CAMBRIDGE
INTERNATIONAL EXAMINATIONS

JUNE 2002

GCE Advanced Level

# MARK SCHEME

## MAXIMUM MARK : 50

## SYLLABUS/COMPONENT :9700 /6

## BIOLOGY
## (OPTIONS (A2))

UNIVERSITY of CAMBRIDGE
Local Examinations Syndicate

## OPTION 1 – BIODIVERSITY

1 (a) **A** – Chordata / chordates *and*
myotomes / segmented muscle blocks / notochord / dorsal nerve cord / post-anal tail / visceral/pharyngeal clefts/slits ;

**B** – Echinodermata / echinoderms *and*
pentamerous symmetry / tube feet /spines ;

**C** – Cnidaria *and*
radial symmetry / tentacles ; **3**

(b) (i) annelid triploblastic, cnidarian diploblastic ;
annelid has double body openings, cnidarian single ;
annelid has CNS / nerve cord, cnidarian nerve net ;
annelid bilaterally symmetrical, cnidarian radially ;
annelid has mesoderm, cnidarian has mesogloea ;
annelid segmented (cnidarian not) ;
annelid has coelom (cnidarian not) ;
annelid has blood vessels / pseudo heart (cnidarian not) **3 max**

(ii) **P** / chaetae, for grip / anchorage ;
ref retraction when moving / protrusion when stationary ;
**Q** and **R** are antagonistic muscles ;
**Q** / circular muscles create long, thin segments (contracted) ;
**R** / longitudinal muscles create short, fat segments (contracted) ;
waves of contraction (run from back to front) ;
muscles work against, coelom / **S** / coelom / **S**, acts as hydrostatic skeleton ;
**4**

(c) (i) heterotrophs / eat organic material ;
in / on, soil ;
eat humus / dead leaves ;
ref to prostomium (gripping food) ;
ref to (muscular) pharynx (swallowing) ; **2 max**

(ii) earthworms, feed selectively / do not eat all soil ;
more of each element (in casts) because these are present in leaves (in higher concentration than soil) ;
calcium from calcium pectate / in cell walls ;
magnesium from chlorophyll ;
carbon from, organic compounds (in leaves) /named organic compound ;
earthworms may bring up leached material which has been deposited in lower layers of the soil ; **3 max**

**Total: 15**

**2 (a)** to provide land for agriculture ;
space for housing / industry ;
road building ;
wood for, building / fuel ;
timber (for sale / export) ;
mining activity ; **3 max**

**(b) (i)** greater mortality at edge than at centre ;
above 60 cm / larger / older, trees most affected ;
uniform percentage mortality up to 60 cm ;
use of figures ( % + diameter) ; **2 max**

**(ii)** conditions at edge less suitable for trees ;
more wind (at edge) ;
larger trees more susceptible to wind damage ;
lower humidity (at edge) ;
more intense grazing (at edge) ;
ref erosion / nutrient loss at edges ;
damage from logging activities ;
*accept converse throughout* **3 max**

**(c) (i)** fewer seedlings in smaller areas ;
always most seedlings at interior (applies to both) ;
less variation in 10 ha than 100 ha / steady decrease in 100 ha (interior to corner) ;
similar number throughout 10 ha fragment and at corners of 100 ha fragment ; **2 max**

**(ii)** higher proportion of 'edge' in smaller fragments ;
so more trees killed ;
especially, larger / older, ones that would be producing (most) seeds ;
trees do not, flower / set seed, so easily at edges ;
(so) fewer seeds produced in smaller fragments ;
environment in smaller fragments, not so suitable for germination / higher rate of transpiration ;
because soil is drier ;
seeds more likely to be eaten before germination in smaller fragments ; **3 max**

**(d)** small fragments will have lower biodiversity than large ones ;
make forest reserves as large as possible ;
corridors between fragments ; **2 max**

**Total: 15**

3 (a) (i) *E. coli* is a prokaryote, *Paramecium* is a eukaryote ;
E has no nucleus, P has nucleus / two nuclei ;
E has naked DNA, P has DNA associated with histones / true chromosomes ;
E DNA is loop, P DNA linear ;
E has no membrane-bound organelles / named organelles, P has ;
E has cell wall, P does not have cell wall ;
E has smaller ribosomes than P ;
E has no cilia, P has cilia ;
E has pili / fimbriae, P does not ;
E does not have contractile vacuole, P has ;
E has plasmid(s), not in P ;
P has food vacuoles, none in E ;
P has, gullet / oral groove, not in E ; **8 max**

