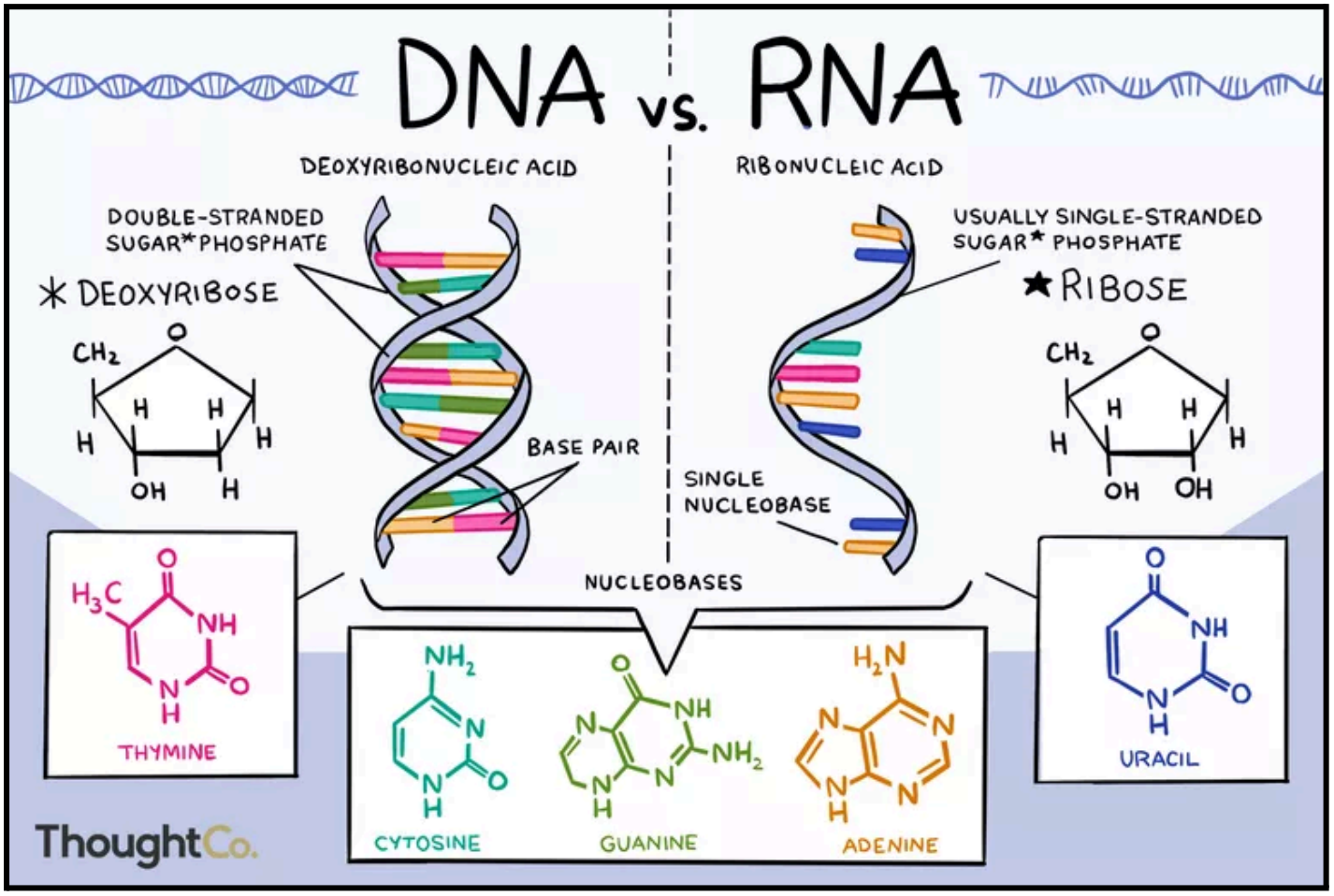
