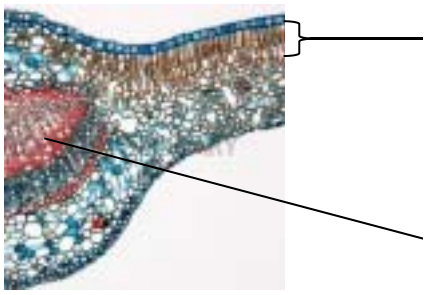
Mark scheme abbreviations:

;	separates marking points
/	alternative answers for the same point
R	reject
A	accept (for answers correctly cued by the question, or by extra guidance)
AW	alternative wording (where responses vary more than usual)
underline	actual word given must be used by candidate (grammatical variants accepted)
max	indicates the maximum number of marks that can be given
ora	or reverse argument
mp	marking point (with relevant number)
ecf	error carried forward
I	ignore
AVP	alternative valid point (examples given as guidance)

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1 (a)



P / palisade mesophyll (tissue) ;

X / xylem (tissue) ;

[2]

(b) *large surface area*
(to get) more, light / carbon dioxide ; **A** gas exchange **I** oxygen

thinness
small(er) / short(er) / reduced, diffusion distance for gases **OR**
fast(er) diffusion of gases ; **A** named gas, either CO_2 or O_2

1 mark only if both points made but not related to features in italics [2]

(c) (i) have chloroplasts / varying thickness of (cell) walls / no plasmodesmata ; [1]

(ii) water potential / Ψ, of (guard) cell(s), increases / becomes less negative ;

water leaves cell(s) ;

(by) osmosis / down a water potential gradient ; **I** diffuses

(guard cell) becomes, flaccid / less turgid / AW ; [max 3]

[Total: 8]

2 (a) has more than one polypeptide ; **A** FSH has 2 / α and β, polypeptides **R** has four

has, prosthetic group / non-protein part / carbohydrate / sugar ; [max 1]

(b) 1 produce / make, monoclonal antibodies specific to (u-h)FSH / anti(u-h)FSH monoclonal antibodies ;

2 ref. to column / framework, for, attachment / immobilisation ; **R** test strip

3 urine, added to / flows past / passed over, antibodies ;

4 (so) allowing, hormone / (h)FSH, to bind (to monoclonal antibodies) ;

5 treatment needed to release, hormone / (h)FSH (from monoclonal antibodies) ; **I** filtering
[max 3]

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(c) 1 sugars need to be added / glycosylation **;** **A** bacteria cannot modify protein

2 needs, Golgi body / rough endoplasmic reticulum **;** **A** bacteria lack, Golgi / rough endoplasmic reticulum

3 ref. to problems in bacteria with, introns / wrong promoter / secretion / **ora** **;** [max 1]

(d) *labels to correct recognisable structures*

(secondary) oocyte **;** **R** ovum

zona pellucida **;**

corona radiata / cumulus oophorus **;**

fluid-(filled space) / antrum **;**

granulosa / follicle / follicular, cells **;**

theca **;** [max 3]

(e) **(i)** *comparison*

1 more mature follicles with r-hFSH **;** **ora**

2 oestrogen (concentration), higher with r-hFSH **;** **ora**

3 comparative data quote **;** e.g. 13 v 8 mature follicles
OR 6.55 v 3.95 nmol dm^{-3} oestrogen concentration
OR manipulated figures
e.g. difference of 5 / 2.6 nmol dm^{-3} /
62.5% increase (r) follicles / 65.8% (r) oestrogen

explanation

4 (because) r-hFSH, purer / more concentrated / **ora**
OR
(some) u-hFSH, damaged by extraction technique / degraded **;** [max 4]

(ii) 1 difference / difference described, is significant **;**

2 not due to chance **;** **A** due to something other than chance

3 smaller than, critical value / value for significance of, 0.05 / 5% **;** [max 2]

[Total: 14]

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3 (a) *self-pollination **ora** for cross-pollination*

1 gametes / alleles / genes / DNA, come(s) from one parent ;

2 gives, less genetic variation / more genetic uniformity ;

3 results in inbreeding ;

4 increases homozygosity / decreases heterozygosity ; [max 3]

(b) anthers and stigma / stamens and carpels, closer together ; [1]

(c) 1 range of flower size in original population ;

2 genetic variation (affecting flower size) in original population ; **I** mutation

3 change in environment / selection pressure,
is absence of, bees / insect pollination (in greenhouse) ;

4 plants with small, flowers / petals, are,
selected for / reproduce / at a selective advantage ; **ora**

5 alleles for small size passed to offspring ; **ora I** gene

6 frequency of, advantageous / smallness, allele increases ; **ora**

7 directional selection ;

8 temperature / irrigation / space / competition, different in field and glasshouse ;

9 small size explanation linked to factor in mp8 ; [max 5]

