

DNA Structure & Replication

Key ideas

Nucleotide = phosphate + deoxyribose sugar + nitrogenous base. **Purines** (A, G) have two rings; **pyrimidines** (T, C) have one.

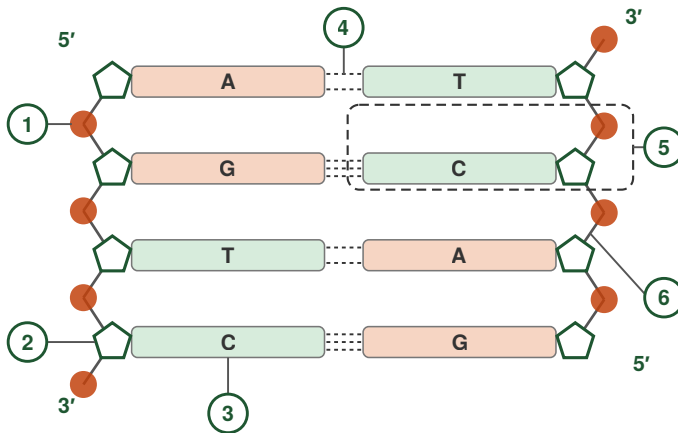
Base pairing: A–T (2 hydrogen bonds), G–C (3 hydrogen bonds). The two strands are **antiparallel**: one runs 5' → 3', the other 3' → 5'.

Chargaff's rule: %A = %T and %G = %C. · **Replication** is semi-conservative; new strands always grow 5' → 3'.

A Label the DNA molecule

3 marks

Word bank: Deoxyribose sugar · Hydrogen bond · Nitrogenous base · Nucleotide · Phosphate group · Sugar-phosphate backbone



1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

B Base pairing and Chargaff's rule

6 marks

7. Write the complementary strand for 5' - A T G C C G T A - 3'. Label the 5' and 3' ends.

8. Write the complementary strand for 5' - G G A T C C T A - 3'. Label the 5' and 3' ends.

9. A DNA sample is 30% adenine. Find the percentages of thymine, guanine and cytosine. Show your reasoning. (2 marks)

10. Another sample is 18% guanine. What percentage is adenine?

11. How many hydrogen bonds hold the double strand of question 7 together?

C Discovering DNA's structure

2 marks

Write the letter of the matching discovery (½ mark each).

12. _____ Erwin Chargaff

13. _____ Rosalind Franklin

14. _____ Watson and Crick

15. _____ Meselson and Stahl

a. Built the first double helix model of DNA (1953)

b. Showed that DNA replication is semi-conservative

c. Found that A = T and G = C in DNA from any species

d. Took X-ray diffraction images (Photo 51) showing DNA is a helix

D Replication enzymes

3 marks

Write the letter of the matching job (½ mark each).

- | | |
|----------------------------------|--|
| 16. _____ Helicase | a. Joins Okazaki fragments into one continuous strand |
| 17. _____ Topoisomerase (gyrase) | b. Unwinds the double helix by breaking hydrogen bonds between bases |
| 18. _____ Primase | c. Replaces RNA primers with DNA nucleotides |
| 19. _____ DNA polymerase III | d. Relieves the twisting strain ahead of the replication fork |
| 20. _____ DNA polymerase I | e. Adds new nucleotides to the 3' end of a growing strand (5' → 3') |
| 21. _____ DNA ligase | f. Builds a short RNA primer so DNA polymerase can start |

E How DNA replicates

6 marks

22. Put the steps of DNA replication in order. (2 marks)

- P DNA polymerase III adds complementary nucleotides in the 5' → 3' direction
Q Helicase unwinds and unzips the double helix at the origin of replication
R DNA ligase joins the Okazaki fragments
S Primase adds a short RNA primer
T DNA polymerase I replaces the RNA primers with DNA

_____ → _____ → _____ → _____ → _____

23. Why is DNA replication called *semi-conservative*?

24. Why is the lagging strand made in short pieces (Okazaki fragments)?

25. Bacteria with only ¹⁵N DNA are moved to a ¹⁴N medium. One DNA molecule replicates twice. How many of the 4 molecules still contain a ¹⁵N strand?