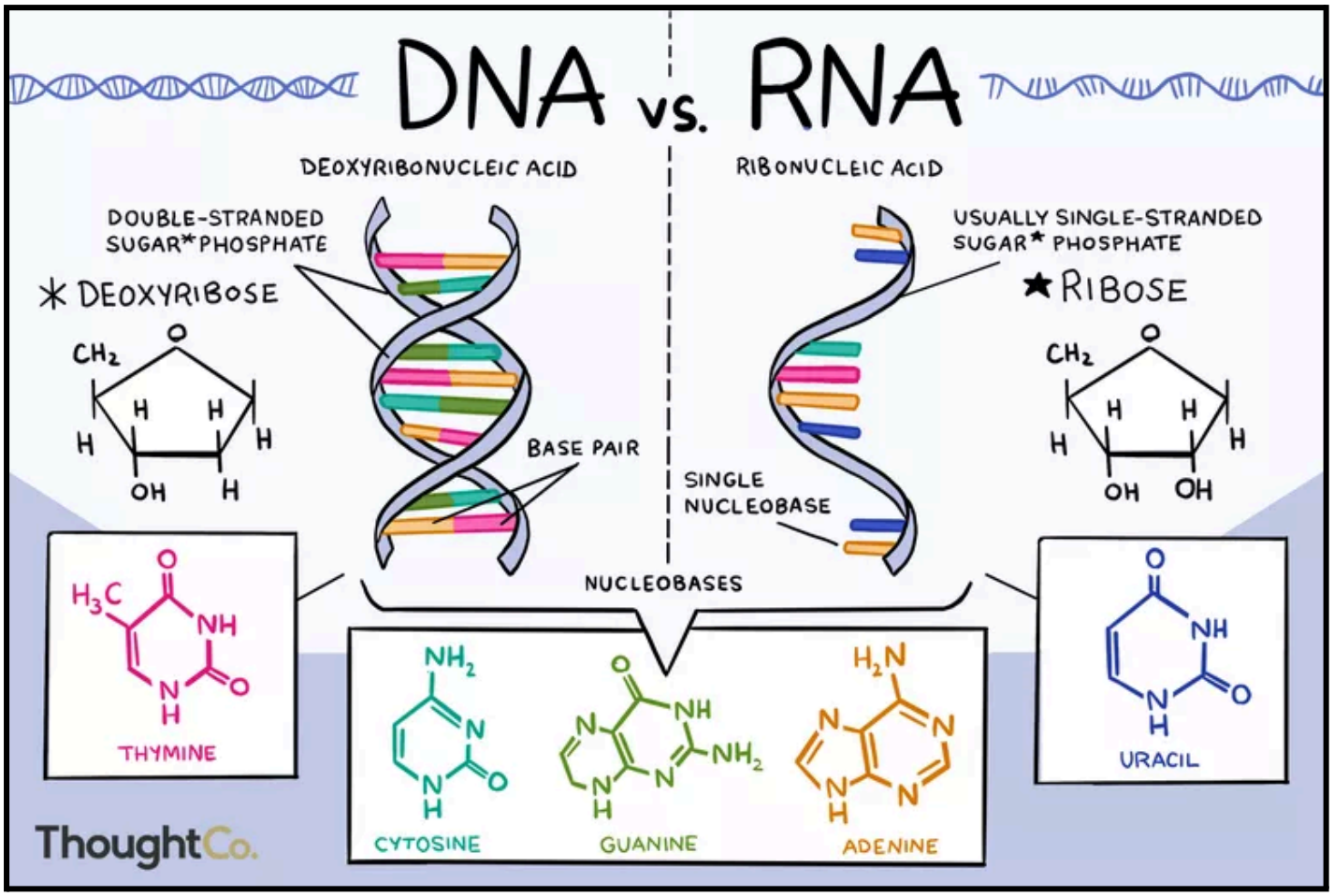
A Level Biology - Answers.

