

UNRAVELLING THE STRUCTURE OF DNA

An important milestone in the history of genetics was the purification of DNA by Oswald Avery and his co-workers in 1945. The realisation by the scientific community that the principle carrier of genetic information and the blueprint for life was DNA led to a number of questions being asked. One of the most crucial of these being, that which was concerned with its molecular structure.

In 1951, a few years later, two scientists, namely, James Watson, an American biologist and Francis Crick an English physicist, collaborated on solving the DNA puzzle about its molecular structure. Although they did little of the original research, they tackled the problem with brilliance, perception, and a great deal of energy. The existing data from experiments on DNA at that time fascinated them. Erwin Chargaff showed that any model of DNA structure would have to contain deoxyribose sugar, phosphate, purines and pyrimidines arranged in a way that would provide variation and a simple way of copying itself. Watson and Crick spent long hours constructing models with cardboard cut-outs, and kept alert for any and every bit of information that might give them an edge. Two English biophysicists, namely, Maurice Wilkins and Rosalind Franklin, had been painstakingly collecting data on X-ray crystallographs of DNA for several hours. With this technique, molecules of DNA bombarded by X-rays produce a photographic image that can predict the three dimensional structure of the molecule. After being allowed to view certain of Wilkin's and Franklin's data privately, Watson and Crick noticed an unmistakable pattern: The molecule appeared to be a double helix. Gradually the pieces of the puzzle fell into place, and a final model was assembled a model that explained all of the qualities of DNA, including how it is copied. Although Watson and Crick were credited for their clarity of their solution, it must be emphasized that their successes was due to the tremendous efforts of a number of other scientists. This historical discovery has shown that the tools of physics and chemistry have very useful applications in the biological sciences. In addition, this discovery set the scene for numerous research in all areas of molecular genetics.

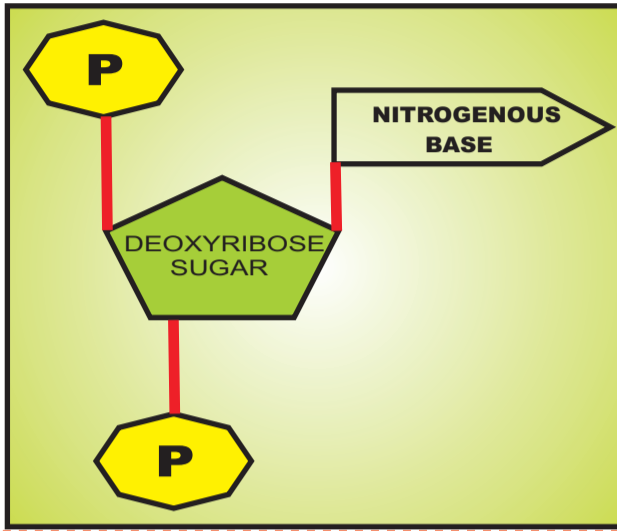
Since the discovery of the double helix, an extensive body of biochemical, microscopic, and crystallographic analysis has left little doubt that the model first proposed by Watson and Crick is correct. A new technique using scanning tunnelling microscopy produces three-dimensional images of DNA magnified two million times.

QUESTIONS

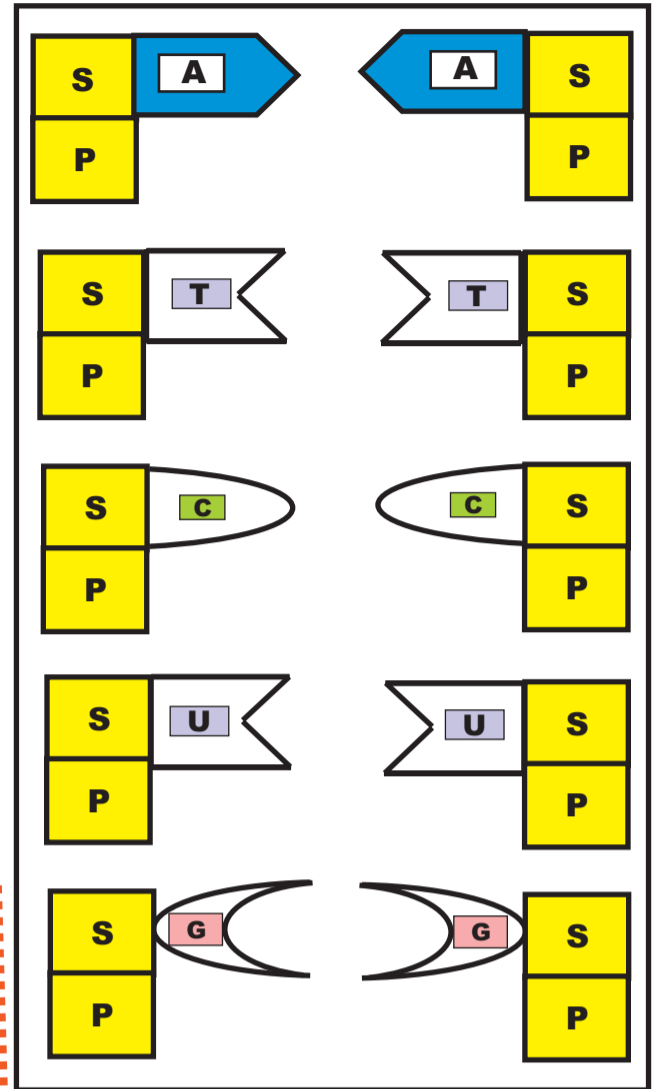
1. Why is it important to purify DNA?
2. Name the structure / substance that carries genetic material.
3. What do you understand by "blueprint"?
4. Describe the technique that was used to gather data on the structure of DNA.

