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Biology
Teach Yourself Series
Topic 10: DNA replication and protein synthesis (Units 2 & 3)

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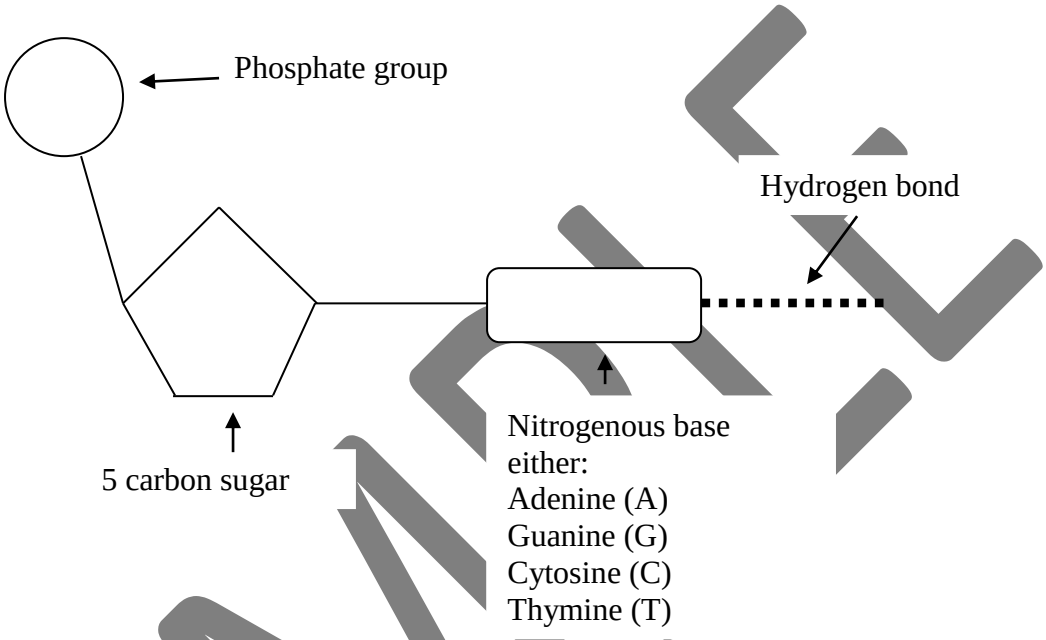
Contents

DNA structure

As it appears in Unit 3

DNA is a double stranded molecule consisting of two complementary strands. It is a polymer made up of individual nucleotides. Each nucleotide contains a phosphate group, a nitrogen base and a sugar molecule. The sugar and phosphate groups make up the backbone and the nitrogen base binds to a second base on the complementary strand. Adenine is complementary to thymine and guanine is complementary to cytosine.



If you know the percentage of one base you can work out the percentage of any other base.

Sample question: If a strand of DNA is made up of 15% thymine what is the percentage of cytosine?

The answer to this question is worked out as follows:

If there is 15% thymine then there has to be 15% adenine because these 2 bases are complementary.

This means that there is 70% left; half of which has to be cytosine and half guanine.

Therefore there is 35% cytosine.

Review Questions

1. If a DNA molecule has 22% cytosine, work out the percentage of each of the other bases.

_____

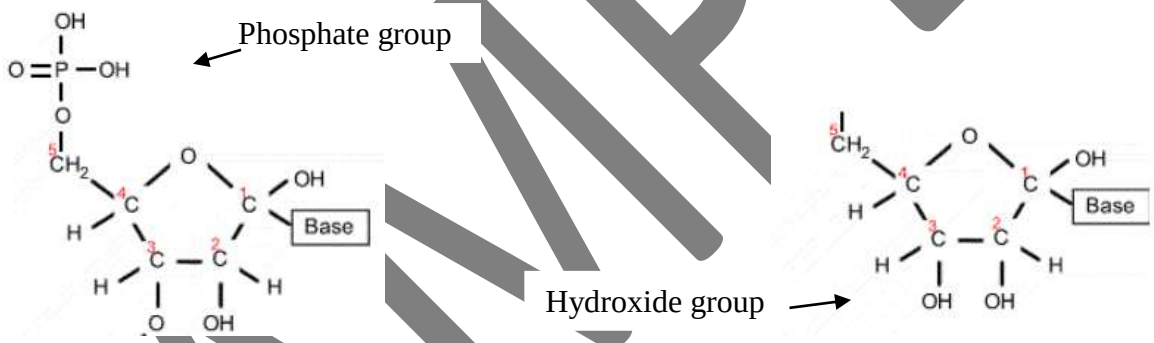
_____

2. A segment of DNA has the sequence AGGTCAATG. What is the sequence of the complementary strand?

_____

The ends of the DNA molecule are referred to as 3 prime (written 3') and 5 prime (5').

Each of the carbon atoms are numbered 1 to 5. As shown on the first diagram below the 5th carbon has a phosphate group attached to it. The second diagram shows a hydroxide group attached to the 3rd carbon.