(ii) genetic engineering / gene technology ;
DNA from other organisms inserted into bacteria ;
any example, e.g. insulin / HGH / BST ;

*Agrobacterium tumefaciens* ;
used as vector / to insert genes, into plants ;
detail ;
example of genes / characters used (disease resistance, resistance to herbicides) ;

*Lactobacillus / Bacillus subtilis / Serratis* ;
as silage inoculant ;
speeds fermentation / increases nutrient content ;

*Acetobacter* ;
Vinegar production ;
Converts ethanol to ethanoic / acetic acid ;

*Bacillus thuringiensis* ;
used as insecticide ;
sprayed onto crops (e.g. cabbages) ;
Bt toxin gene inserted into crop plants ;

blue-greens / cyanobacteria / *Spirulina* ;
grown for single cell protein ;

ref oil spills ;
e.g. bacterium ;

*Streptococcus / Lactobacillus* ;
cheese / yoghurt, production ;
bacteria convert sugars to lactic acid ;

thermophillic bacteria ;
as source of enzymes ; **6 max**
e.g. proteases / lipases / amylases, for washing powders ;

(iii) *Saccharomyces* used for this ;
fermentation ;
converts sugars to ethanol / alcohol ;
production of gasohol / alcoholic beverages ;

bread making ;
ref carbon dioxide production ;

antibiotic production / named antibiotic ;
detail / *Penicillium* / *Streptomyces* ;

blue cheeses ;
detail / flavour / inoculation detail ;

mycoprotein ;
detail / *Fusarium* / ref non-meat protein / low fat / high fibre ;

sources of enzymes ;
detail ; **6 max**

**Total: 20**

**(b) (i)** bryophytes have no / relatively unspecialised, vascular tissue ;
filicinophytes have xylem and phloem ;
xylem has (vessels and) tracheids ;
b have rhizoids ;
f (sporophyte) have true roots / f have rhizoids only on gametophyte ;
b have thallus ;
f have leaves / fronds ;
frond detail, e.g. rachis, pinnae ;
b have no true stem ;
f have stem with supporting tissue ;
f (often) have underground stem / rhizome ;
b have dominant gametophyte stage, f has dominant sporophyte stage ;
(some) bs have no stomata, (all) f have stomata ;
f have sporangia in clusters / sori, on leaves, b do not ;
detail sporangia structure e.g. tapetum, annulus ;
b detail of sporophyte e.g. capsule with peristome ; **8 max**

(ii) poorly adapted / confined to damp environments ;
R dark / shady
(gametophytes) have rhizoids for anchorage to substrate ;
rhizoids for absorption of, water / ions ;
some water transport tissues ;
but not well-developed ;
spores are resistant to desiccation ;
no lignin / so rely on turgor for support ;
so cannot grow very tall ;
leaves (usually) one cell thick ;
(most have) no cuticle ;
so lose water (by evaporation) easily ;
gametes require water for, fertilisation / sperm to swim ;
gametes surrounded by (sterile) cells that prevent drying out ;
some have stomata that can be closed ;
some have waxy cuticle ;
some mosses can survive long periods of desiccation /
ref Sphagnum 'wick' effect ; **6 max**

(iii) well adapted to life on land ;
coniferophyte has vascular tissue, so water is transported to all cells / provide support ;
tracheids / lignified cells / woody tissue ;
secondary growth provides more, supporting / conducting, tissue ;
so can grow large / tall ;
so can intercept more light for photosynthesis ;
has (true) roots so can obtain water from, deep in soil / over wide area / ref anchorage ;
leaf shape / cuticle reduces water loss / transpiration ;
bark / cork, resistant to fire ;
wind pollination ;
male gametes, inside pollen grains, protected / resistant to drying ;
fertilisation internal / gametes do not have to swim / gametes move down pollen tube ;
fertilisation not dependent on wet conditions ;
embryo develops in / protected in, seed ;
wind dispersal ;
seed can lie dormant through, dry / cold, conditions ; **6 max**

