Name	Date started	Target end date

GCE A LEVEL — BIOLOGY UNIT 4 QUESTION PACK

1075 (Legacy BY5) · New spec Unit 4 Topic 5 · A2 unit, first sat 2017, 90 marks, 2h paper

REVISE
.wales

BIOLOGY — UNIT 4 · MEIOSIS, MUTATION & SOURCES OF VARIATION

4.4 Variation and evolution — meiosis, sources of genetic variation, gene and chromosome mutations

Meiosis as the source of genetic variation through independent assortment of homologous chromosomes and crossing-over, together with random gamete fusion at fertilisation, and the role of point mutations (substitution, insertion, deletion) illustrated by the β-globin variants of haemoglobin including sickle-cell.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~26 min

Derived from the legacy BY5 papers' pace of ~1.6 min/mark, padded for long-prose answers (16 marks over 2 questions).

*You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC BY5 papers (2008 modular spec, 2011–2017) that maps onto new-spec A2 Unit 4 Topic 5 (4.4).

Questions are ordered by source paper date.

INSTRUCTIONS

Use black ink or black ball-point pen. Show all working — quality of written communication will affect marks. A calculator is allowed. Diagrams included in answers must be fully annotated.

For Examiner's use only

Q	Source	Max	Mark
1	BY5 Jun 14 Q3	8	
2	BY5 Jun 17 Q1	8	
Total		**16**	

Meiosis, Mutation & Sources of Variation — what the new spec asks

WJEC GCE A Level Biology (from 2015) · Unit 4: Variation, Inheritance & Options · Topic 4.4.

Meiosis I — reduction

- Homologous chromosomes pair (synapsis) at prophase I.
- Crossing-over at chiasmata exchanges DNA between non-sister chromatids.
- Independent assortment of homologue pairs at metaphase I.

Meiosis II — equational

- Sister chromatids separate as in mitosis.
- Four haploid daughter cells produced from one diploid parent.
- Each gamete is genetically unique.

Sources of variation

- Independent assortment ($2^{23} \approx 8.4$ million combinations in humans).
- Crossing-over — recombines maternal and paternal alleles.
- Random fertilisation — any sperm with any egg.

Gene mutations

- Substitution — one base replaced; can be silent, missense, or nonsense.
- Insertion / deletion — shifts reading frame; usually severe.
- Sickle-cell — single base change (GAG → GTG) in β-globin.

Chromosome mutations

- Non-disjunction — failure to separate; aneuploidy (e.g. trisomy 21).
- Inversion, translocation, duplication, deletion at chromosome level.
- Detected by karyotyping.

Continuous vs discontinuous

- Continuous (e.g. height, mass) — polygenic + environmental.
- Discontinuous (e.g. blood group) — monogenic; distinct categories.
- Normal distribution often emerges from polygenic inheritance.

Crib sheet »

Meiosis, Mutation & Sources of Variation in one page

Quick-reference notes — revisit before each question.

Meiosis I

Homologous chromosomes pair (bivalents).

Crossing-over at chiasmata.

Independent assortment of bivalents.

Meiosis II

Sister chromatids separate.

Like mitosis but no DNA replication beforehand.

Four haploid cells per parent cell.

Variation sources

Independent assortment.

Crossing-over.

Random fertilisation.

Mutation (rarer but creates new alleles).

Substitution

One base for another.

Silent (synonymous), missense, or nonsense.

Sickle-cell: GAG→GTG, Glu→Val in β-globin.

Frameshift

Insertion or deletion of bases not multiples of 3.

Shifts reading frame downstream.

Usually catastrophic.

Chromosome mutation

Non-disjunction → aneuploidy (e.g. Down's trisomy 21).

Inversion, translocation, deletion, duplication.

Continuous vs discontinuous

Continuous: polygenic + environment; normal distribution.

Discontinuous: distinct categories (e.g. ABO).

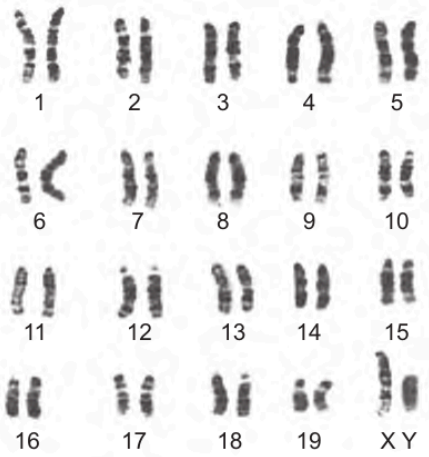
Causes of mutation

Replication errors (rare with proofreading).

