2008 'A' Level
H2 Biology
Mark Scheme

PAPER 1 (MCQ)

1	**A**
2	**B**
3	**C**
4	**A**
5	**B**

6	**A**
7	**B**
8	**A**
9	**C**
10	**D**

11	**B**
12	**A**
13	**C**
14	**B**
15	**B**

16	**D**
17	**D**
18	**C**
19	**C**
20	**C**

21	**D**
22	**A**
23	**C**
24	**B**
25	**C**

26	**B**
27	**D**
28	**D**
29	**A**
30	**A**

31	**C**
32	**B**
33	**C**
34	**A**
35	**D**

36	**A**
37	**B**
38	**B**
39	**D**
40	**C**

PAPER 2 (CORE)

QUESTION 1

(a)

(i)

1 Metaphase
2 Anaphase

(ii)

1 centromeres divide after 15 min **R centromeres split**
2 chromatids separate to become chromosomes which are then pulled apart by spindle fibres to opposite poles of the cell

REJECT vague references to moving of chromatids without reference to spindle fibres
REJECT vague references to ends of the cells rather than poles of the cell

(iii)

1 poles move closer together and then move further apart
2 ref supporting data
3 role of pole-to-pole fibres (polar microtubules/polar spindle fibres) in elongating the centre of the spindle so that poles are pushed further apart

REJECT poor reference to curve C moving

(b)

1 repetitive DNA
2 involved in chromatids adhesion followed by division during anaphase
3 ref to kinetochore formation on centromeres, being proteins which bind onto centromeres to anchor spindle fibres so that they could be pulled to the poles
4 involved in chromatid alignment and separation

(c)

1 homologous chromosomes form bivalents in meiosis but not mitosis
2 crossing over occurs in meiosis but not in mitosis
3 homologous pairs line up at the equator in meiosis but in mitosis chromosomes line up singly
4 homologous chromosomes separate in anaphase 1 of meiosis but chromatids separate in anaphase of mitosis
5 meiosis results in the haploid number of chromosomes but mitosis maintains the diploid number.
6 there are 2 divisions in meiosis but only one in mitosis.

Examiner's comments: Note that each mark requires a difference to be stated between the behaviour of chromosomes in meiosis and mitosis.

QUESTION 2

(a)

1 (base) substitution **REJECT missense mutation, point mutation**

(b)

1 tertiary structure of the molecule changes;
2 ref different R groups of hydrophobic valine (substituting hydrophilic glutamic acid) involved in protein folding;
3 effect on HbS occurs at low oxygen concentration, hydrophobic regions on different molecules stick together, solubility of deoxygenated HbS decreases
4 HbS will polymerize into fibres, ability to carry oxygen decreases.

(c)

1 Affected red blood cells (**REJECT HbS)** will adopt a sickle shape;
2 ref tendency for red blood cells to stick/clump together;
3 sickle shaped red blood cells clog capillaries, preventing other cells from moving through capillaries; obstruction of blood flow to organs, organ damage occurs
4 shorter lifespan of red blood cells resulting in anaemia in patients.

Examiner's comments: A large number of candidates thought that once the HbS had polymerised it could not carry oxygen again.

(d)

(i)

1 Gene for HbF would be transcribed/activated/expressed;
2 Resulting in translation of mRNA to produce HbF.

(ii)

1 Less HbS in red blood cells and so there would be less polymerization
2 Less sickling of red blood cells would in turn lead to longer lifespans of red blood cell

3 HbF has a higher affinity for oxygen
4 as more oxygen can be transported

QUESTION 3

(a)

1 Haemagglutinin (HA), a glycoprotein found on the viral envelope, recognises and bind to specific receptor molecules (sialic acid) on the cell surface membrane of epithelial cells (adsorption)
2 The virus then enters via a vesicle to form endocytic vesicles (endocytosis); viral envelope then fuses with the membrane of endocytic vesicle
3 capsid released into the cytosol enzymatically removed and genome enters nucleus

(b)

1 Use of host cell's ribosomes on rough endoplasmic reticulum (rER) to translate the viral (+) mRNA into viral proteins

Examiner's comments: Reject vague reference to the use of the host cell machinery

