



IB DP BIOLOGY

Theme D · Continuity and Change

TOPICAL WORKSHEET

D1 DNA & Protein Synthesis · D2 Cell Division
D3 Reproduction & Inheritance · D4 Natural Selection

Standard and Higher Level · Syllabus 2025

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Section A — Multiple Choice (15 marks)

Circle the letter of the best answer to each question. Each question is worth 1 mark.

1. DNA replication is described as semi-conservative because [1]
A both new DNA molecules are made entirely of new nucleotides
B each new DNA molecule consists of one original (parental) strand and one newly synthesized strand
C only half of the DNA molecule is replicated each time
D replication only occurs in half of all cells
2. The enzyme responsible for unwinding the DNA double helix during replication is [1]
A DNA polymerase
B DNA helicase
C RNA polymerase
D DNA ligase
3. During transcription, which base on the mRNA strand pairs with adenine on the DNA template strand? [1]
A thymine
B uracil
C guanine
D adenine
4. Translation of mRNA into a polypeptide chain takes place at the [1]
A nucleus
B Golgi apparatus
C ribosome
D lysosome
5. Mitosis results in the production of [1]
A four genetically different haploid daughter cells
B two genetically identical diploid daughter cells
C one large diploid cell
D four genetically identical haploid daughter cells
6. Meiosis results in the production of [1]
A two genetically identical diploid cells
B four genetically different haploid daughter cells
C two genetically different diploid cells
D one genetically identical diploid cell

- 7.** A gene mutation is best defined as **[1]**
- A a change in the number of chromosomes in a cell
 - B a change in the nucleotide sequence of DNA
 - C the process of crossing over during meiosis
 - D the normal process of DNA replication
- 8.** Which stage of the cell cycle is generally the longest in most actively dividing cells? **[1]**
- A mitosis (M phase)
 - B interphase
 - C cytokinesis only
 - D prophase only
- 9.** In a monohybrid cross between two heterozygous individuals ($Aa \times Aa$), the expected phenotype ratio among the offspring is **[1]**
- A 1:1
 - B 1:2:1
 - C 3:1
 - D 9:3:3:1
- 10.** Continuous variation, such as human height, typically results from **[1]**
- A a single gene with two alleles only
 - B the combined effect of many genes (polygenic inheritance) and environmental factors
 - C mutation alone, with no genetic basis
 - D meiosis without fertilization
- 11.** A phenotype is best described as **[1]**
- A the complete set of alleles an organism carries for a particular gene
 - B the observable characteristics of an organism, resulting from genotype and environment
 - C a diagram showing the inheritance of a trait across generations
 - D the process by which gametes are formed
- 12.** Natural selection acts on **[1]**
- A heritable variation within a population
 - B variation that cannot be passed on to offspring
 - C identical individuals within a population only
 - D organisms after they have already reproduced

- 13.** The change in the frequency of dark-coloured peppered moths during the industrial revolution is often cited as an example of **[1]**
- A genetic drift only
 - B natural selection (industrial melanism)
 - C artificial selection
 - D a mutation with no selective advantage
- 14.** A change in the allele frequencies of a population over successive generations is a definition of **[1]**
- A mutation
 - B evolution
 - C fertilization
 - D meiosis
- 15.** Random changes in allele frequency due to chance, which tend to have a greater effect in small populations, are best described as **[1]**
- A natural selection
 - B genetic drift
 - C gene flow
 - D polygenic inheritance

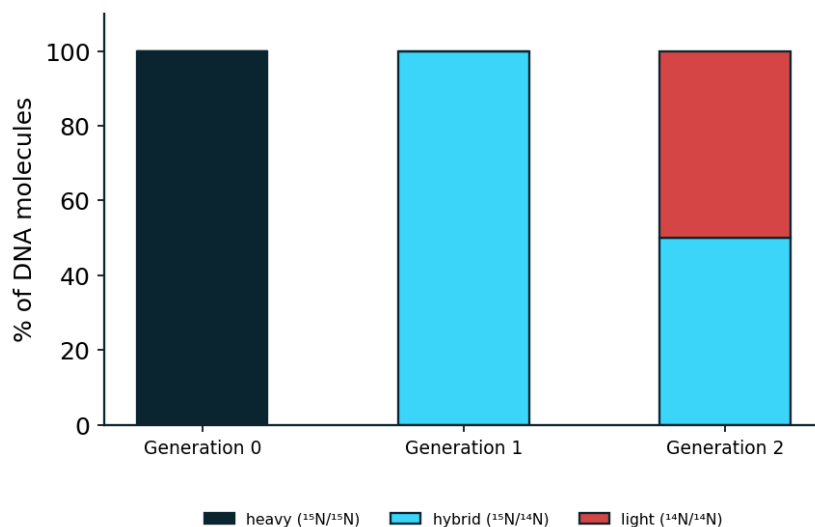
Section B — Structured Questions (65 marks)

Answer all questions in the space provided. Working must be shown for full marks.

