Model Answers: Hard

1

The correct answer is **D** because:

- There are 153 base pairs total on the strand of DNA, therefore there are 153 bases on each strand.
- 153 – 31 – 22 – 52 = **48 adenine (A) bases on strand 1**
- Adenine pairs with thymine, therefore if there is 48 adenines on strand 1, there are **48 thymine (T) on strand 2**.

2

The correct answer is **B** because:

- A DNA molecule has two complementary strands.
- Each strand is a chain of **nucleic acids**.
- Each nucleic acid has **1 phosphate**, **1 pentose sugar** and **1 base**.
- The complementary base pairs are:
  - cytosine and guanine
  - adenine and thymine

- Therefore, the number of each constituent is:
  - 14000 x 2 = **28000 pentose sugars**
  - 14000 x 2 = **28000 phosphate groups**
  - equal ratios (1:1) of **cytosine: guanine** and **adenine : thymine**

3

The correct answer is **B** because:

- This experiment separates the DNA by weight – heavier DNA will appear towards the bottom of the test tube and lighter DNA at the top
- Before any DNA replication takes place (generation zero) **all** the nitrogen in DNA is **heavy** ^{15}**N** and will therefore be the band closest to the bottom of the tube
- During the first **replication cycle** (generation one), the old ^{15}N DNA will unwind and the two strands will separate. ^{14}N containing free nucleotides will be added to complement the original strands
- The result will be two **hybrid DNA** molecules – all the DNA will have one **strand** of heavy ^{15}**N** (this is the original and conserved DNA made from when bacteria was in ^{15}N medium) and the other new strand will contain **light** ^{14}**N**. Therefore, one band can be seen higher up the test tube than generation zero
- In the second division (generation two), the hybrid DNA unwinds and the two strands separate and two new **complementary** strands are made. This produces:

- One DNA molecule that has **one** ^{15}**N** strand and **one** ^{14}**N** strand (this will be the same weight as generation one
- Another DNA molecule that consists of **two** ^{14}**N strands** which is the lightest band

4

The correct answer is **D** because:

- Within each sample of DNA, the percentage of adenine and thymine are very similar, and the percentage of cytosine and guanine are very similar.
- This shows that the four bases exhibit complementary pairing because the ratios of **adenine : thymine** and **cytosine : guanine** are nearly equal.
- Due to experimental error the numbers are not perfect however in cells the ratios will be exact
- These two sets of **complementary bases** are due the shape of the bases and the ability for **hydrogen bonds** to form between them. These hydrogen bonds ensure the DNA molecule is **stable** and the complementarity enables DNA to replicate using both strands

A is incorrect as the abundance of any particular base does not relate to size or shape. It is the sequence of the bases that result in a specific amino acid sequence, and therefore protein.

B is incorrect as the data shows the percentage of each base, not the exact amount. Therefore, all values for the bases of each DNA sample adds to 100%.

C is incorrect as the structure of DNA in all animals is the same – a double helix. This data does not give any information about the sequence of DNA, which determines the similarity of two organisms.

5

The correct answer is **D** because:

- Before any DNA replication takes place the parent DNA is two original black strands.
- During the first **replication cycle**, the old (black) DNA will unwind and the two strands will separate. New free nucleotides (grey) are added to complement the original strands resulting in two **hybrid DNA** molecules: one **strand** of original black DNA and the strand of new grey DNA.

- In the **second division**, each hybrid DNA unwinds, and the two strands separate and two new **complementary** grey strands are made. Each of the hybrid DNA molecules from cycle 1 produces:
    - One DNA molecule that has one **black** strand and one **grey** strand
    - Another DNA molecule that consists of **two grey strands** which is the lightest band.
- Therefore, a total of 2 hybrid DNA molecules and 2 grey DNA molecules are produced.

6

The correct answer is **C** because:

- **Helicase** is the enzyme that unwraps the **DNA double helix** and breaks **hydrogen bonds** to enable access to the bases.
- **DNA polymerase** assembles **complementary free nucleotides** to hydrogen bond to the original DNA to form a new DNA molecule.
- **DNA ligase** catalyses the formation of **phosphodiester bonds** which are the covalent bonds that occur between a **phosphate group** of one nucleic acid and the **deoxyribose sugar** of another to join the new nucleotides together and form a complete **strand**.

RNA polymerase is not needed for DNA replication, the enzyme is used to produce RNA used in **protein synthesis**.

7

The correct answer is **A** because:

- Nucleic acids are joined by a type of covalent bond called a **phosphodiester bond**, shown by A.
- These bonds occur between carbon 3 of the **pentose sugar** and the **oxygen** of the **phosphate group** of different nucleic acids.

B is incorrect as this is an **ester bond** found in lipids and glycerol.

C is incorrect as this is a **carbon oxygen** bond found in sugars.

D is incorrect as this is a **peptide bond** found between amino acids in proteins.