26. After a third round of replication, what fraction of the molecules are hybrid?

F Spot the mistake

2 marks

27. A student writes: "In DNA, adenine pairs with uracil." Explain the error and correct it.

28. A student writes: "DNA polymerase builds both new strands continuously in the same direction as the fork." Explain the error and correct it.

DNA Structure & Replication **ANSWER KEY****Key ideas**

Nucleotide = phosphate + deoxyribose sugar + nitrogenous base. **Purines** (A, G) have two rings; **pyrimidines** (T, C) have one.

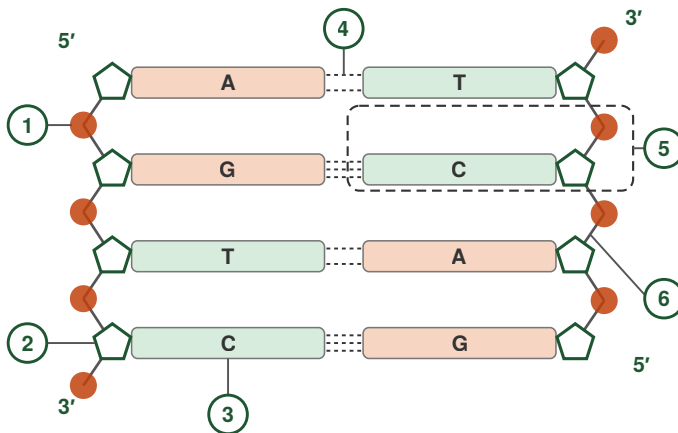
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A Label the DNA molecule

3 marks

Word bank: Deoxyribose sugar · Hydrogen bond · Nitrogenous base · Nucleotide · Phosphate group · Sugar-phosphate backbone



1. Phosphate group
2. Deoxyribose sugar
3. Nitrogenous base
4. Hydrogen bond
5. Nucleotide
6. Sugar-phosphate backbone

B Base pairing and Chargaff's rule

6 marks

7. Write the complementary strand for 5' - A T G C C G T A - 3'. Label the 5' and 3' ends.

3' - T A C G G C A T - 5'

8. Write the complementary strand for 5' - G G A T C C T A - 3'. Label the 5' and 3' ends.

3' - C C T A G G A T - 5'

9. A DNA sample is 30% adenine. Find the percentages of thymine, guanine and cytosine. Show your reasoning. (2 marks)

A = T, so T = 30%. G + C = 100 - 60 = 40%, so G = C = 20% each.

10. Another sample is 18% guanine. What percentage is adenine?

C = 18%, so A + T = 64% and A = 32%

11. How many hydrogen bonds hold the double strand of question 7 together?

4 A–T pairs × 2 + 4 G–C pairs × 3 = 20 hydrogen bonds

C Discovering DNA's structure

2 marks

Write the letter of the matching discovery (½ mark each).

12. c Erwin Chargaff

13. d Rosalind Franklin

14. a Watson and Crick

15. b Meselson and Stahl

a. Built the first double helix model of DNA (1953)

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Q Helicase unwinds and unzips the double helix at the origin of replication
R DNA ligase joins the Okazaki fragments
S Primase adds a short RNA primer
T DNA polymerase I replaces the RNA primers with DNA

 Q → S → P → T → R

23. Why is DNA replication called *semi-conservative*?
Each new DNA molecule keeps one original strand and has one newly made strand.
24. Why is the lagging strand made in short pieces (Okazaki fragments)?
DNA polymerase can only add nucleotides in the 5' → 3' direction. The lagging strand runs the opposite way to the fork, so it is built backwards in short pieces as the fork opens.
25. Bacteria with only ¹⁵N DNA are moved to a ¹⁴N medium. One DNA molecule replicates twice. How many of the 4 molecules still contain a ¹⁵N strand?
2 (both are hybrid ¹⁵N/¹⁴N molecules)
26. After a third round of replication, what fraction of the molecules are hybrid?
2 of 8 = 1/4

F Spot the mistake

2 marks

27. A student writes: "In DNA, adenine pairs with uracil." Explain the error and correct it.
Uracil is only found in RNA. In DNA, adenine pairs with thymine (two hydrogen bonds).
28. A student writes: "DNA polymerase builds both new strands continuously in the same direction as the fork." Explain the error and correct it.
DNA polymerase only works 5' → 3', so only the leading strand is continuous; the lagging strand is made in Okazaki fragments.