Nucleotide Structure and Backbone Formation

IB Biology - A1.2 Nucleic acids | Level: SL core | Suggested time: 40 minutes

Assessment pattern Multiple choice Short answer Data response Extended response	Total marks 27 Coverage SL focus with integrated application	Syllabus focus • A1.2.2 Components of a nucleotide • A1.2.3 Sugar-phosphate backbone of DNA and RNA • Condensation reactions linking nucleotides

Instructions

- Answer all questions unless your teacher tells you otherwise.
- Show biological reasoning clearly in short-answer, data-response and extended-response items.

Section A - Multiple choice

Choose the best answer in each case.

1. Which combination correctly describes a nucleotide? [1]

   A. Phosphate + pentose sugar + nitrogenous base

   B. Fatty acid + glycerol + base

   C. Amino acid + phosphate + sugar

   D. Pentose sugar + amino acid + phosphate

2. In a nucleic acid polymer, the repeating 'backbone' is made by covalent bonds between: [1]

   A. Adjacent nitrogenous bases

   B. Sugars and phosphates of neighboring nucleotides

   C. Two phosphate groups only

   D. Two sugars only

3. What type of reaction forms the bond between adjacent nucleotides? [1]

   A. Hydrolysis

   B. Condensation

   C. Neutralization

   D. Oxidation

4. Why is the sugar-phosphate backbone important? [1]

   A. It stores ATP for the cell.

   B. It provides a strong covalently bonded chain.

   C. It causes proteins to fold.

   D. It replaces the nitrogenous bases.

5. At one end of a nucleic acid strand there is typically: [1]

A. A base with no sugar attached

B. A phosphate group bonded to only one sugar

C. A protein cap

D. No chemical group at all

Section B - Short answer

6. State the three components of a nucleotide. [3]

7. Explain why the sugar-phosphate backbone is described as a strong framework for DNA or RNA. [3]

8. A nucleic acid strand contains 15 nucleotides. State how many condensation reactions were needed to build it and explain your answer. [3]

Section C - Data response / case study

9. Data response - Polymer length and water release [7]

A student modelled RNA synthesis by joining nucleotide monomers into strands of different lengths.

Table 1. RNA strand length and products of polymerization

RNA strand length (nucleotides)	Number of new covalent links	Water molecules released
4	3	3
8	7	7
12	11	11
20	19	19

9(a) Describe the relationship between strand length and the number of water molecules released. [2]

9(b) Predict the number of water molecules released when a strand of 30 nucleotides is formed. [2]

9(c) Explain why the number of condensation reactions is not the same as the number of nucleotides. [3]

Section D - Extended response

10. Explain how nucleotides form a stable nucleic acid polymer. [6]

Nucleotide Structure and Backbone Formation - Answer key and marking guidance

IB Biology - A1.2 Nucleic acids | Level: SL core | Suggested time: 40 minutes | Accept equivalent biologically accurate wording where appropriate.

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General marking guidance

- Award credit for clear biological meaning even if wording differs from the model answer.
- Do not award more than the maximum marks shown for each question.
- For extended responses, reward linked explanation rather than isolated word lists.

Multiple choice answers

Q	Answer	Why it is correct
1	A	Each nucleotide contains one phosphate group, one pentose sugar and one nitrogenous base.
2	B	The sugar of one nucleotide bonds to the phosphate of the next.
3	B	A condensation reaction links nucleotides and releases water.
4	B	Covalent bonds make the nucleic acid strand stable.
5	B	One end has an unbound phosphate linked to a single sugar.

Short answer and data response guidance

6. State the three components of a nucleotide. [3]

- One phosphate group.
- One pentose sugar (ribose or deoxyribose).
- One nitrogenous base.

Marking guidance: Award 1 mark for each correct component, max 3.

7. Explain why the sugar-phosphate backbone is described as a strong framework for DNA or RNA. [3]

- Adjacent nucleotides are linked by covalent bonds.
- Covalent bonds require relatively high energy to break.
- This makes the strand stable as hereditary information is stored or transferred.

Marking guidance: Award 1 mark per valid explanatory point, max 3.

8. A nucleic acid strand contains 15 nucleotides. State how many condensation reactions were needed to build it and explain your answer. [3]

- 14 condensation reactions were needed.
- A bond forms between each pair of neighboring nucleotides.
- Therefore the number of links is one fewer than the number of nucleotides.

Marking guidance: Award 1 mark for the correct number and up to 2 marks for the explanation.

9(a). Describe the relationship between strand length and the number of water molecules released. [2]

- As strand length increases, the number of water molecules released increases.
- The number of water molecules is always one fewer than the number of nucleotides in the strand.

Marking guidance: Award 1 mark for each valid trend statement, max 2.

9(b). Predict the number of water molecules released when a strand of 30 nucleotides is formed. [2]

- 29 water molecules.

Marking guidance: Award 1 mark for the correct prediction and 1 mark if linked to the pattern n-1.

9(c). Explain why the number of condensation reactions is not the same as the number of nucleotides. [3]

- A condensation reaction forms a bond between two neighboring nucleotides.
- The first nucleotide does not require a previous nucleotide to bond to.
- Therefore only the links between nucleotides are counted.

Marking guidance: Award up to 3 marks for a clear explanation.

Extended response guidance

10. Explain how nucleotides form a stable nucleic acid polymer. [6]

- Each nucleotide contains a phosphate, pentose sugar and nitrogenous base.
- Nucleotides join by condensation reactions.
- The sugar of one nucleotide bonds to the phosphate of the next.
- This creates an alternating sugar-phosphate backbone.
- A water molecule is released each time a new bond forms.
- The covalent backbone gives the strand stability.

Marking guidance: Award up to 6 marks for a logical description from monomer to stable polymer.