The DNA strands in the double stranded molecule are not only complementary but are also antiparallel. This means that one strand runs in the 3' to 5' direction while the other runs in the 5' to 3' direction. It is important to understand this when studying DNA synthesis.

5' ATGGCTAGCC 3'

TACCGATCGG

3' 5'

In an exam if the ends are not specified then you can just write out the complementary sequence, but if the ends are specified in the question then they must also be specified in the answer.

Review Question

3. A segment of DNA has the following sequence 3' GTCCAGCAAT 5'. What is the sequence of the complementary strand?

_____

RNA structure

As it appears in Unit 3

RNA is also a polymer consisting of nucleotides, but there are some differences:

- RNA is single stranded.
- The sugar is ribose rather than deoxyribose.
- Uracil substitutes for thymine.

Review Question

4. A segment of DNA has the sequence AGGTCAATG. What is the sequence of the complementary mRNA strand?

_____

Solutions to Review Questions

1. 22% G; 28% A; 28% T

2. TCCAGTTAC

3. 5'CAGGTCGTTA3'

4. UCCAGUUAC

5. The black bars are the parent strands. The white bars are the newly synthesised bars.

6. The answers are as follows:

i. DNA helicase is responsible for unwinding the parent DNA molecule and breaking the hydrogen bonds between the two strands.
ii. DNA polymerase moves along the template strand and assembles a complementary daughter strand.
iii. DNA ligase joins the Okazaki fragments together.

7. The answers are as follows:

i. GGU = gly
ii. UAG = stop
iii. AAG = Lys
iv. CGG = Arg

8. CCU, CCC, CCA, CCG

9. Stop codons differ from other codons because they code for a release factor rather than an amino acid.

10. AUG

11. The table should include the following information:

Amino acid	Codons that code for that amino acid	Number of codons that code for that amino acid
Alanine (Ala)	GCU, GCC, GCA, GCG	4
Arginine (Arg)	CGU, CGC, CGA, CGG, AGA, AGG	6
Asparagine (Asn)	AAU, AAC	2
Aspartic acid (Asp)	GAU, GAC	2
Cysteine (Cys)	UGU, UGC	2
Glutamine (Gln)	CAA, CAG	2
Glutamic acid (Glu)	GAA, GAG	2
Glycine (Gly)	GGU, GGC, GGA, GGG	4
Histidine (His)	CAU, CAC	2
Isoleucine (Ile)	AUU, AUC, AUA	3
Leucine (Leu)	UUA, UUG, CUU, CUC, CUA, CUG	6
Lysine (Lys)	AAA, AAG	2
Methionine (Met)	AUG	1
Phenylalanine (Phe)	UUU, UUC,	2
Proline (Pro)	CCU, CCC, CCA, CCG	4
Serine (Ser)	UCU, UCC, UCA, UCG, AGU, AGC	6
Stop	UAA, UAG, UGA	3
Threonine (Thr)	ACU, ACC, ACA, ACG	4
Tryptophan (Trp)	UGG	1
Tyrosine (Tyr)	UAU, UAC	2
Valine (Val)	GUU, GUC, GUA, GUG	4

12. The leading strand is used as the template as it can be synthesised continuously in the 5' to 3' direction.

13. The answers are as follows:

i. Parent molecule = double stranded DNA
ii. Product 1 = primary transcript
iii. Product 2 = mRNA

14. Product 1 has both introns and exons. Product 2 only contains exons.

15. The first modification is the removal of the introns and the exons are then spliced together. A methylated cap and polyA tail are added.

16. RNA polymerase.

17. The role of mRNA is to be read by the ribosome and result in the assembly of a polypeptide.

18. The cap and tail are required for orientation to ensure that the mRNA is read in the correct direction.

19. The introns have been removed and the exons have been spliced together by RNA ligase.

20. mRNA is being read by a ribosome and a polypeptide is being assembled.

21. Polypeptide

22. Ribosome

23. The amino acid sequence is Methionine Cysteine Glutamic acid Alanine Histidine Valine Leucine Asparagine.

24. AUG UGU GAA GCU CAU GUU UUA AAC

25. TAC ACA CTT CGA GTA CAA AAT TTG

26. ATG TGT GAA GCT CAT GTT TTA AAC

27. Start = UAC; Asn = UUG; Cys = ACA; His = GUA; Pro = GGG; Ser = AGU; Val = CAA

28. AUG AAC UGU CAU CCC UCA GUU

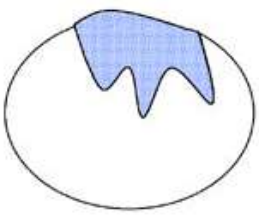
29. TAC TTG ACA GTA GGG AGT CAA

ATG AAC TGT CAT CCC TCA GTT

30. Gene regulation is necessary as protein synthesis requires energy. If proteins are only produced when needed energy can be conserved.

31. RNA polymerase.

32. The diagram should look like this:



33. Lactose should be complementary to the repressor since it has to bind to the repressor, causing it to change shape and release the promoter gene.