DNA & RNA

Name:



DNA and protein synthesis
➔ **Know the structure of DNA, including the structure of the nucleotides (purines and pyrimidines), base pairing, the two sugar-phosphate backbones, phosphodiester bonds and hydrogen bonds.**

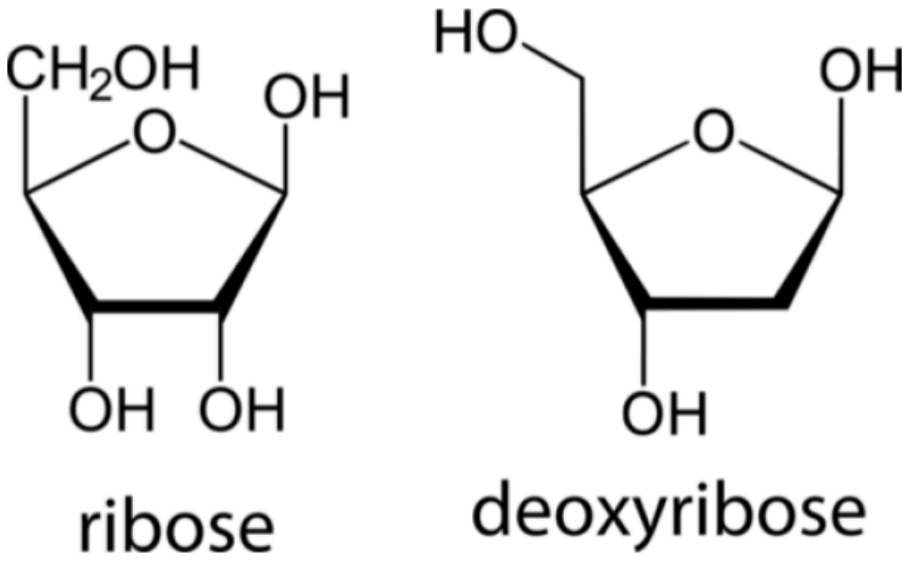


Key questions

1. **What kind of molecule is DNA?**
2. **What is the DNA molecule composed of?**
3. **Describe the shape of the DNA molecule and why it has this shape.**

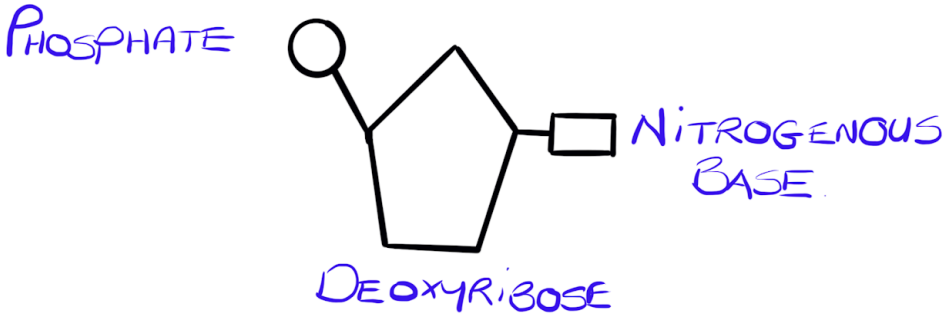
1. DNA is a type of polymer - a polynucleotide composed of monomers called nucleotides.
2. DNA is composed of nucleotides of which there are four types.
Each nucleotide is composed of a phosphate, a ribose sugar called deoxyribose and a nitrogenous base of which
there are four types, adenine, thymine, cytosine and guanine.
3. The DNA molecule is a double helix composed of antiparallel strands of DNA.

Structure of a nucleotide - Deoxyribose & Ribose

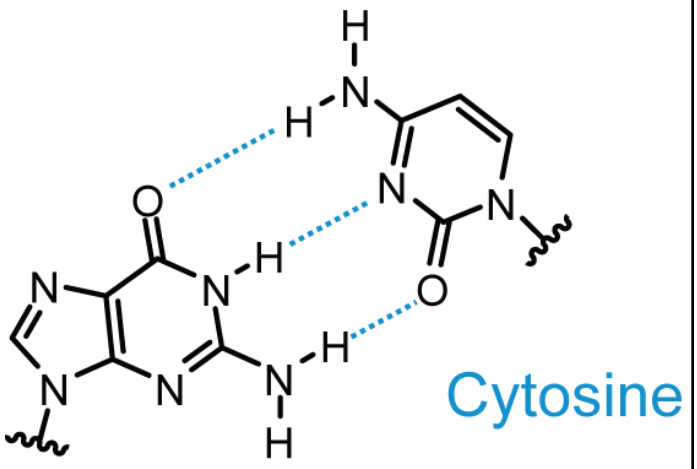


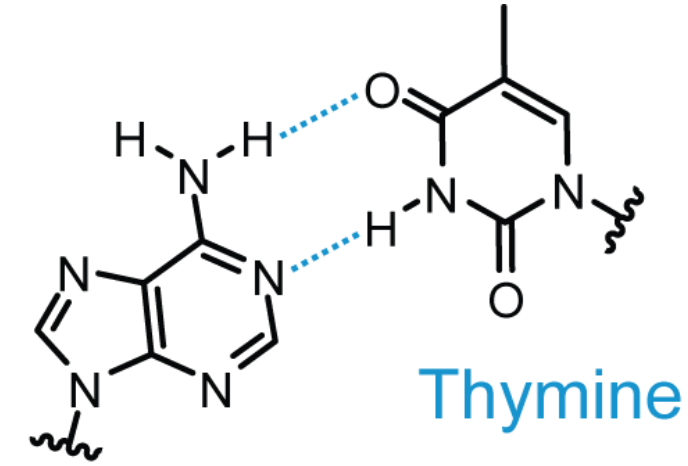
4. **What is the significance of ribose and deoxyribose in relation to nucleotides?**
5. **Draw the structure of a nucleotide in the space below.**

