

CAMBRIDGE
INTERNATIONAL EXAMINATIONS

June 2003

GCE A LEVEL

MARK SCHEME

MAXIMUM MARK: 50

SYLLABUS/COMPONENT: 9700/06

BIOLOGY
Paper 6 (Options (A2))



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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;

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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

T₂ – 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;

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(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

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(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]

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Option 2 – Biotechnology

- 1 (a)** use of living organisms/biological agents/animals/plants/cells/
microorganisms;
to, produce useful products/produce foods/produce medicines/
produce chemicals/process other materials/treat waste;
in fermenter/culture vessel/AW; **max 2**
- (b)** ref. availability of information;
ref. public knowledge/understanding/awareness (of information);
ref. complexity of issues;
ref. actual/potential benefits importance;
ref. actual/potential risks;
ref. perceptions of benefit/risk;
ref. political/commercial pressures;
ref. misinformation/AW; **max 4**
- (c) (i)** initial levels, normal higher than GM/ora;
normal has a more rapid rise from 0-4 days/ora;
normal reaches much higher level at 4/8 days/ora;
normal stays same level from (approx.) 4-8 days/while GM rises
slightly;
normal drops again after 7/8 days/GM continues to rise after 7/8 days; **max 3**
- (ii)** idea of – start later;
idea of – happen slower; **2**
- (iii)** not ripe/green when picked;
long shelf life/AW;
will not over-ripen;
do not ripen too quickly;
do not become squashy/firmer;
AVP; **max 2**
- (iv)** ref. moral principles/personal choice/values of society/AW;
ref. to actual/potential/perceived advantages/named advantage;
ref. to actual/potential/perceived risks/hazards/named risk/hazard;
AVP. **max 2**

[15]

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- 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)** attenuated/weakened organism can survive attenuation/still have
ability to cause disease;
or regain pathogenicity/regain ability to cause disease;
very rare/AW;
ref. allergy to vaccine/hypersensitivity;
ref. side effects;
named side effect linked to appropriate vaccine;
chance of serious injury or death;
but chance of dying of disease much greater; **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]**

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- 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 (15°-18° C);
 ref. effects of low temperatures (e.g. flowers liable to split/weaker flower stems/slower growth);
 ref. effect of higher temperatures (e.g. denaturation of enzymes);
 requires Na⁺/Ca²⁺ levels to be high to establish plants;
- N supplied as, nitrate/not ammonium salts;
 ref. pH around 6/below 7;
 ref. low humidity/need for ventilation;
 AVP (e.g. CaNO₄ requirements decrease during flowering/wider spacing between cuttings reduces disease);

max 8

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

max 6

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(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;

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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;
 under moist conditions/soaked;
 causes germination of grain;
 enzymes/amylases hydrolyse starch;
 dry in kiln;
 crush dried grain/milling/grist;
 mashing/mix crush grain with water;
 allow further breakdown of starch;
 add hops;
 for flavour;
 and sterilise wort;
 add yeast;
 fermentation;
 produce CO₂ and alcohol;

grapes;
 crushed;
 to extract sugars;
 etc. for wine;

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

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- (iii) use *Fusarium*;
grown on flour waste/named medium;
other nutrient sources, e.g. glucose/minerals/ammonia;
continuous aseptic culture;
air lift fermenter;
heat exchanger;
mycelium harvested;
centrifuged;
water content reduced;
RNA reduced;
by ribonucleases/heating to 60-70°C;
pressed/processed;
flavour added;
colour added;
high protein content;
no cholesterol.

max 6

[20]

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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**

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- (b) (pericarp) becomes, more fleshy/other possible change;
growth/swells;
colour change;
increase in, attractants/sugars/scent; max 3
- (c) *needs knowledge of:*
undifferentiated/meristematic, cells in, cutting/other propagule;
stimulated by plant growth substances/plant growth regulators;
auxin/cytokinin;
form adventitious roots;
ref. tissue culture; max 3
- (d) asexual reproduction;
genetically identical/clone;
original susceptible so all susceptible to same pathogen;
only change via mutation; max 3
- (e) meiosis fails;
in pollen mother cell/embryo sac mother cell;
problem, in synapsis/when homologous chromosomes pair;
in prophase 1;
crossing over between, three chromosomes/six chromatids,
results in tangle; max 3
- Total: 15**
- 3 (a) (i) *absolute growth rate:* also called actual growth rate;
measure of how rate of growth varies with time;
plot of increase in parameter in unit time against time;
e.g. kg per year plotted against year/(dm/dt) against (t)/other e.g.;
useful for showing, when growth is most rapid/how rate changes with time;
- relative growth rate:* also called specific growth rate;
takes into account existing growth;
absolute growth rate divided by parameter;
e.g. change in mass in one year divided by mass at beginning of year (dm/dt .
 $1/m$);
shows growth rate relative to size of organism; max 6
- (ii) suitable example; (*that will allow for samples over time*)
large number of organisms;
in identical conditions;
e.g. of condition (e.g. temperature/water supply/humidity/nutrients);
second e.g. of condition;
samples taken at regular intervals;
randomly;
organism separated from medium;
dried in oven/other suitable conditions;
cooled in desiccator;
repeat to constant mass;
average dry mass; max 8

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- (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 characteristics in female;
stimulates spermatogenesis;
LH (ICSH) from anterior pituitary;
stimulates ovulation;
stimulates formation of corpus luteum;
stimulates secretion of progesterone;
stimulates secretion of testosterone;
ref. secondary sexual characteristics in male;
FSH and LH control menstrual cycle;

max 8

- (iii) secretes, thyroxine/T₄;
secretes, triiodothyronine/T₃;
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

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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**

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- (b) (i) study of ion transport through cell membrane;
if no CFTR/protein (produced and put into cell membrane) then no transport; **2**
- (ii) inability to transport HCO_3^- ;
change in transport ratio;
transport ratio < 0.1 : 1.0;
increase in acidity/decrease in pH;
ref. effect on mucus; **max 3**
- (iii) poor digestion of protein;
lipid;
starch;
malnutrition;
ref. to effect on production of, insulin/glucagon; **max 2**
- Total: 15**
- 3 (a) (i) to alter phenotype of domesticated animals or plants;
trait of, use/value, to man.
- Allow following examples of use:*
quantitative agricultural plant improvement;
quantitative agricultural animal improvement;
qualitative agricultural improvement (plant or animal);
ornamental example in plants;
ornamental example in animals;
other example; (i.e. sporting, etc.) **max 6**
- (ii) plant without resistance crossed with resistant plant;
offspring 1 seeds sown;
offspring 1 plants challenged by disease/AW;
resistant offspring 1 interbred;
selection and interbreeding continued for many generations;
resistant offspring 1 backcrossed to parent;
for background genes;
for traits other than resistance;
selection and backcrossing continued for many generations;
resistant parent, same species/primary (or secondary) gene pool;
resistant parent, different species/tertiary gene pool;
practical detail 1;
practical detail 2; [male sterility/removal of anthers/bagging/pollination]
gene bank/landrace/wild species; **max 8**
- (iii) orthodox seeds;
seeds dehydrated;
stored at -20°C ;
storage life doubled by 5°C (A approx.) reduction in temperature;
storage life doubled by 2% (A approx.) reduction in humidity;
germination tests every 5 years;
recommended threshold value = 85% germination;
then seeds grown and fresh seed collected;
recalcitrant seeds cannot be dried and frozen; **max 6**
- Total: 20**

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- (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