[Total: 9]

4 (a) (i) 1 habitat loss / urbanisation / roads / agriculture ; **R** deforestation

2 human damage (to plants) ; e.g. trampling / camping / picking

3 climate change ; e.g. drought / storms

4 soil erosion ;

5 loss of pollinators ;

6 use of herbicides ;

7 competition with / eaten by, introduced species ;

8 pollution ; [max 2]

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(ii) 1 to maintain biodiversity **;**

2 to maintain, food chains / food webs / stability of ecosystems **;**

3 to maintain, genetic diversity / genetic variation / gene pool **;**

4 resources (for humans) **;** e.g. biofuel / food / medicines / wood

5 aesthetic reasons / (eco)tourism **;**

6 to maintain, nutrient cycle / soil structure / climate stability **;**

7 *idea of* ethical duty **;** [max 3]

(b) 1 gibberellin moves (from embryo) to aleurone layer **;**

2 gene, switched on / transcribed / used to make mRNA **;**

3 amylase produced **; I** released / stimulated

4 (amylase), hydrolyses / digests, starch to maltose **; I** breaks down / converts **/** glucose

5 for, respiration / ATP / energy **;**

6 for, growth / development / cell division / mitosis, in embryo **;**

7 AVP **;** e.g. role of, DELLA / PIF [max 4]

(c) (i) *survival:*

1 less risk of extinction (for high seed survival compared with low survival) **;**

germination percentage:
for low survival:

2 as % germination increases, risk of extinction decreases **;**

for high survival:

3 as % germination increases risk of extinction decreases until,
30–36 % germination, then risk of extinction increases **;**

4 use of paired figures **;** e.g. quote % germination and risk of extinction for each of:
high v low [mp1]
2 points on low survival line [mp2]
2 points on high survival line [mp3]
allow ± one grid square for figures [max 3]

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(ii) *yes*

1 (scraping) increases germination **;**

2 more germination lowers risk of extinction **; ora**

3 if seeds don't survive long / for low survival value seeds, scraping is good **;**

no

4 if seeds do survive long-term / for high survival value seeds, a store of seeds remains in soil **;**

5 (avoid risk of) all germinating at once and perhaps all dying **;** [max 3]

[Total:15]

5 (a) 1 two (complete) sets of chromosomes / diploid / 2n **;**

2 one of each chromosome, from each parent / maternal and paternal **;**

3 to allow (homologous) pairs to form during, meiosis / prophase 1 / reduction division **;** [max 2]

(b) most / high % / more than 70%, of females in **three** populations prefer calls from their own population **;**

less than half / 44%, of females in, **one** population / population 60, prefer calls from their own population **; ora** [2]

(c) *yes*

1 different chromosome numbers **;**

2 cannot interbreed to form fertile offspring / hybrids infertile **;**

3 (because) not all chromosomes will be able to pair in meiosis **;**

4 live in different, habitats / climatic regions
OR
geographical isolation **;**

5 (so) unlikely to interbreed / reproductively isolated **;**

6 most females prefer males from their own population **; ora**

7 differences in mating, call / behaviour **;**

no

8 some females, willing to mate with / prefer, males from other populations **;**

9 phenotypically / morphologically, similar **;** [max 4]

[Total: 8]

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6 (a) *toxin may*

1 bind to receptors on postsynaptic (membrane) **;**

2 (so) stops ACh binding / inhibits depolarisation / no action potentials / Na^+ ion channels stay shut **;**

3 (so) stimulates ACh receptors / causes (continuous) depolarisation / causes action potentials / opens Na^+ ion channels **;**

4 reduces / stops, release / recycling, of ACh (by presynaptic neurone) **;**

5 inhibits acetyl cholinesterase / AW **; R** denatures [max 3]

(b) 1 enter, presynaptic neurone / AW **;**

2 causes vesicles (containing ACh) **;**

3 to, move to / fuse with, (presynaptic) membrane **;**

4 (so) ACh released (into synaptic cleft) / exocytosis **;** [max 3]

(c) 1 ensure one-way transmission **;**

2 filter out infrequent impulses / temporal summation **; I** weak

3 allow, interconnection / integration, of, nerve (cell) pathways / many neurones **;**
OR
spatial summation / convergence of impulses / divergence of impulses **;**

4 ref. memory / learning **;**

5 idea of inhibitory effect **;** [max 2]

[Total:8]

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7 (a) 1 glucose phosphorylated by ATP **;**

2 (forms) hexose / fructose, bisphosphate **;**

3 raises energy level of / activates, glucose / sugar
OR
lowers activation energy of reaction **;**