4. The structures of ribose and deoxyribose are similar. The difference being deoxyribose is missing an -OH group at carbon 2. Tis results in one less oxygen, hence the name deoxyribose - missing oxygen.



Base pairing





6. **What are purines & pyrimidines?**
7. **Explain how complementary base pairing works in DNA molecules?**
8. **What are Chargaff's ratios?**

6. **Purines are nitrogenous bases that make up the two different kinds of nucleotide bases in DNA & RNA, Adenine and Guanine. Purines have two-carbon nitrogen ring bases.**

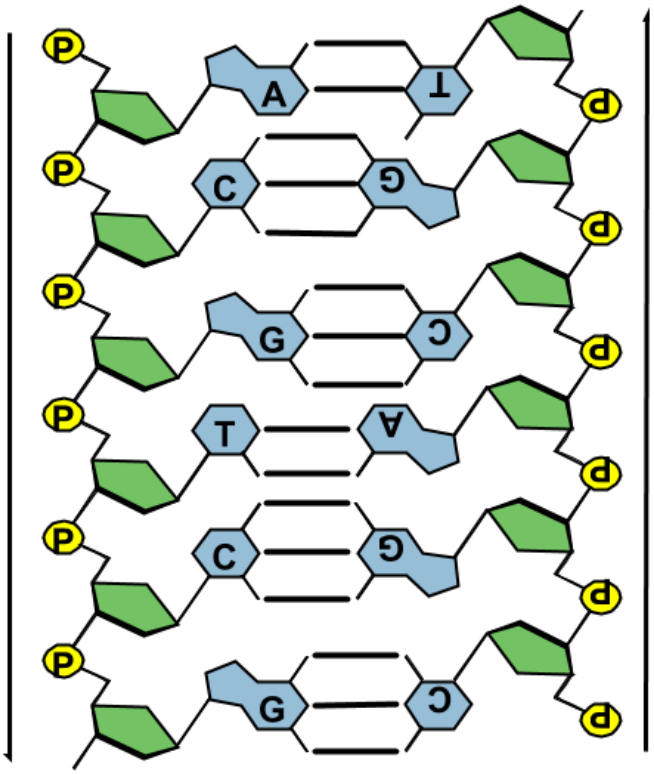
   Pyrimidines are nitrogenous bases with one carbon nitrogen ring. Thymine and cytosine are the pyrimidines that make up DNA and also Uracil which replaces Thymine in RNA.

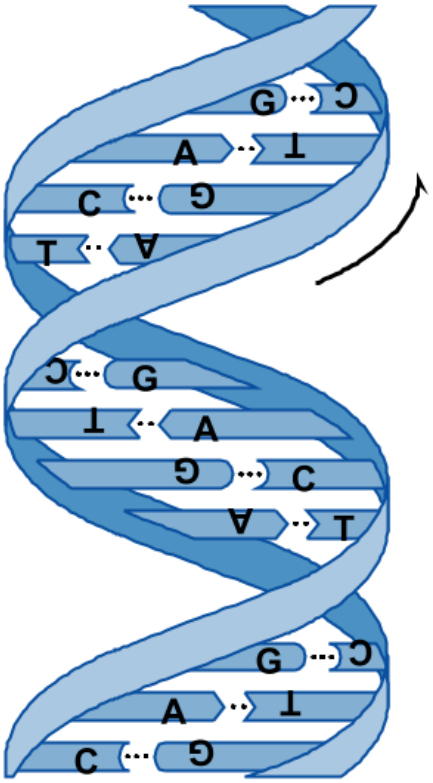
7. **Complementary base pairing is the phenomenon where in DNA guanine always hydrogen bonds to cytosine and adenine always binds to thymine. The bond between guanine and cytosine shares three hydrogen bonds compared to the A-T bond which always shares two hydrogen bonds.**

8. **Chargaff's rules states that DNA from any cell of all organisms should have a 1:1 ratio (base Pair Rule) of pyrimidine and purine bases and, more specifically, that the amount of guanine is equal to cytosine and the amount of adenine is equal to thymine.**

   The exception to this is in ssDNA viruses.