(c)

1 encodes RNA polymerases which are not present in host cell;
2 Conversion of viral negative strand RNA to positive strand RNA for translation into viral proteins (Only positive strand RNA can be used)

(d)

1 neuraminidase enables enzymatic removal of sialic acid (from the viral envelope to prevent agglutination of the enveloped virus;
2 if neuraminidase is inhibited, new viruses cannot emerge from the infected cells to infect other cells

QUESTION 4

(a)

1 ionizing radiation like UV light, gamma rays, X-rays / chemical carcinogens like tar in cigarette smoke;
2 may induce mutations in DNA;

3 gain-of-function mutation in proto-oncogene leads to activation of oncogene
4 resulting in increased cell division (**REJECT cell growth**)

5 loss-of-function mutation in tumour suppressor genes leads to inactivation of both tumour suppressor genes
6 resulting in inability to slow down cell cycle in presence of DNA damage

(b)

(i)

1 involved in normal cell division;
2 encodes proteins involved as transcription factors stimulating expression of other genes / encodes signal transduction molecules that stimulate cell division / encodes cell cycle regulators.

Examiner's comments: Candidates often failed to gain credit because their responses were not precise enough. Often candidates confused cell growth with cell division.

(ii)

1 mutated form of proto-oncogene;
2 results in uncontrolled cell division, leading to cancer

(c)

1 translocation of Myc proto-oncogene near to a gene regulatory sequence (ref highly active promoter) / increased gene amplification
2 increased transcription of Myc gene,
3 therefore increased translation of Myc mRNA

(d)

1 gene amplification results in more copies of Mdr1, leading to more copies of the transporter;
2 with more copies of the transporter, more drugs would be removed from the cell, causing the resistance to drugs

Examiner's comments: Many incorrectly suggested that with more transporters more drugs would enter the cell to cause the resistance.

(e)

1 use of a inhibitor that will bind to and block transporter
2 drugs cannot be removed from the cell

QUESTION 5

(a)

Parental phenotypes:	Purple				x	Purple			
Parental genotype:	RrEe					RrEe			
Parental gametes:	RE	Re	rE	re		RE	Re	rE	re

F_1 genotypes:

Punette square:

	RE	Re	rE	re
RE	RREE	RREe	RrEE	RrEe
Re	RREe	RRee	RrEe	Rree
rE	RrEE	RrEe	rrEE	rrEe
re	RrEe	Rree	rrEe	rree

purple grains
red grains
white grains

F_1 phenotypes:	Purple grains	Red grains	White grains
F_1 phenotypic ratio:	9	3	4

1 Parental genotype – RrEe
2 Parental gametes – RE, Re, rE, re
3 F_1 genotypes
4 corresponds genotypes to phenotypes (legend for Punett square)
5 F_1 phenotypic ratio
6 correct presentation of genetic diagram

Examiners' comments: A quick way to come up with the ratio is to divide the total number of the three phenotypes by 16.

Phenotype		**Divide by 199.125**	**Approximate ratio**
Purple grains	1836	9.22	9
Red grains	578	2.90	3
White grains	772	3.87	4
Total	**3186**		

Since the Punnett square has 16 genotypes, 3186 divided by 16 = 199.125. Next, divide each of the observed numbers by 199.125 to obtain the approximate ratios!

(b)

1 to determine if the difference between observed and expected results is significant or due to chance
2 to draw conclusions when there are differences from expected ratios

(c)

1 Epistasis

(d)

1 Both R and E alleles code for enzymes in a metabolic pathway when the products of one stage becomes the substrate of the next
2 rr is epistatic over the E/e locus
3 if a dominant allele is not present (or if both alleles of the gene present are recessive), its step in the metabolic pathway is blocked and white grains are produced

(e)

1 cross the white grain plant with a red plant with genotype RRee or Rree
2 cross would give either all red or red and white grains
3 if any purple grains are seen, then the original plant grown from a white grain must have at least one E at the E/e locus

QUESTION 6

(a)

A

1 Binding of interferon to α-inteferon receptors results in receptor dimerisation
2 activating Tyk2 and Jak1 on tails of the receptors, both of which add phosphate (from ATP) to the other polypeptide (autophosphorylation)