Mutagens: UV, X-rays, chemicals (mustard gas).

Examiner only

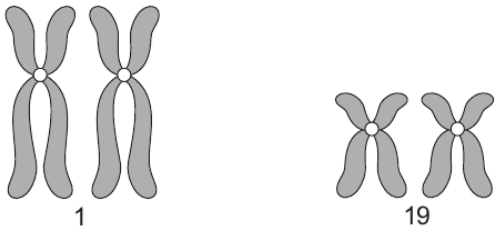
3. The photograph below shows the pairs of chromosomes found in a body cell of a mouse.



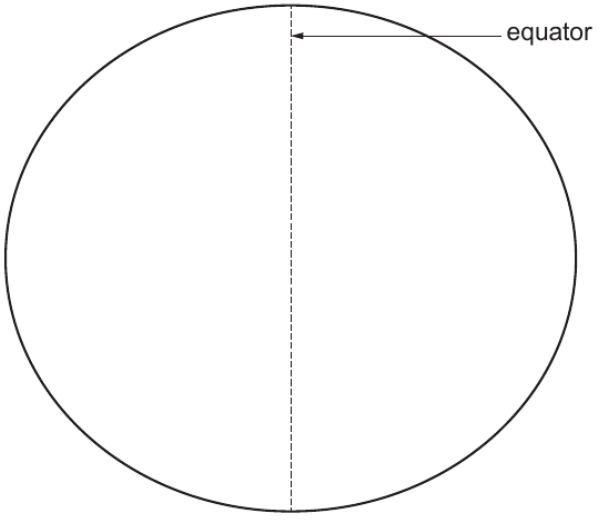
(a) What is the diploid number of the mouse? [1]

.....

(b) The chromosomes in pairs 1 and 19 are commonly represented diagrammatically as:



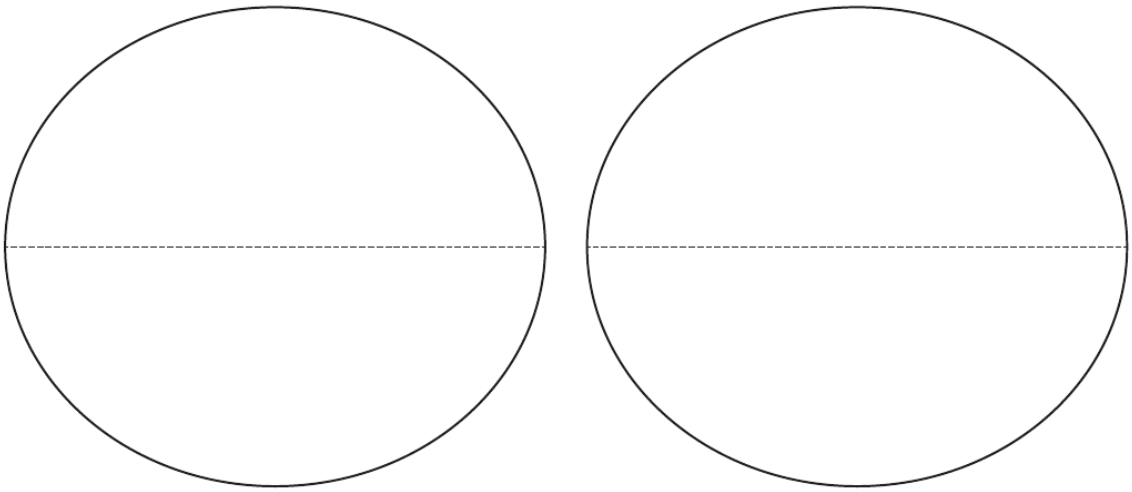
(i) Using the cell outline below draw diagrams to show how these pairs of chromosomes are arranged in **metaphase I** of meiosis. [1]



(ii) On your drawing label; chromatid, centromere, centriole, spindle fibres. [2]

Examiner only

(iii) Using the cell outlines below draw diagrams to show how the chromosomes would subsequently be arranged in **metaphase II** of meiosis. [1]



(iv) State **three** ways in which meiosis contributes to variation in mouse offspring. [3]

.....