Different Ways to Represent the DNA Double Helix





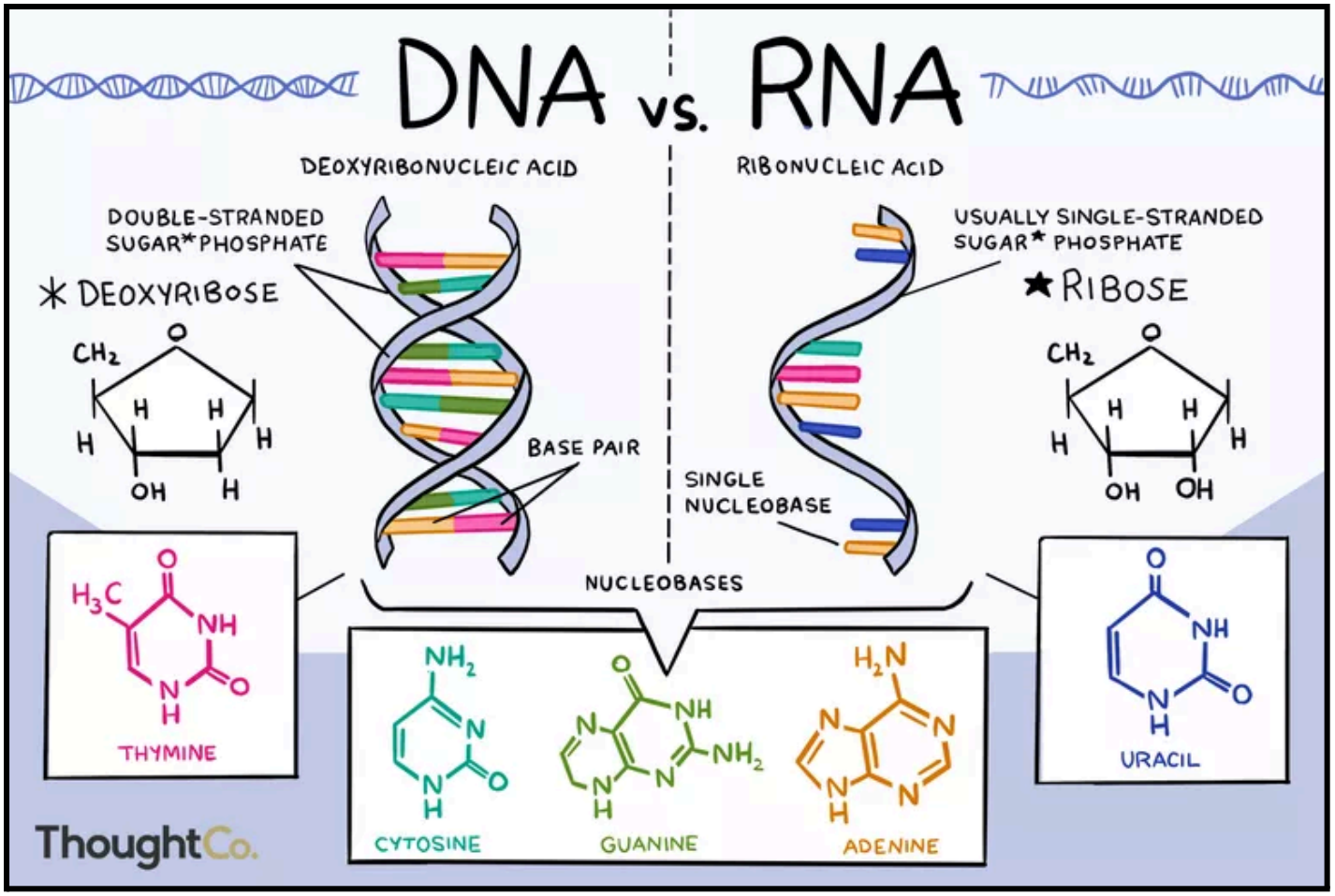
9. **With reference to the diagram explain the shape of the DNA Double helix**

DNA is double stranded, and the strands are antiparallel because they run in opposite directions.