D1 DNA & Protein Synthesis

Question 1 [7 marks]

The Meselson-Stahl experiment provided evidence for semi-conservative DNA replication. Bacteria were grown in a medium containing only the heavy isotope ^{15}N , then transferred to a medium containing only the light isotope ^{14}N ; DNA density was analysed after each round of replication (given data).



Proportion of heavy, hybrid, and light DNA over two generations of replication (given data).

- (a) Using the graph, describe the composition of the DNA after one generation of replication in ^{14}N medium. [2]

- (b) Explain how the results after two generations support the semi-conservative model of replication (rather than a conservative model). [2]

- (c) Predict the percentage of hybrid and light DNA that would be present after a third round of replication (Generation 3). [3]

Question 2 [6 marks]

Protein synthesis involves the processes of transcription and translation, sometimes referred to as the 'central dogma' of molecular biology.

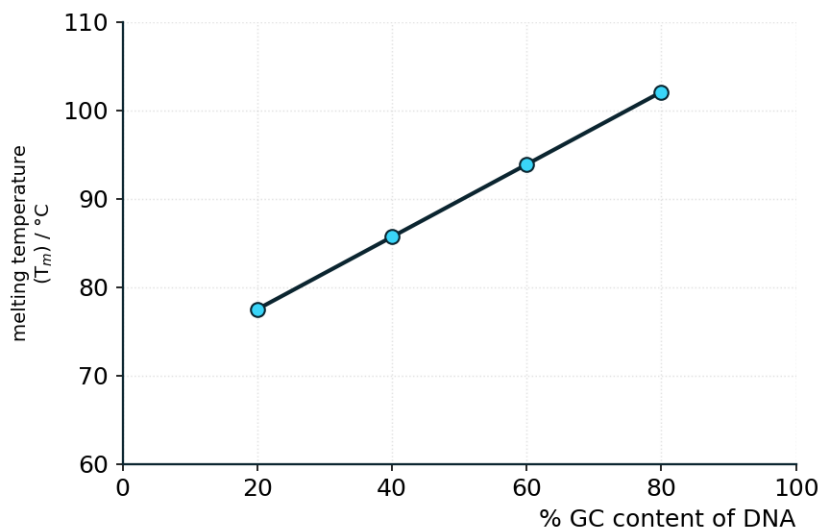
(a) State where, in a eukaryotic cell, transcription takes place, and where translation takes place. [2]

(b) Outline the process of transcription. [2]

(c) Outline the process of translation. [2]

Question 3 [7 marks]

The graph shows how the melting temperature (T_m) of a DNA sample – the temperature at which the two strands separate – varies with its percentage GC content (computed using a simplified empirical model).



DNA melting temperature vs %GC content (computed, simplified model).

(a) Using the graph, describe the relationship between %GC content and DNA melting temperature. [2]

(b) Explain, in terms of hydrogen bonding, why DNA with a higher GC content has a higher melting temperature. [2]

(c) Using the trend shown, predict the melting temperature of a DNA sample with a GC content of 55%. [3]

D2 Cell Division

Question 4 [6 marks]

Mitosis and meiosis are both forms of nuclear division, but they serve very different biological roles.

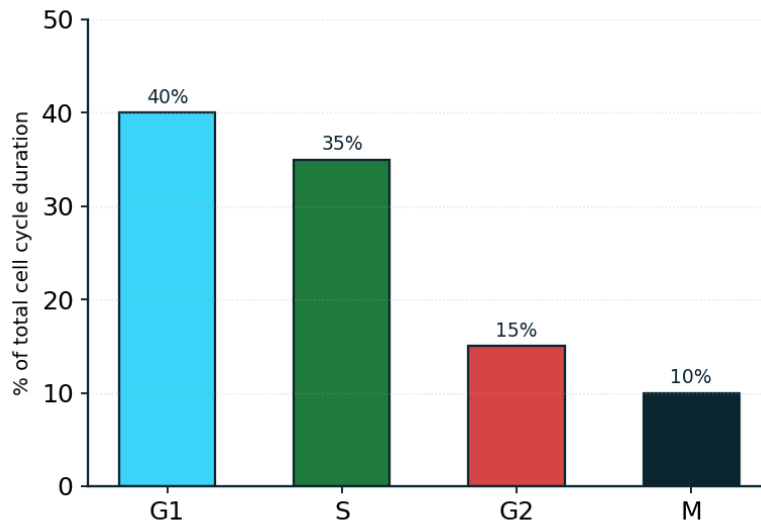
(a) State two differences between mitosis and meiosis. [2]

(b) State the biological role of mitosis, and the biological role of meiosis. [2]

(c) Explain how meiosis contributes to genetic variation among offspring. [2]

Question 5 [7 marks]

The bar chart shows the relative duration of each phase of the cell cycle for a typical dividing cell with a 24-hour cell cycle (given data).



Relative duration of cell cycle phases (given data, % of a 24-hour cycle).

(a) Using the graph, identify which phase of the cell cycle occupies the greatest proportion of time. [2]

(b) Calculate the actual time, in hours, spent in the M (mitosis) phase of this 24-hour cell cycle. [2]

(c) Describe what occurs during the S phase of the cell cycle. [3]

Question 6 [6 marks]

Mutations are changes in the nucleotide sequence of DNA, and can have a range of effects.