8

The correct answer is **D** because:

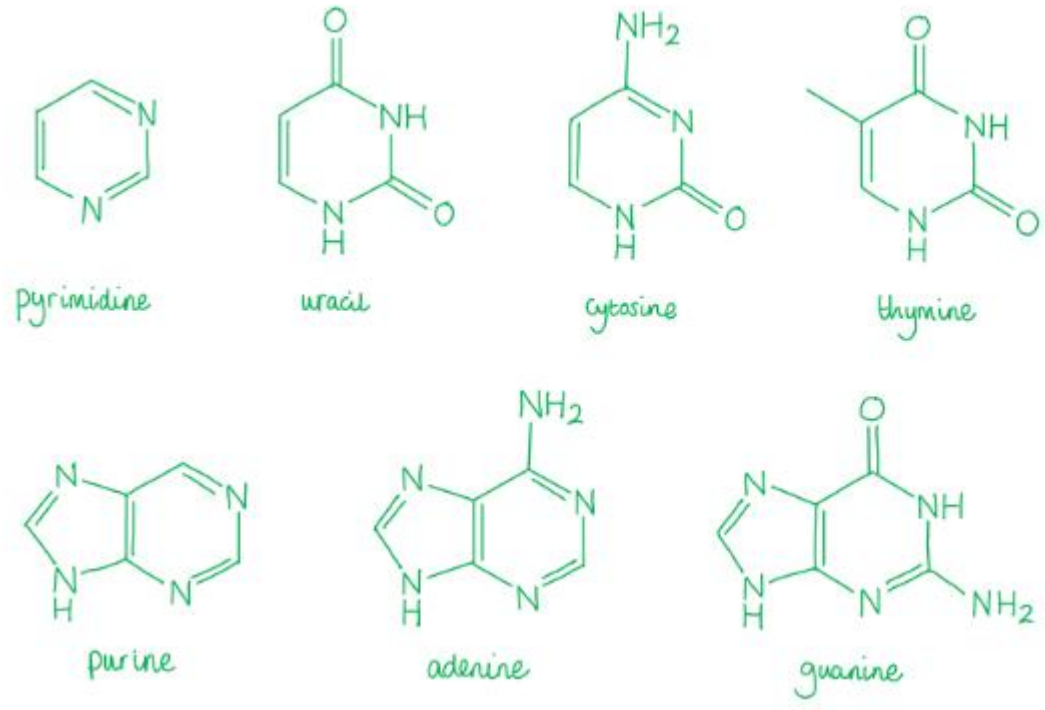
- Firstly, the **DNA helix** is unwound and the **hydrogen bonds** between complementary base pairs are broken (4).
- Breaking the **hydrogen bonds** allows the two strands to be separated (1), which gives space for each to be made into a new DNA molecule.

- Free **DNA nucleotides** are paired with **complementary** nucleotides on each strand by the enzyme **DNA polymerase** (2) and hydrogen bonds form between them (3).
- The free nucleotides are connected by covalent bonds called **phosphodiester bonds** (5). The formation of these bonds is catalysed by **DNA ligase**.

9

The correct answer is **B** because:

- Reducing sugars are sugars that has an **OH group** attached to the **number 1 carbon** which can reduce other molecules.
- A deoxyribose sugar is part of the nucleic acid structure, which are the building blocks for DNA. Deoxyribose sugars are **reducing** as the OH group on number one carbon allows it to bind the **nitrogenous base** to form a nucleic acid.
- A type of covalent bond called a **phosphodiester bond** is formed between the **OH group of deoxyribose** carbon-3 and an **oxygen in the phosphate** group of another nucleic acid. This creates the **'phosphate-sugar backbone'** of a DNA strand.



- There are two strands of nucleic acids in a DNA molecule. The strands are joined by **hydrogen bonds** forming between complementary bases. **Two** hydrogen bonds form between **adenine** and **thymine** and **three** hydrogen bonds form between **cytosine** and **guanine**.

10

The correct answer is **B** because:

- This experiment separates the DNA by weight – heavier DNA (^{15}**N**) will appear towards the bottom of the test tube and lighter DNA (^{14}**N**) at the top.
- Before any DNA replication takes place (generation zero) **all** the nitrogen in DNA is **heavy** ^{15}**N** as this is the medium the bacteria have been growing in. Therefore, the band will be closest to the bottom of the tube.
- During the first **replication cycle** (generation one), the original ^{15}N DNA will unwind and the two strands will separate. **Free nucleotides** made from ^{14}**N** will be added by DNA polymerase to complement the original strands and DNA ligase will attach them into a new strand of DNA.
- The result will be two **hybrid DNA** molecules – all the DNA will have one **strand** of heavy ^{15}**N** (this is the original and conserved DNA made from when bacteria was in ^{15}N medium) and the other new strand will contain **light** ^{14}**N**. Therefore, the weight of DNA will be halfway between all ^{15}**N** DNA and all ^{14}**N** DNA and a single band will be seen in the middle of the test tube.

A is incorrect as this is shows generation zero, all DNA is made from ^{15}**N.**

C is incorrect as this is shows conservative replication, the is DNA that is all ^{14}**N** and DNA that is all ^{15}**N**.

D is incorrect as this shows DNA only made with ^{14}**N** which will be the result of many replication cycles in ^{14}**N** medium.