Each DNA molecule has two strands of nucleotides. Each strand has sugar phosphate backbone, but the orientation of the sugar molecule is opposite in the two strands.

Both of the strands of DNA double helix can grow in 5' to 3' direction, but they grow in opposite directions due to opposite orientation of the sugar molecule in them. (We will explore the synthesis of DNA molecules via the process of semi conservative replication)

The antiparallel orientation allows for the base pairs to compliment one another. Antiparallel DNA is also more structurally stable than parallel DNA.



10. State the differences between DNA & RNA.

	DNA	RNA
Sugar	Deoxyribose	Ribose
Bases	Thymine Adenine Cytosine Guanine	Uracil (replaces Thymine) Adenine Cytosine Guanine
Base pairing	Thymine pairs with Adenine. Guanine pairs with Cytosine	Adenine pairs with Uracil Guanine pairs with Cytosine
Length	Can be very long (length of a chromosome)	Short → approx 95 bases long for tRNA → Thousands of bases long for mRNA (Transcript of a DNA gene sequence)
Strandedness	Double stranded (most of the time)	Single stranded (most of the time)

Examination Practice

Q1.(a) The table shows some substances found in cells. Complete the table to show the properties of these substances. Put a tick in the box if the statement is correct.

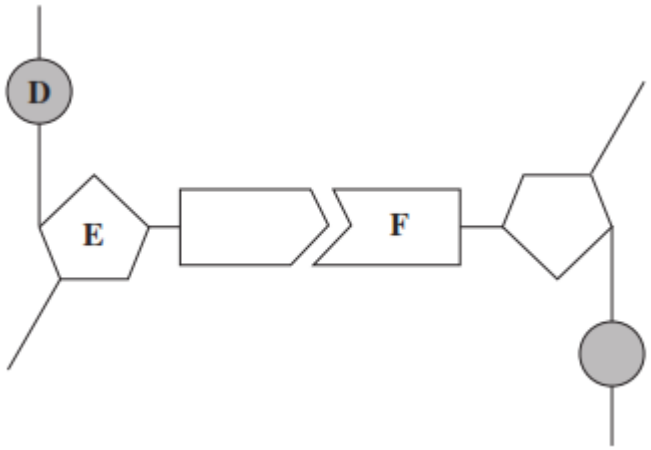
Statement	Substance			
	Starch	Glycogen	Deoxyribose	DNA helicase*
Substance contains only the elements carbon, hydrogen and oxygen	Y	Y	Y	N
Substance is made from amino acid monomers	N	N	N	Y
Substance is found in both animal cells and plant cells	N	N	Y	Y

- DNA Helicase is an enzyme responsible for breaking the H bonds between nucleotides during DNA replication. As it is an enzyme it is a protein composed of amino acids.

(4)

(Total 4 marks)

Q2. (a) The diagram shows one pair of nucleotides of a DNA molecule.



Name

D. Phosphate
E. Deoxyribose (pentose sugar)
F. Nitrogenous Base

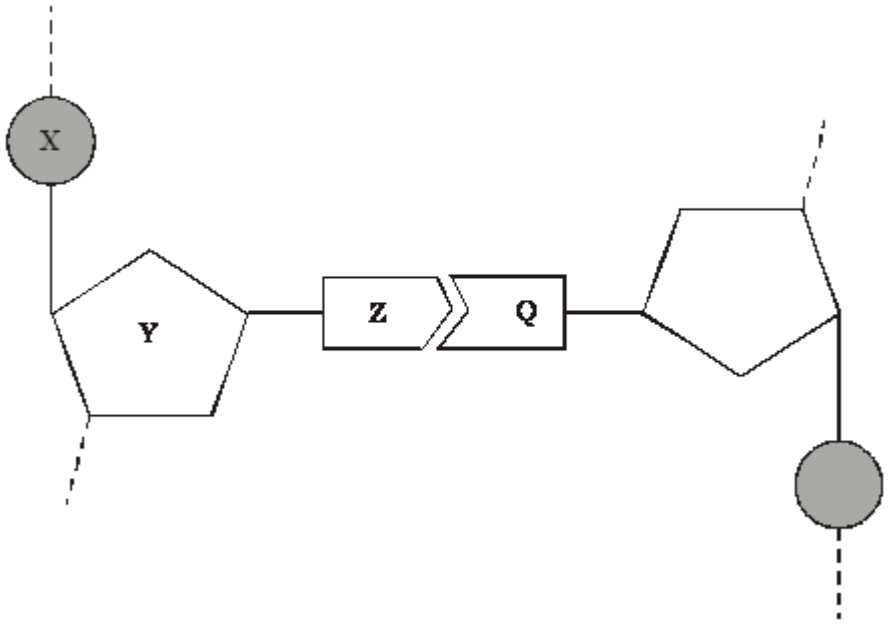
(3)

(b) Complete the table to give two differences between the structure of DNA and the structure of RNA.