**Total: 20**

## OPTION 2 - BIOTECHNOLOGY

**1 (a)** involves breakdown of starch by acid hydrolysis / amylase ;
to sugars / named sugar ;
anaerobic fermentation ;
named organism : *Saccharomyces cerevisiae* / *Zygomyces* / *Zygomonas*;
ref controlled conditions ;
ref distillation ;
detail e.g. sterilised apparatus / batch process / aerobic initially ; **4 max**

**(b)** less need to extract / transport fossil fuels ;
oil is finite / biofuels are made from renewable sources / reduces use of fossil fuels ;
biofuels produce fewer harmful emissions during production ;
biofuels produce fewer harmful emissions during combustion ; **3 max**
reduction in the build up of greenhouse gases ;

**(c)** *advantages*

(engine performance) - good / more powerful ;
(exhaust emissions) - less pollution / named example ;

*disadvantages* – ***max 3***

(maintenance costs) - parts costs more / need replacing more often ;
(fuel tank weight) - car heavier ;
(drivability) - harder to drive ;
(solvent action) - any spillage damages the paintwork more ;
(cold weather start) - harder to start car in colder climates ; **4 max**

**(d)** country already produces oil ;
requires a ready source of fermentable carbohydrate ;
requires a cheap power supply for distillery ;
not all countries have the appropriate technology ;
no use in cold climates ; **2 max**

**(e)** other fuels expensive / not available ;
uses waste materials ;
reduces deforestation ;
reduces soil erosion ;
sludge left can be used as a fertiliser / increases soil fertility ;
localised production ;
**2 max**

**Total: 15**

**2 (a)** oxygen consumption / rate oxygen is used up ;
pH ;
$H_2O_2$ production / rate $H_2O_2$ formed ; **2 max**

**(b) (i)** undernourished / stunted growth ;
fatigue / fainting / coma ;
high blood sugar levels / glucose in urine ;
excessive thirst ;
eye damage ; **2 max**

**(ii)** sugar consumption increases with time ;
number of cases of diabetes increases with time ;
use of figures ;
increase in sugar consumption related to increase in diabetes ; **3 max**

**(iii)** not a direct relationship between sugar consumption and diabetes ;
named other factor involved e.g. exercise / other dietary factors / improved diagnosis ;
genetic link ; **2 max**

**(c)** injections no longer needed ;
reduces the long-term chance of infection ;
cures the disease ;
leads to a better lifestyle / less need to watch diet as carefully ; **2 max**

**(d)** cow /pig insulin differs in structure from human insulin ;
side effects / may cause an allergic immune system reaction in some people ;
possibility of disease transmission ;
genetically engineered insulin can be produced in any quantity ;
cheaper to produce ;
some people will not / inject themselves with insulin from animals (for religious / personal reasons) ;
human insulin quicker effect ; **4 max**

**Total: 15**

**3 (a) (i)** organism *Fusarium graminearum* ;
grown at 25 - 35°C ;
looped air flow fermenter / pressure cycle fermenter ;
any named nutrient requirement eg $NH_3$ / glucose / minerals salts ;
choline increase hyphal length ;
cooling jacket / heat exchanger ;
continuously harvested ;
RNA reduced ;
by heating to 60 - 70°C ;
produces mycoprotein fibres / filaments ;
need to be extracted and purified ;
cut / coloured / flavoured to produce final product ; **8 max**

**(ii)** ref fruit ripening ;
better tasting fruit / vegetables ;
prevents fruit softening / spoilage ;
yield stability ;
locate important genetic traits and fast track them into breeding material;
e.g. stress tolerance genes to the cold / high pH tolerance ;
pest / disease control ;
modification of oils / starch / protein / fibre content ;
enhanced digestibility for forage animals ;
e.g. Canola plant producing oils for lubricants / detergents ;
potatoes with starches that absorb less fat on cooking ;
increase yield saves water in areas requiring irrigation ;
will reduce demands on the environment / less space required ;
crop digestibility may provide benefits in wood pulping ; **6 max**