B

1 activated Tyk2 and Jak1 recruit and phosphorylate specific relay proteins Stat2, Stat 1, and SH2 domains
2 which when activated, leave the interferon receptors as a complex, associate with other gene regulatory proteins to bind α-interferon response element in target gene, activating transcription of target gene

Examiners' comments: Responses were not precise enough. The question asks for a description of stages **A** and **B** and therefore by **using the information given in the diagram** i.e. specifically referring to Jaks, SH2 domains, STATs and phosphorylation rather than just proteins, tyrosine kinases, relay proteins, activation, more marks would have been gained by many candidates

(b)

1 large and polar molecule
2 unable to pass through hydrophobic core of the phospholipid bilayer of cell surface membrane

(c)

1 signal amplification
2 single ligand molecule can activate an increasing number of molecules at each consecutive step in the signal transduction pathway to elicit a large response

3 ability to regulate or control the response
4 ref. specificity of response depends on the collection of signalling molecules involved

5 ability of a molecule reaching a cell membrane to activate genes in the nucleus
6 Allows for transmission of signal across membrane barriers. Hydrophilic ligands are able to activate gene expression in the nucleus even though these molecules cannot traverse the hydrophobic cell membrane

7 a single signal molecule to trigger numerous cellular reactions at once
8 the cell then integrates information from different signalling pathways to initiate an appropriate response

9 activation of many cells simultaneously
10 different cells can respond differently to the same chemical signal

QUESTION 7

(a)

1 type of food available;
2 details of food types like type of seeds/cactus flowers and fruits;
3 availability of food / competition for food (with descriptions)

(b)

1 Increase in BMP4 expression increases beak height and width
2 Increase in CaM increases beak length
3 Ref. the extent of expression such as low/moderate etc. or the balance of expression

(c)

1 BMP4 and CaM present in the ancestor
2 Different levels of gene expression which leads to variation in birds
3 Selection pressure like availability of different food types
4 Finches that can feed successfully will survive and reproduce, passing on genes to offspring

Examiners' comments: A significant number of candidates incorrectly referred to traits/characteristics rather than genes being passed to offspring

(d)

1 Islands could function as a geographical barrier or isolation;
2 Presence of different conditions on the different islands;
3 Lack of gene flow between finches of evolving populations.

QUESTION 8

(a) Describe how the Calvin cycle differs from Krebs cycle. [7]

Calvin Cycle	Krebs Cycle
Occurs in stroma of chloroplast.	Occurs in matrix of mitochondrion.
Electron carrier = $NADP^+$	Electron carrier = NAD^+
Carbon dioxide is fixed by Rubisco.	Carbon dioxide released by oxidative decarboxylation.
ATP used in the reduction of PGA to PGAL, and the regeneration of RuBP.	ATP synthesised by substrate level phosphorylation.

(b) Explain the small yield of ATP under anaerobic conditions in both yeast and mammals. [8]

1 anaerobic respiration took place in the absence of oxygen
2 without oxygen as the final electron acceptor
3 NAD not regenerated from NADH
4 therefore electron transport chain and subsequently the link reaction and then the Krebs cycle stopped.

5 in yeast, pyruvate was converted to ethanol and carbon dioxide
6 in mammals pyruvate converted to lactate
7 NAD regenerated in both processes
8 only glycolysis would occur
9 resulting in two molecules of ATP
10 produced via substrate level phosphorylation.

Examiner's comments: Some candidates however, although usually gaining full marks, also unnecessarily included full details of glycolysis and aerobic respiration in their answers.