4 breaks down to **two** TP **;**

5 6C → 2 × 3C **;**

6 hydrogen (atoms) removed / dehydrogenated / oxidised **;**

7 2 reduced NAD formed **; A** NADH / $NADH_2$

8 ref. to 4 ATP produced / net gain of 2 ATP **;**

9 pyruvate produced **;**

10 AVP **;** e.g. ref. to substrate level phosphorylation / dehydrogenase / phosphofructokinase / hexokinase [max 6]

(b)

	substrate level phosphorylation	oxidative phosphorylation	
enzymes are involved	✓	✓	
occurs in cytoplasm	✓	×	;
occurs in mitochondria	✓	✓	;
channel proteins are involved	×	✓	;

[3]

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(c) *seeds soaked in water*

1 little / no, oxygen (in water) **;**

2 (mostly) anaerobic respiration **;**

seeds after 12 hours in the soil

3 (more) aerobic respiration / less anaerobic respiration **;**

4 mixture of substrates **;** e.g. 2 of carbohydrates, proteins and lipids

seedlings after 21 days

5 aerobic respiration **;**

6 substrate is, glucose / carbohydrate **;**

7 ref. to presence of leaves / photosynthesis **;** [max 6]

[Total:15]

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8 (a) gene mutation **;**

a change in the, base(s) / nucleotide(s) **;**
e.g. base, substitution / deletion / addition [2]

(b) *parental genotypes*
CC^aBb x C^hC^aBb ;

gametes
CB Cb C^aB C^ab x C^hB C^hb C^aB C^ab ; *allow on Punnett square*

offspring genotypes **; ;** *deduct one mark for each error*
max 1 ecf for offspring genotypes if only 4 given

offspring phenotypes **;**

phenotypes linked to genotypes **;**

	C^hB	**C^aB**	**C^hb**	**C^ab**
CB	**CC^hBB** full black	**CC^aBB** full black	**CC^hBb** full black	**CC^aBb** full black
Cb	**CC^hBb** full black	**CC^aBb** full black	**CC^hbb** full red	**CC^abb** full red
C^aB	**C^aC^hBB** Him black	**C^aC^aBB** albino black	**C^aC^hBb** Him black	**C^aC^aBb** albino black
C^ab	**C^aC^hBb** Him black	**C^aC^aBb** albino black	**C^aC^hbb** Him red	**C^aC^abb** albino red

[6]

[Total:8]

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9 (a) 1 obtain mRNA from β cells (of islets of Langerhans of pancreas) **;**

2 reverse transcriptase **;**

3 make (single-stranded) cDNA **;**

4 DNA polymerase used to make cDNA double stranded **;**

5 sticky ends created **; A** description

6 (obtain) plasmids **;**

7 cut with restriction, endonuclease / enzyme **; A** named e.g. EcoR1

8 ref. complementary sticky ends **;**

9 cDNA / insulin gene, mixed with plasmid **;**

10 DNA ligase **;**

11 seals nicks in sugar-phosphate backbone **; R** anneals [max 8]

(b) 1 (recombinant) plasmids mixed with bacteria **;**

2 (some) bacteria, take up plasmids / transformed **;**

3 heat shock / calcium chloride solution / Ca^{2+} ions / electroporation **;**

to identify bacteria containing plasmids

4 grow on, agar / medium, containing antibiotic (A) **; A** ampicillin

5 plasmid contains, antibiotic (A) / ampicillin, resistance gene(s) **;**

6 bacteria with plasmid survive **; ora**

to identify recombinant bacteria

7 replica plate **; A** description e.g. sponge / velvet pad / absorbent paper

8 (onto) agar / medium, containing second antibiotic (B) **; A** tetracycline

9 *(*tet^R / B / 2^{nd}) resistance gene inactivated (by insertion of new, DNA / gene) / AW **;**

10 (ID) colonies from, 1^{st} / ampicillin, plate that do not grow on, 2^{nd} / tetracycline, plate **;** [max 7]

[Total:15]

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10 (a) *batch / penicillin*

1 nutrients, decrease / run out ;

2 so, secondary metabolite / penicillin, made ;

3 fermenters can be used (after cleaning) for different process ;

4 if problem occurs only one batch affected ;

5 needs little, monitoring / attention (once set up) ;

continuous / mycoprotein

6 (fungus) kept in, exponential / log, phase (of growth) ;

7 (so) high, biomass / yield / production rate ;

8 little / no, downtime ;

9 small, vessels / space, required;

10 cost-effective ; [max 8]

(b) 1 mouse is injected with an antigen ;

2 wait for immune response to occur ;

3 clonal selection ; **A** description e.g. antigen binds to, specific / virgin, B cell

4 clonal expansion ; **A** description e.g. mitosis / division / cloning of B cells

5 B-lymphocytes / plasma cells, are extracted ;

6 from the mouse's spleen ;

7 fused with, cancer / myeloma / tumour, cells ;

8 hybridoma cells formed ;

9 hybridoma cells producing antibodies are identified ;

10 cultured on a large scale (to secrete monoclonal antibodies) ; [max 7]

[Total:15]

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