	DNA	RNA
	Double stranded	Single stranded
	Sugar is deoxyribose	Sugar is ribose
	Bases are adenine, cytosine, thymine and guanine	Bases are adenine, cytosine, guanine and uracil. Uracil replaces Thymine
	Very long	Much shorter

(2)
(Total 5 marks)

Q3. The diagram shows one nucleotide pair of a DNA molecule.



(a) Name the parts of the nucleotide labelled X, Y and Z.

X. Phosphate
y.Deoxyribose
z.Nitrogenous base

(3)

(b) What type of bond holds Z and Q together?

Hydrogen bond

(1)

(c) A sample of DNA was analysed. 28% of the nucleotides contained thymine. Calculate the percentage of nucleotides which contained cytosine. Show your working.

If T = 28% Then A = 28%

28 + 28 = 56 Therefore C+G= 56

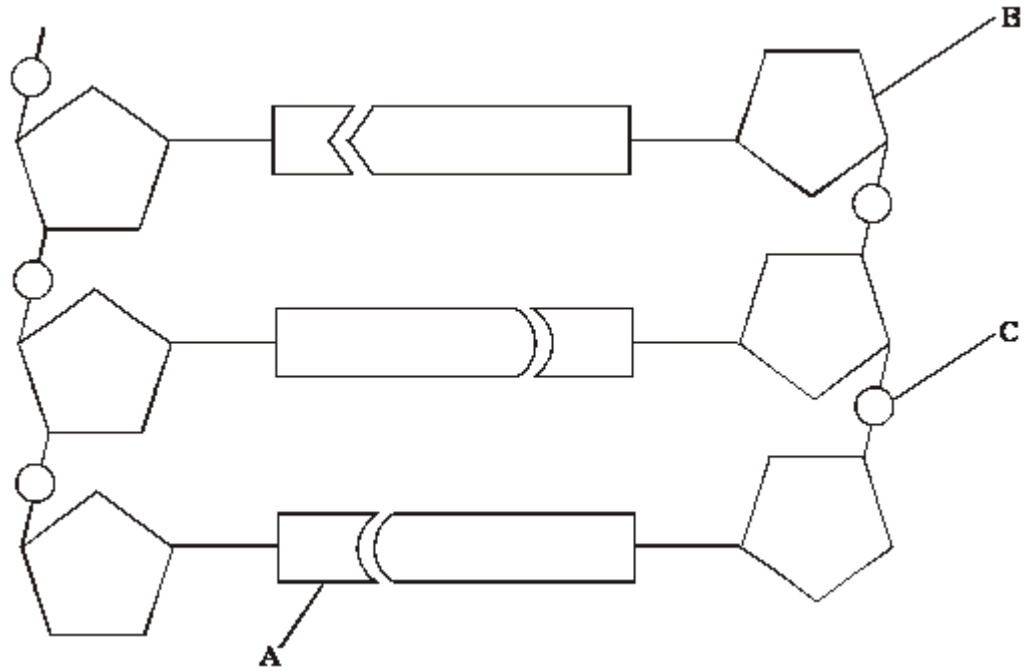
Therefore C= 56/2 = 28% & G=56/2 = 28%

Answer 28%

(2)

(Total 6 marks)

Q4. **The diagram shows a short section of a DNA molecule.**



(a) **On the diagram draw a box round one nucleotide.**

(1)

(b) **Use the letters in the diagram to indicate a part of the molecule which**

(i) **is not a base and is different in an RNA molecule;**

B - is Deoxyribose (not a nucleotide) and woule be Ribose in an RNA molecule.

(ii) **contains nitrogen.**

A - Nitrogenous base - Contains Nitrogen

(2)

(c) **(i)** **The sequence of bases on one strand of DNA is important for protein synthesis. What is its role?**

The sequence of bases on a DNA molecule provides the triplet code or codons that provide the genetic code for the sequence of amino acids to be incorporated into the primary structure of a protein.