**(iii)** enhanced / accelerated livestock improvement programmes ;
by taking advantage of genes not readily accessible ;
through normal selective breeding ;
e.g. enhanced disease resistance ;
chickens that resist infection by *Salmonella* ;
produce milk which contains therapeutic / medically important proteins ;
to alter the milk to improve nutritional value ;
achieved by inserting copies of human genes for these proteins ;
and attaching them to regulatory genes ;
so that the inserted gene only works in the mammary glands ;
leaner meat produced ; **6 max**

**Total: 20**

(b) (i) increases yield ;
saves water in areas requiring irrigation ;
less space required ;
plants genetically engineered able to fix nitrogen ;
external fertilisers not necessary ;
excess fertiliser no longer causing pollution ;
resistant to the attack of insects ;
resistant to disease ;
prevents fruit softening / spoilage ; **6 max**

(ii) starter culture of bacteria ;
*Lactobacillus bulgaricus*, / *Lactobacillus acidophilus* ;
and *Streptococcus thermophillus* / *Bifido bifidum* ;
added to milk ;
incubated at 38 - 46°C ;
*Lactobacillus* breaks down protein ;
releasing peptides ;
which encourage *Streptococcus* to grow ;
*Streptococcus* produces formic acid and $CO_2$ ;
which stimulate *Lactobacillus* ;
pH reduced to 4.4 - 4.6 ;
*Lactobacillus* produces lactic acid ;
both organisms produce acetaldehyde ;
which gives yoghurt its characteristic flavour ; **7 max**

(iii) (inject) papain ;
a protease ;
into cattle immediately before / after slaughter ;
enzyme circulates through tissues ;
begins breakdown of fibrous proteins / collagen / elastin ;
holding connective tissue together ;
releases muscle fibre ;
reduces storage time ;

may cause an allergic reaction in some people ;
public suspicious of treated meat ; **7 max**

**Total: 20**

## OPTION 3 – GROWTH, DEVELOPMENT AND REPRODUCTION

1 (a) allometric ; **1**

(b) (i) baby at birth has head half as big ; (or eight week fetus has head twice as big)
adult has head one quarter as big ; (or fetus has head four times as big) **2**

(ii) hormones ;
growth hormone / thyroxin / testosterone ;
growth of brain early ;
growth of sense organs / examples of sense organs ;
ref gene switching (in different tissues) ; **3 max**

(c) (i) most birth masses around 3 kg ;
fewest deaths / lowest mortality, just above 3 kg ;
approx 3% mortality (A 2.5 – 3.5%) ;
increased mortality at lower and higher birth masses ;
ref supporting figures of extreme birth masses and mortality ; **3 max**

(ii) natural selection ;
favours birth masses close to 3 kg approx ;
heavy and light babies more likely to die ;
ref stabilising selection ;
so alleles (genes) for 3 kg birth masses passed on ; **2 max**

(d) smokers have 17 - 18% / most, babies at 3 kg ;
non smokers have 18.5 – 19.5% / most, babies above 3 kg ;
on average, smokers have lighter babies ; **2 max**

(e) IUGR / intrauterine growth retardation ;
carbon monoxide, diffuses across placenta / forms carboxyhaemoglobin / reduces oxygen to fetus ;
nicotine, affects nervous system / fetal circulation / placenta ;
birth complications / premature births ;
resistance to infection reduced ;
breathing problems / lungs immature, afterbirth ;
vitamin C uptake of mother reduced ; **2 max**

**Total: 15**

2 (a) carbohydrate – sucrose from phloem / parent plant declines ;
glucose declines, as used for synthesis / respiration ;
starch initial reserve ;
ref to amylase ;
oil – oil synthesised from carbohydrates ;
starch converted to oil ; **4 max**

**(b)** low density / mass, allowing easier dispersal ;
equal mass of lipid yields more energy than equal mass of carbohydrates ;
ref to higher proportion of hydrogen relative to oxygen ;
ref reduced microbial attack ; **2 max**

**(c)** digestion / hydrolysis ; R breakdown
ref enzymes / lipases ;
fatty acids for synthesis ;
ref respiration ;
detail of respiration ; **3 max**