.....

.....

.....

.....

.....

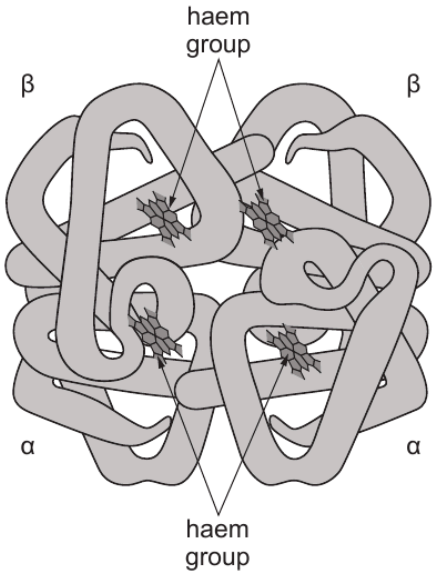
8

BLANK PAGE

Examiner only

Answer **all** *questions.*

1. A haemoglobin molecule contains four polypeptide chains, two α chains and two β chains, as shown:



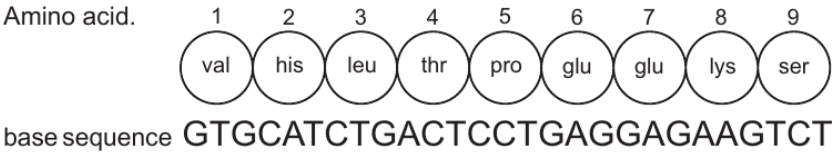
(a) (i) What is the highest level of protein structure shown by this molecule? [1]

.....

(ii) According to the one gene one polypeptide hypothesis, how many genes are required to code for this haemoglobin molecule? [1]

.....

The diagram below shows the first nine amino acids of a β chain, together with the nucleotide base sequence of the gene which codes for its synthesis:



More than 300 variations in the amino acid sequence of the β chain have been recorded. The table below shows some of them.

Name of variation	Amino acid number	Amino acid substitution	Mutation
Raleigh	1	val to ala	GTG to GCG
Deer Lodge	2	his to arg	CAC to CGC
Warwickshire	5	pro to arg	CCT to TCT
S	6	?	GAG to GTG
Rio Grande	8	lys to thr	AAG to ?

Examiner only

(b) **Complete the diagram below** to show the amino acid sequence in the Rio Grande variation. [1]

The table below shows the amino acids coded for by different **DNA** base triplets.

Second Letter

First Letter	T	C	A	G	*Third Letter*
T	TTT, TTC **phe**; TTA, TTG **leu**	TCT, TCC, TCA, TCG **ser**	TAT, TAC **tyr**; TAA stop; TAG stop	TGT, TGC **cys**; TGA stop; TGG **trp**	T C A G
C	CTT, CTC, CTA, CTG **leu**	CCT, CCC, CCA, CCG **pro**	CAT, CAC **his**; CAA, CAG **gln**	CGT, CGC, CGA, CGG **arg**	T C A G
A	ATT, ATC, ATA **ile**; ATG **met**	ACT, ACC, ACA, ACG **thr**	AAT, AAC **asn**; AAA, AAG **lys**	AGT, AGC **ser**; AGA, AGG **arg**	T C A G
G	GTT, GTC, GTA, GTG **val**	GCT, GCC, GCA, GCG **ala**	GAT, GAC **asp**; GAA, GAG **glu**	GGT, GGC, GGA, GGG **gly**	T C A G

(c) Use the table to find:

(i) **One** mutation which causes the Rio Grande variant. [1]

AAG to .....

(ii) The amino acid substitution that occurs in the S variant. [1]

..... to .....

People with the S variation suffer from a condition called sickle cell anaemia. In this condition, their red blood cells change shape when blood oxygen concentration is low.

(d) Explain how the substitution of an amino acid in the β chains can bring about this change. [3]

.....

.....

.....

.....

END OF QUESTION PACK

2 questions · 16 marks · ~26 min
Source: WJEC BY5 (2008 modular spec, 2011–2017)
Curated for WJEC Biology 2015 spec A2 Unit 4 — Topic 5 (4.4)