(1)

(ii) **How are the two strands of the DNA molecule held together?**

Hydrogen bonds

(1)

(iii) Give one advantage of DNA molecules having two strands.

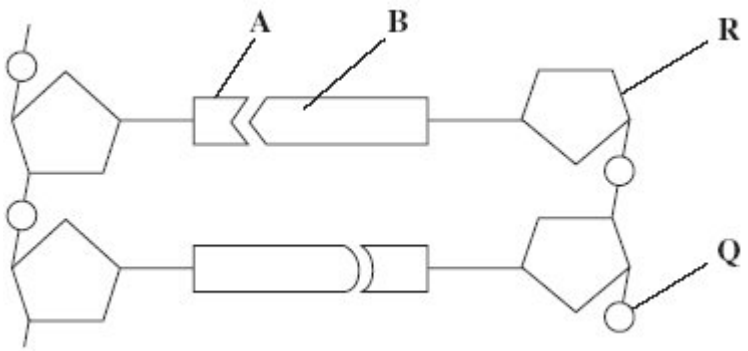
Each strand serves as a template for the replication of another strand to allow synthesis of DNA during S phase of the cell cycle.
Provides stability for the molecule.
Protects the nitrogenous bases from damage (which would lead to a mutation)

(1)

(Total 6 marks)

Q5. Figure 1 shows a short section of a DNA molecule.

Figure 1



(a) Name parts R and Q.

R - Deoxyribose
Q - Phosphate

(2)

(b) Name the bonds that join A and B.

Hydrogen

(1)

(c) Ribonuclease is an enzyme. It is 127 amino acids long.

What is the minimum number of DNA bases needed to code for ribonuclease?

3 bases = 1 codon

1 codon provides the code for an amino acid.

Therefore 127 x 3 = 381 bases (or 381 considering that the last codon would be a stop codon)

(1)

(d) Figure 2 shows the sequence of DNA bases coding for seven amino acids in the enzyme ribonuclease.

Figure 2

GTT	TAC	TAC	TAC	TCT	TCT	TTA

- ➔ GTT occurs once and we know it is Gln
- ➔ TAC occurs three times (so must be Arg, as it appears 3 times)
- ➔ TCT occurs twice so must be Met

The number of each type of amino acid coded for by this sequence of DNA bases is shown in the table.

Amino acid	Number present
Arg	3
Met	2
Gln	1
Asn	1

Use the table and Figure 2 to work out the sequence of amino acids in this part of the enzyme. Write your answer in the boxes below.

Gln	Arg	Arg	Arg	Met	Met	Asn
GTT	TAC	TAC	TAC	TCT	TCT	TTA

(1)

(e) Explain how a change in a sequence of DNA bases could result in a non-functional enzyme.

Changing the base sequence changes the codons
Which provides the genetic code for the sequence of amino acids in the primary structure of a protein.
Changing codons can change the amino acid in the sequence.
Affecting the folding of the protein and its overall tertiary structure.
Which in the case of an enzyme affects the shape of the active site which would prevent the formation of an enzyme substrate complex.

(3)

(Total 8 marks)

Q6. (a) Nucleic acids, such as DNA, are polymers, made up of many repeating monomer units. Name the monomer from which nucleic acids are made.

Nucleotides

(1)

(b) The table shows the percentage of different bases in the DNA of some organisms.

Organism	Percentage of each base			
	Adenine	Guanine	Cytosine	Thymine
Human	31.2	18.8	18.8	31.2
Cow	27.9	22.1	22.1	27.9
Salmon	29.4	20.6	20.6	29.4
Rat	28.6	21.4	21.4	28.6
Virus	24.7	24.1	18.5	32.7

A= 28.6
Therfore T = 28.6
A+T = 28.6 + 28.6 = 57.2

Therefore C+G = 100 - 57.2 = 42.8
C = 42.8/2 = 21.4
G = 42.8/2 = 21.4

(i) Calculate the missing figures for rat DNA and write them into the table.

(2)

(ii) The virus has single-stranded DNA as its genetic material. Explain the evidence from the table which suggests that the DNA is single-stranded.

Virus is composed of ssDNA
Therefore no matching base pairs
So Chargaff's ratios do not apply. There will not be equal numbers of A & T and C & G.

(2)
(Total 5 marks)