(a) Distinguish between a substitution mutation and a deletion mutation. [2]

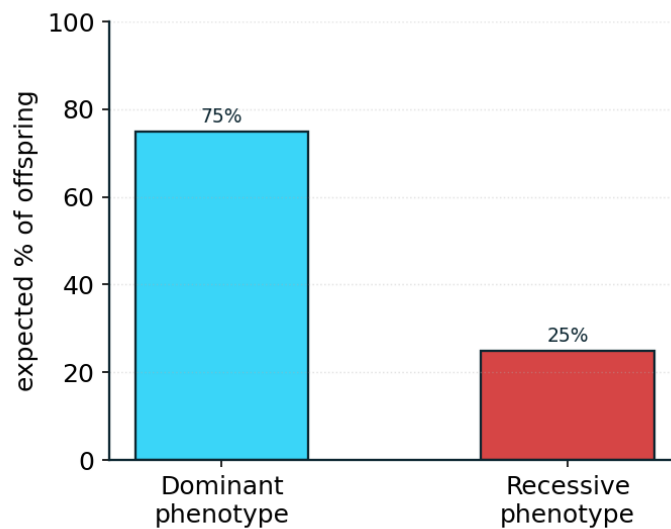
(b) Explain why a deletion mutation is often more harmful to the resulting protein than a substitution mutation. [2]

(c) Explain why most mutations do not have a significant effect on an organism's phenotype. [2]

D3 Reproduction & Inheritance

Question 7 [7 marks]

The bar chart shows the expected phenotype ratio among the offspring of a monohybrid cross between two heterozygous individuals, $Aa \times Aa$, where A (dominant) codes for the dominant phenotype and a (recessive) codes for the recessive phenotype (computed).



Expected phenotype ratio for a monohybrid cross, $Aa \times Aa$ (computed).

(a) Using the graph, state the expected phenotype ratio (dominant : recessive) for this cross. [2]

(b) Using a Punnett square (or genotype reasoning), explain why this 3:1 ratio arises from an $Aa \times Aa$ cross. [2]

(c) In a large sample of 200 offspring from this cross, calculate the expected number showing the dominant phenotype. [3]

Question 8 [6 marks]

Variation among individuals in a population can be classified in different ways.

(a) Distinguish between continuous variation and discontinuous (discrete) variation, giving one example of each. [2]

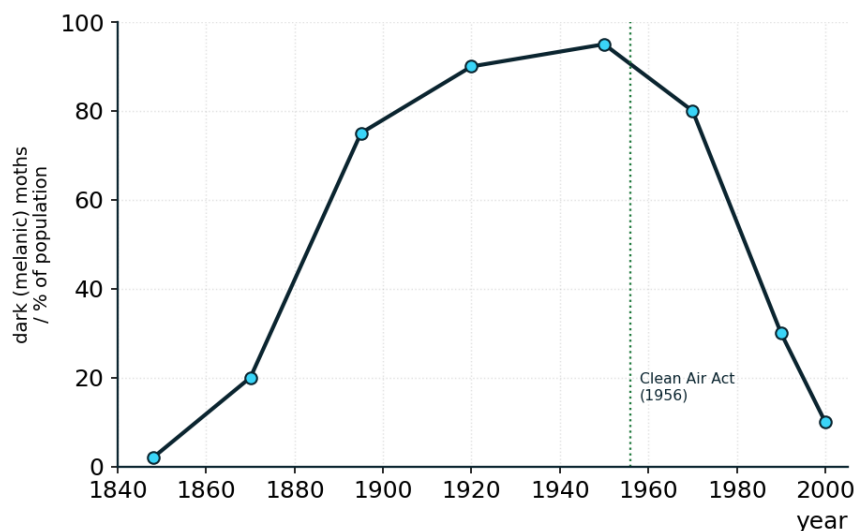
(b) Explain why discontinuous variation is usually controlled by a single gene, while continuous variation is usually polygenic. [2]

(c) Explain how the environment can contribute to variation, even between individuals with identical genotypes. [2]

D4 Natural Selection

Question 9 [7 marks]

The graph shows the percentage of dark (melanic) peppered moths in a population near an industrial city, from 1848 to 2000 (given data), a classic example of natural selection.



Percentage of dark (melanic) peppered moths over time (given data).

(a) Using the graph, describe how the percentage of dark moths changed between 1848 and 1950. [2]

(b) Explain, in terms of natural selection, why dark moths became more common during this period of heavy industrial pollution. **[2]**

(c) Using the graph, describe and explain the change in the percentage of dark moths after 1950. **[3]**

Question 10 [6 marks]

Evolution by natural selection requires several key conditions to operate.

(a) State three conditions necessary for natural selection to occur in a population. **[2]**

(b) Distinguish between natural selection and genetic drift. **[2]**

(c) Outline two forms of evidence (other than direct observation of natural selection) that support the theory of evolution. **[2]**