Constructing DNA and RNA molecules

Study all the information about nucleic acids gained by you thus far, construct a model of DNA using cardboard or any other relevant materials.



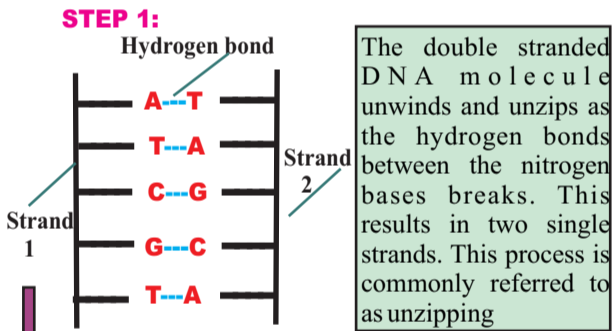
DNA MODEL



PROCESS OF DNA REPLICATION

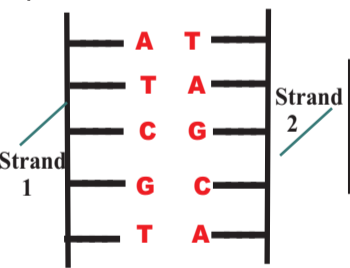
DNA replication occurs before cell division. The series of simplified diagrams below will explain how DNA replicates.

STEP 1:



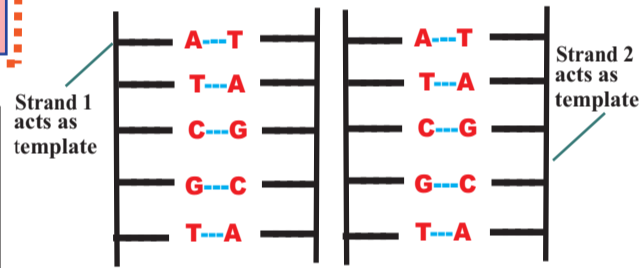
The double stranded DNA molecule unwinds and unzips as the hydrogen bonds between the nitrogen bases breaks. This results in two single strands. This process is commonly referred to as unzipping.

STEP 2:



Each separate strand serves as a template for the synthesis of a new complementary strand.

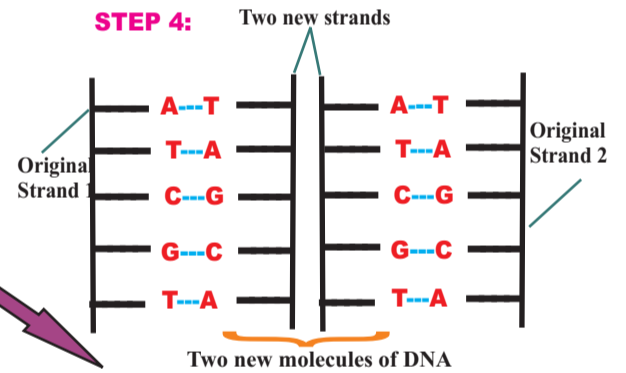
STEP 3:



Several free nucleotides with two extra phosphates are found in the nucleus. The extra phosphates activate the nucleotides. The bases of the activated nucleotides pair up with their complementary base on each of the original DNA strand.

From the series of steps above it can be seen that the process of DNA replication begins with one double stranded molecule and ends with two double stranded molecules of DNA. Each of these strand contains one strand from the original molecule plus a new complementary strand assembled from free nucleotides in the nucleus. Each new double stranded molecule is identical to the original strand.

STEP 4:



The sugar and the phosphates of the new nucleotides are then linked by an enzyme controlled reaction. This enzyme is DNA polymerase. DNA polymerase will only link an incoming nucleotide to the growing new chain if it is complementary to the base on the old strand. Hence the chance of a mistake occurring is minimal.

THE GENETIC CODE

First base in codon	Second base in codon				Third base in codon
	A	G	U	C	
A	Phenylalanine (AAA)	Serine (AGA)	Tyrosine (AUA)	Cysteine (ACA)	A
	Phenylalanine	Serine	Tyrosine	Cysteine	G
	Leucine	Serine	Stop	Stop	U
	Leucine	Serine	Stop	Tryptophan	C
G	Leucine	Proline	Histidine	Arginine	A
	Leucine	Proline	Histidine	Arginine	G
	Leucine	Proline	Glutamine	Arginine	U
	Leucine	Proline	Glutamine	Arginine	C
U	Isoleucine	Threonine	Asparagine	Serine	A
	Isoleucine	Threonine	Asparagine	Serine	G
	Isoleucine	Threonine	Lysine	Arginine	U
	Methionine (start)	Threonine	Lysine	Arginine	C
C	Valine	Alanine	Aspartate	Glycine	A
	Valine	Alanine	Aspartate	Glycine	G
	Valine	Alanine	Glutamate	Glycine	U
	Valine	Alanine	Glutamate	Glycine	C

ACTIVITY

Study the micrographs of human red blood corpuscles to answer the questions that follow.

1. Normal haemoglobin is called haemoglobin A, while that which causes sickle cells is called haemoglobin S.
 - 1.1 As pointed out earlier, haemoglobin is a protein. How is it possible for two forms of the same protein to be formed?
 - 1.2 Study a part of (first eight) two amino acid sequences of beta haemoglobin. One is that of a normal type of haemoglobin while the other is for the mutated form.

val-his-leu-thr-pro-glu-glu-lys ----- normal

val-his-leu-thr-pro-val-glu-lys ----- mutated

- 1.2.1 What do you understand by a mutation?
- 1.2.2 List the difference/s between the two forms of proteins.
- 1.2.3 Suggest why this mutation might have occurred. Refer to codons and DNA triplets
- 1.2.4 Explain why genetic codes have to be precise.