(c) State the similarities between ATP production in mitochondria and chloroplasts and suggest why these similarities exist. [5]

Similarities

1 Have electron carriers embedded in membranes - inner membrane of mitochondrion and thylakoid membrane of chloroplast
2 ref electron transport chain
3 generation of a proton gradient by energy released from electron transport chain
4 potential energy of the proton gradient is used for the synthesis of ATP from ADP and Pi. by ATP synthetase **Reject ATPase**

Why similarities exist

1 both are once prokaryotes
2 both have endosymbiotic origins

QUESTION 9

(a) Describe how classification differs from phylogeny. [7]

1 classification = placing organisms into groups with reference to the terms kingdom, phylum, etc ;
2 based on their characteristics ;
3 binomial naming system was used

4 phylogeny was based on evolution;
5 involved passing genes from ancestors to descendants;

6 ref. phylogenetic tree;
7 ref. to use of DNA base sequences;

(b) Explain the advantages of using molecular methods in classifying organisms. [8]

1 able to measure the degree of relatedness
2 able to compute probable relatedness;
3 able to analyze nucleotide sequences;
4 major phenotypic differences may be due to small genetic differences;
5 some molecular differences are not visible, such as supergenes*;
6 able to use living and dead material;

7 molecular methods not dependent on subjective judgements or observations;
8 molecular methods involved quantitative differences;
9 ref.to molecular clock;
10 molecular methods can avoid the pitfalls of convergent evolution;

* A **supergene** is a group of neighbouring genes on a chromosome which are inherited together because of close genetic linkage and are functionally related in an evolutionary sense, although they are rarely co-regulated genetically

(c) Suggest how viruses evolved. [5]

1 ref. polyphyletic nature of virus evolution and therefore there is no common ancestor;
2 there are different types of viruses;
3 viruses evolve with their host
4 viruses thought to evolve as escaped genes
5 evolved from degenerate cells.

PAPER 3

QUESTION 1

(a)

(i)

1 recognise and binds to the specific sequence of bases of DNA at the restriction enzyme site
2 restriction enzyme site is 4-6 bases long
3 cuts/cleaves DNA through hydrolysis of phosphodiester bonds between nucleotides;

(ii)

1 DNA loaded into the wells in agarose gel
2 Apply an electric current, DC (direct current)
3 Negatively charged DNA moves towards the positive end of the electrode
4 Fragments of DNA separated based on molecular size
5 ref. gel matrix acting as molecular sieve;
6 longer DNA fragments migrate slower and found nearer to the wells of the gel
7 shorter fragments migrate faster and found further away from the wells
8 due to larger resistance

Not necessary – ref to description of the fragmentation of DNA by RE
Not necessary – ref to staining or visualisation of the fragments
NB: Some confuse anode and cathode

(b)

1 Percentage increase in length = 0.2/1.1 X100
2 18.2% or 18%

(c)

(i)

1 Fragment F is the topmost band for individual B & C

(ii)

1 C was <u>heterozygous</u>
2 Possessed a <u>normal allele</u> and a <u>mutant allele</u> on <u>homologous chromosomes</u>;
3 Largest band corresponding to 1.3kb indicates presence of the mutant allele due to the loss of the restriction site
4 Presence of 2 bands corresponding to 0.2kb and 1.1kb indicates presence of the normal allele as restriction enzyme cuts the allele twice.

Examiner's comments: Many candidates simply restated the principle of electrophoresis, identifying the size of the band and explaining the position of each instead of associating them correctly with the appropriate allele.

QUESTION 2

(a)

(i)

1 Cells with the ability to self-renew
2 Continually divide by mitosis

3 Unspecialized
4 Do not have any cell-specific structures for any specialized functions

5 Undifferentiated
6 Ability to differentiate into specialized cells

(ii)

1 eg. blood stem cells
2 multipotent, not totipotent or pluripotent
3 derived from the bone marrow
4 able to differentiate into red blood cells, white blood cells, and blood platelets;
5 **normal roles** = replacement of worn out blood cells from daily blood turnover and fighting infections, as well as through normal wear and tear, disease, injury.

1 eg. embryonic stem cells;
2 not totipotent but are multipotent
3 derived from inner cell mass of the blastocyst
4 able to differentiate into almost any cell type to form any organ or type of cell except the extra-embryonic tissues
5 **normal roles** = give rise to various organs in organism / multiple specialized cell types that make up the heart, lung, skin and other tissues in the developing foetus

1 eg. zygotic stem cells;
2 totipotent, pluripotent and multipotent
3 derived from cells in the morula (first few divisions after fertilization / fusion of an egg and sperm)
4 able to differentiate into any cell type of the body including extra-embryonic tissues
5 **normal roles** = give rise to the whole organism

(b)

(i)

1 substitution mutation in DNA encoding start codon;
2 results in no recognition by ribosomes;
3 mRNA not translated.