**(d)** dry mass would fall initially ;
reserves used up ;
reserves respired ;
ref to oil / starch ;
carbon dioxide released ;
after plumule / leaves emerged ;
when photosynthesis exceeds respiration ;
dry mass would increase ; **4 max**

**(e)** breaks dormancy ;
acts on aleurone layer ;
amylase / hydrolytic enzymes, activity increased / starch digestion affected ;
effect on protein synthesis / RNA synthesis ;
rise during chilling / may remove need for cold period ;
ref gene switching ;
acts with IAA in elongation ; **2 max**

**Total: 15**

**3 (a) (i)** (2 different methods)
method and appropriate plant ;;
part / parts of plant involved ;;
practical detail of selected technique ;; **6**

(ii) *advantages*

only one parent needed ;
offspring genetically identical / clones ;
known growing conditions ;
known time of maturity / all together ;
known quality / characteristics / example ;
large numbers / rapid production, (from one stock plant) ;
plant diseases avoided with meristems ;
micropropagation at any time of year ;
(exotic) plants that are hard to produce from seed can be propagated ;
cloning following genetic engineering ;

*5 max for advantages*

*disadvantages*

labour intensive ;
problem of disease transmission ;
problem of disease spread through a whole crop ;
problems of harvesting at one go ; **7 max**

(iii) meiosis ;
producing pollen ; (**R** male gametes by meiosis)
producing embryo sac ; (**R** female gametes by meiosis)
independent assortment ;
detail ;
crossing-over ;
detail ;
new allele combinations ;
non-disjunction ;
random fusion of gametes ;
two parents involved ;
ref natural selection ;
ref to cross-pollination ; **7 max**

**Total: 20**

3 (b) (i) secretion of thyroxin / $T_4$ and tri-iodothyronine / $T_3$ ;
iodine / iodide concentrated from blood ;
thyroglobulin made / stored ;
hydrolysed / ref enzyme action ;
secretion into, blood plasma / capillaries ;
thyroxin controls BMR ;
ref oxygen / food utilisation / heat generation ;
cellular respiration / mitochondria stimulated ;
thyroxin acts on nucleus / DNA / genes ;
switches on RNA synthesis ;
protein synthesis ;
growth / development affected ;
skeleton / bone ;
mental development ;
heart rate ; **8 max**

**(ii)** ref cold / season / body temperature ;
hypothalamus produces TRH / TRF;
TRH / TRF stimulates anterior pituitary to produce TSH ;
low thyroxin causes anterior pituitary to secrete TSH ;
high thyroxin inhibits TSH ;
action via hypothalamus ;
ref negative feedback in right context ;
ref homeostasis ;
ref blood vessels from hypothalamus to ant pituitary ; **6 max**

**(iii)** ref menopause symptoms ;
ref hysterectomy / ovaries removed ;
ovaries less sensitive to FSH ;

consideration of age for HRT ;
oestrogen taken in pills / implants ;
osteoporosis / loss of calcium from bones ;
oestrogen antagonistic to parathormone ;
reduced risk of CHD ;
ref to side effects ;
example of side effects (blood clotting) ; **6 max**

**Total : 20**

## OPTION 4 – APPLICATIONS OF GENETICS

**1 (a) (i)** dominant ;
epistasis ; **2**

**(ii)** Inhibition / suppression ;
codes for, protein/polypeptide ;
which blocks expression of banding locus ;
codes for abnormal enzyme ;
which cannot make band pigment ;
AVP ;; **3 max**

**(b)** *P* [BBMM] x bbmm ;
*gametes* BM x bm ;
$F_1$ BbMm unbanded ;

*Allow error carried forward (ECF/consequential) marks for $F_1$ gametes and $F_2$ gametes*

BM Bm bM bm x same ;

*Punnett square* genotypes ; ;
phenotypes ; ;

| gametes | BM | Bm | bM | bm |
|---|---|---|---|---|
| BM | BBMM unbanded | BBMm unbanded | BbMM unbanded | BbMm unbanded |
| Bm | BBMm unbanded | Bbmm unbanded | BbMm unbanded | Bbmm unbanded |
| bM | BbMM unbanded | BbMm unbanded | bbMM midbanded | bbMm midbanded |
| bm | BbMm unbanded | Bbmm unbanded | bbMm midbanded | bbmm five-banded |

