Gene expression

The role of DNA – chains of information

DNA strands are capable of self-recognition and self replication.

Duplication of the genetic information can take place every time a cell divides.

Information encoded in the structure can be passed from one generation to another.

Parent DNA molecules can produce identical daughter copies in a process known as replication

The major interest of DNA is as the blueprint for the synthesis of proteins – the enzymes, antibodies and structural proteins which determine the nature and function of an organism.

The amino acid sequence of each polypeptide chain is encoded in a specific stretch of DNA or gene.

The message that is coded in a gene generates copies of a particular polypeptide chain through a two-stage process:

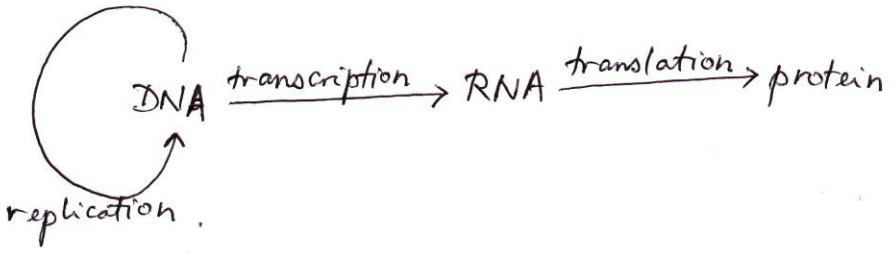
- Transcription — The DNA template is first copied into an intermediary nucleic acid molecule, mRNA.
- Translation — mRNA molecules direct the assembly of the polypeptide chain.
  The translation process involves ribosomes attaching to, and moving along, the mRNA as the polypeptide chain is synthesised.

Ribosomes are small organelles contained within a cell, about 20nm across, which are made up from about 50 different proteins and three large RNA molecules of their own.

The double helix of DNA controls heredity on the molecular level.

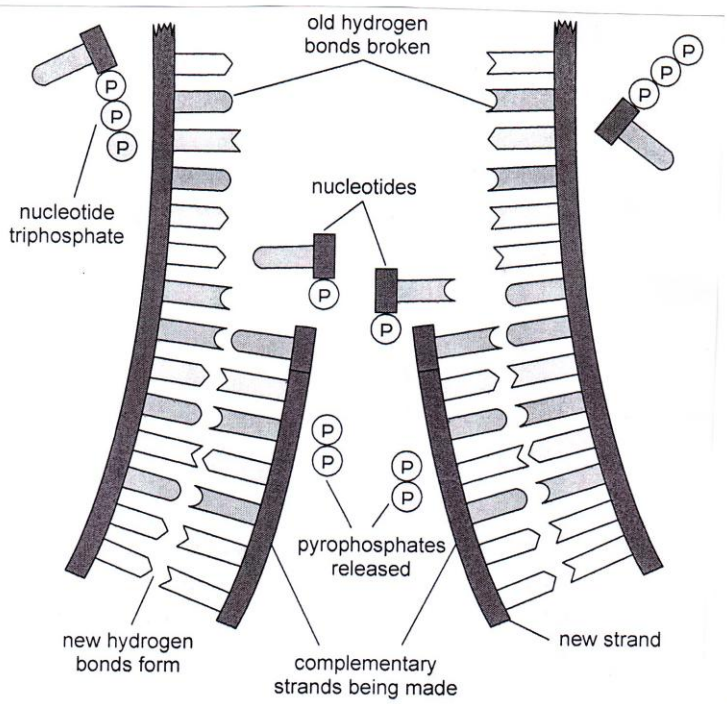
DNA does both:
- preserves the genetic information – replication.
- uses itself to direct the synthesis of proteins — transcription and translation.

The overall flow of genetic information between generations and its expression by the cells of an organism are:



Replication – the biological assembly of new DNA

Replication is a process requiring a number of different enzymes and other compounds.



A strand of DNA acting as template for replication.