4 Insertion/deletion of nucleotides in DNA;
5 results in frameshift mutation /change in reading frame of mRNA;
6 premature termination of mRNA translation

R! stating of which genes were mutated and relating these genes to the different causes of SCID.

(ii)

1 packaging of DNA/plasmid containing normal allele of gamma-c gene into liposomes
2 phospholipid bilayer of liposome mimic structure of biological membranes
3 entry of liposomes into cell by fusion with cell membranes and release of DNA/plasmid containing normal allele of gamma-c gene into cytoplasm of stem cell

Examiner's comments: Many candidates did not use the terms gene, genome, allele and plasmid appropriately.

(iii)

1 Targets specific cells/cell types;
2 ref. retrovirus targets dividing cells;
3 ref. adenovirus targets epithelial cells;
4 due to cell-specific recognition of receptors by viruses;
5 leading to higher efficiency of gene transfer;

6 incorporation of the normal allele into the stem cells' genome;
7 stability of genes inserted/longer lasting effect;
8 due to possibility of normal allele being passed on to descendent cells;

9 introduction of the allele into the nucleus;

(c)

1 stem cells can differentiate to form <u>lymphocytes</u>;
2 with <u>normal functioning allele</u> in all cells;

3 stem cells can self-renew to replace lymphocytes which have limited life-span;
4 more permanent cure.

R! Answers relating to immune response and rejection of donor cells were irrelevant.
Examiner's comments: Many candidates left out the comment that stem cells could differentiate to form lymphocytes with the normal functional allele. Answers in terms of lymphocytes, rather than stating the advantages of using stem cells, were considered weak responses.

QUESTION 3

(a)

(i)

1 has <u>one</u> origin of replication;
2 able to replicate itself.

3 contains one restriction site;
4 to allow insertion of DNA fragments to be cloned.

5 contains genetic/selectable markers;
6 to allow identification of transformed cells.

7 contains multiple cloning site;
8 allows use of different REs.

(ii)

1 kanamycin resistance is a selectable genetic marker;
2 used to identify transformed cells that contained plasmids;

3 cells with plasmid on the <u>replica plate</u> would show resistance to kanamycin will survive when grown in kanamycin medium;

4 cells without plasmid on the <u>replica plate</u> would be selected against and do not survive in kanamycin medium

(b)

1 plant cells grown in aseptic conditions;
2 grown in culture vessels;
3 with nutrients and plant growth regulators/hormones;
4 to stimulate explants to divide by mitosis;
5 formation of callus;
6 induced to proliferate;
7 repeated sub-culturing;
8 differentiation into particular tissues;
9 via varying concentrations of plant growth regulators;
10 e.g. auxin: cytokinin concentrations for root and shoot formation respectively;

(c)

(i)

1 higher yield;
2 plants producing CpTi have a lower percentage of mean leaf area eaten by insects;
3 ref to 21% in CpTi plants;
4 ref to 52% in control plants;

(ii)

1 trypsin inhibitor functions as non-competitive inhibitor;
2 inhibitor binds to sites other than active site;
3 inhibits action of trypsin;
4 changes shape of trypsin active site;

5 proteins cannot recognize and bind to active site;
6 no digestion of proteins (R! food)
7 insects die of malnutrition or starvation;

QUESTION 4

(a)

1 Identify all the genes in human DNA (ref. 30,000 genes)
2 Determine the DNA sequences (ref. 3 billion base pairs)
3 Store this information in databases and make the sequence totally and freely accessible
4 Improve tools for data analysis
5 Transfer related technologies to the private sector
6 Address the ethical, legal, and social issues (ELSI) that may arise from the project.