*ratio* 12 unbanded : 3 midbanded : 1 five-banded ; **8 max**

**(c) (i)** genes on the same chromosome ; **1**

**(ii)** 1 unbanded pink: 1 banded yellow ; **1**

**Total: 15**

**2 (a)** Correct ref to PCR ;
cut (into fragments) ;
by enzymes ;
restriction enzyme / named restriction enzyme ;
buffered ;
loaded into wells at one end ;
of (agarose) gel ; **4 max**

**(b)** fragment including mutant allele shorter / lighter ;
moves further / faster (in electrophoresis) ;
*[A converse points]* **2**

**(c)** code for, tissue type / self v. not self ;
4 (6) genes ;
many alleles ;
rejection if not matched ;
some more important than others (in rejection) ;
ref haplotype / linkage / supergene ;
match, more likely in family / rare outside family ; **4 max**

**(d)** dominant allele added to existing genotype ;
recessive inactive so effect dominant seen ;
mutant dominant would have to be, inactivated / selectively removed ;
not, easy / feasible as yet ; **3 max**

**(e)** normal mouse has two normal mouse β globin alleles ;
with, switch / promoter ;
in usual place in chromosome ;
much, easier / quicker, to, express / transcribe, than added human gene ;
heterozygous mouse has one inactive allele / only one active allele ;
so human gene switched on ;
ref figures; (x2 or half) **2 max**

**Total: 15**

3 (a) (i) form of gene bank ;
source of genetic variation ;
source of alleles ;
of recently unfashionable traits ;
of unrecognised traits ;
for selective breeding ;
in future ;
possible resistance to, pathogens / pests / climatic conditions ;
may be needed to counteract inbreeding ; **6 max**

(ii) named animal ;
e.g. of trait selected for ;
parents chosen for trait(s) ;
and general fitness ;
ref progeny testing to identify suitable parent ;
especially for selection of sex limited trait ;
ref heritability / $V_G$ ;
ref background genes to suit conditions ;
ref AI to maximise offspring from suitable male ;
and to allow long-distance mating ;
ref embryo transplantation to maximise offspring from suitable female ;
idea selection over many generations ;
ref avoiding inbreeding ; **8 max**

(iii) inbreeding depression ;
loss of, fitness / fertility ;
loss of genetic variation ;
loss of alleles ;
loss of heterozygosity / increase in homozygosity ;
increase in, expression of/ homozygous, deleterious recessives ;
increase in 'overdominance' ;
animals normally 'outbreeders' ;
outbreeders affected more than inbreeders ; **6 max**

**Total: 20**

**3 (b) (i)** *either*
unpredictable / spontaneous / random change ;

*gene mutation – max 4*
change in structure of DNA ;
change in base sequence ;
addition / deletion ;
substitution / inversion ;
detail e.g. ref frame shift ;

*chromosome mutation – max 4*
change in chromosome structure ;
inversion / translocation / duplication / deletion ;
change in number of chromosomes ;
change in number of sets of chromosomes ;
ref. auto / allopolyploidy ;
detail ; **6 max**

**(ii)**

| *CF – max 4* | *HD – max 4* |
|---|---|
| recessive allele v. | dominant allele ; (*1 mark*) |
| autosomal / chromosome 7 ; | autosomal / chromosome 4 ; (*both autosomal = 1*) |
| deletion ; | stutter /(triplet) repeat ; |
| triplet missing ; | CAG ; |
| homozygote recessive has CF ; | heterozygote develops HD ; |
| heterozygote carrier ; | |
| 2 carriers have 1 in 4 chance of producing CF child / other statement of inheritance ; | heterozygote has 1 in 2 chance of passing allele to child ; |
| common in Caucasians v. | rare ; (*1 mark*) |

**8 max**

**(iii)** (most bacteria) reproduce rapidly ;
frequent DNA replication ;
chances for, mutation / mistake / error increased ;
no / fewer, editing enzymes ;
mutation passed to large number of descendents / ref vertical transmission ;
mutation may be on plasmid ;
transferred via horizontal transmission ;
even to different species ;
conjugation / process described ;
transformation / transduction / process described ;
ref selection ; **6 max**

**Total: 20**