The replication process can be explained as a sequence of steps:

- The hydrogen bonds and van der Waals' forces between the base pairs in part of a DNA molecule are broken.
- This part of the double helix unwinds.
- Nucleotide triphosphate are brought up one by one to the seperated part of the chain.

- Enzymes catalyse the polymerisation reaction.

During the polymerisation process, the nucleotide triphosphates are converted to nucleotides and pyrophosphate.

The nucleotides pair up with the complementary bases on the original strand.

DNA polymerase is one of the enzymes involved in this reaction.

Note:

In reality, after the helix unzips, one chain is replicated one nucleotide at a time.

The replication of the other chain has to wait until a number of bases in the strand become free.

This is because each strand is replicated in the 5'—to—3' direction.

Each new strand contains a sequence of bases that is complementary to the original strand.

So if the order of bases in part of the original strand is:

—A T G C C G T T A A G T—

then the complementary sequence on the new strand is:

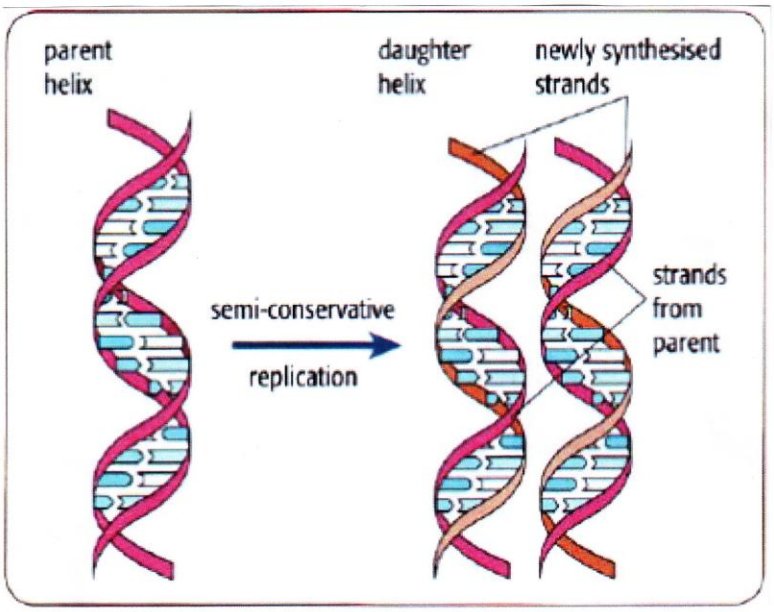
—T A C G G C A A T T C A—

Two new strands are formed using the original strands as templates for the synthesis.

The two double helices formed are identical.

Each new strand contains a complementary sequence of bases as dictated by the order of the bases in the original strand.

Thus two daughter molecules are formed from the parent double helix.



strand of DNA acting as template for replication.

This form of replication is known as semi-conservative replication because each daughter molecule contains one new strand and one original strand.

Exercise 1

DNA is replicated semi-conservatively.
Explain the meaning of semi-conservative.

Workings

Two new strands are formed from the each of original strand.
After replication, each daughter molecule contains one new strand an one original strand.

Exercise 2

The base sequence in part of the 5' to 3' parent strand of DNA is

-TAGAAAGCTCAG-

What is the DNA sequence in the corresponding part of the new strand made during replication?

Workings

A - T ; C - G

The complementary strand is,

3'-ATCTTTCGAGTC-5'

Exercise 3

An analysis of the bases in a sample of double-stranded DNA gave the partial result adenine 23 mol % and guanine 27 mol %. What would you expect the rest of the analysis to show? Explain your answer.

Workings

Since adenine is complementary to thymine and guanine is always complementary to cytosine, thymine 23 mol % and cytosine 27 mol %

Exercise 4

What role do hydrogen bonds play in the accurate replication of DNA?

Workings

The hydrogen bonds are formed between the base pairs.

Two hydrogen bonds formed between each adenine - thymine pair (A=T)

Three hydrogen bonds are formed between a guanine-cytosine pair (G≡C)

The bases will line up so that the hydrogen bonding is maximised.