(b)

Genetic testing

1 improve diagnosis of disease (e.g. detecting rare alleles involved in common disease)
2 genetic testing or screening
/ detect genetic predispositions to disease e.g. allow the identification of gene variants that are important for the maintenance of health, particularly in the presence of known environmental risk factors

Pharmacogenetics

3 facilitates the study of complex diseases involving multiple genes and their interactions with other genes, and environmental factors
4 create drugs based on molecular information
5 design "custom drugs" (pharmacogenomics) based on individual genetic profiles
6 use of gene therapy to treat certain genetic diseases

Comparative genomics

7 HGP data allows for comparative genomics / comparative studies with genomes of other model organisms. This is useful for development of animal models of disease development.
8 Allows quick identification of genes encoding proteins found to be involved in cancer/disease through homology searches of identified gene sequences with database sequences.

DNA Identification

9 identify potential suspects whose DNA may match evidence left at crime scenes
10 exonerate persons wrongly accused of crimes
11 identify crime and catastrophe victims
12 establish paternity and other family relationship
13 match organ donors with recipients in transplant programs

Bioarchaeology, Anthropology, Evolution, and Human Migration

14 Study evolution through germline mutations in lineages
15 Study migration of different population groups based on maternal inheritance
16 Study mutations on the Y chromosome to trace lineage and migration of males

Examiner's comments: ref. to genetic testing or screening should be further elaborated with it relation to early diagnosis or detection.

(c)

1) Privacy / confidentiality of genetic information

- Difficult to determine who owns and controls the genetic information or who should have access to it

2) Fairness in the use of genetic information in non-health care settings, including the potential for misuse.

- Difficult to determine who should have access to genetic information, eg. insurers, employers, courts, schools, adoption agencies, the military
- Forensic DNA databanks. Ensuring that they are used for the purpose for which they were collected and protected from misuse. Also, where the public has also assisted the police by volunteering genetic samples to assist in the investigations of unsolved crimes, ensure that special protections are put in place for the DNA samples and the information generated

3) Patenting of DNA sequences

- Patenting of DNA sequences may limit their accessibility and development into useful products
- Intellectual property issues surrounding access to and use of genetic information by both researchers and the public)

4) Fairness in the accessibility of data/material/technologies

- May lead to inequity between developed and undeveloped countries in access to and use of new genetic information and technologies to improve human health

5) Clinical issues including the education of doctors and other health-service providers, people identified with genetic conditions, and the general public about capabilities, limitations, and social risks and implementation of standards and quality-control measures

- The education of healthcare professionals, policy makers, students, and the public about genetics and the complex issues that result from genomic research
- The integration of new genetic technologies, such as genetic testing, into the practice of clinical medicine.

6) Ethical issues surrounding the design and conduct of genetic research with people, including the process of informed consent.

7) Uncertainties associated with gene tests for susceptibilities and complex conditions (e.g., heart disease) linked to multiple genes and gene-environment interactions.

- Accuracy, reliability, and utility of genetic test (An individual is much more than the sum of their genes: the individual's environment can modify the expression of genetic messages to the body and many factors are not genetic that make an individual who they are)
- Reliability of the genetic tests for pre-natal decision making, like abortion

8) Reproductive issues such as the adequacy of information for parents / individuals and the rights for decision making for complex and potentially controversial procedures

- Inappropriate applications of genetic testing such as for the sole purpose of family balancing (sexing of a fetus for this reason) or its use in paternity testing without the informed consent of all parties involved

9) Possible discrimination for individuals with known genetic defects / prone to genetic diseases in different areas of life

- e.g. genetic discrimination in employment and insurance
- abortion of fetuses with minor disorders
- psychological impact and stigmatization due to an individual's genetic differences

10) The historical, social, psychological impact of genomics-derived data of race, ethnicity, kinship and individual and group identity

- Use of genetic data to define racial groups, or of racial categories to classify biological traits, is prone to misinterpretation
- The social implications for both individuals and society, of discovering genetic contributions related to human traits and behaviors such as stigmatized by the suggestion that alleles associated with what some people perceive as 'negative' physiological or behavioural traits are more frequent in certain populations

11) Conceptual and philosophical implications regard human responsibility and degree of genetic influence on behaviour and hence the party responsible

12) The line between medical disease and enhancement is controversial. Need for setting of boundaries in applications of the genetics technology.

R! Answers that are repetitive and simply pose a series of unanswered questions,