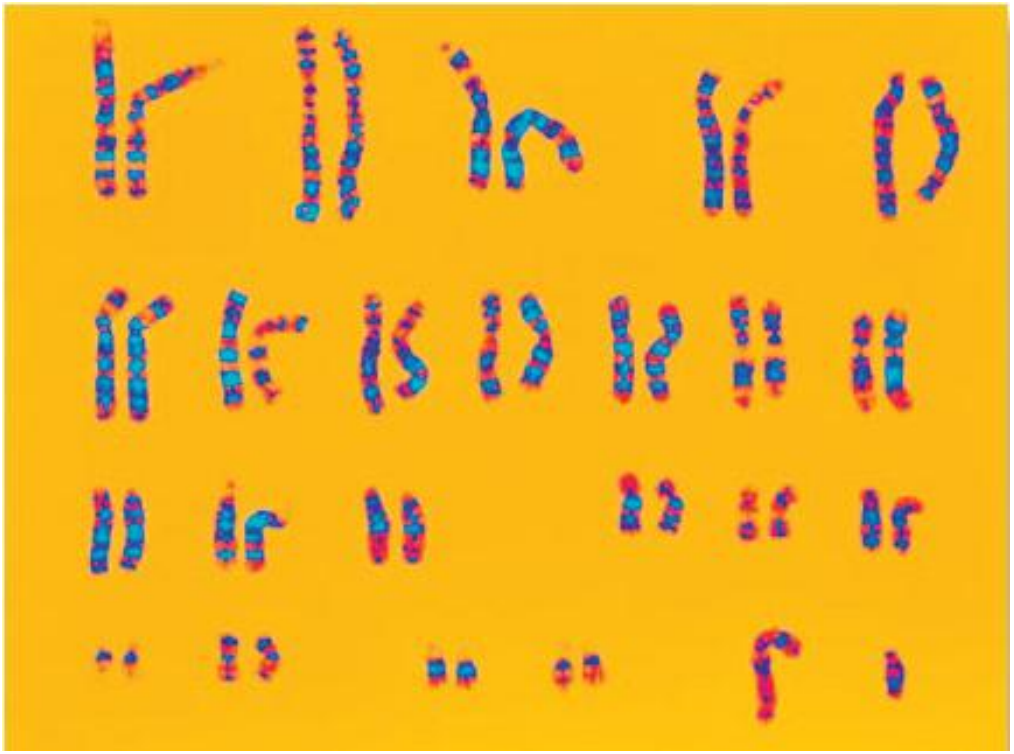
DNA



Chapter 13, Page 203

Heinemann Chemistry 2

13.1 The biological importance of DNA.

Within the nucleus of almost every cell, 46 DNA molecules or chromosomes contain approx. 20 000 to 25 000 genes that act as a blueprint directing which proteins are to synthesised by the cell.

DNA is able to determine the characteristics of the entire person. It is unique as it is able to manufacture another identical molecule to itself.

13.2 The structure of DNA.

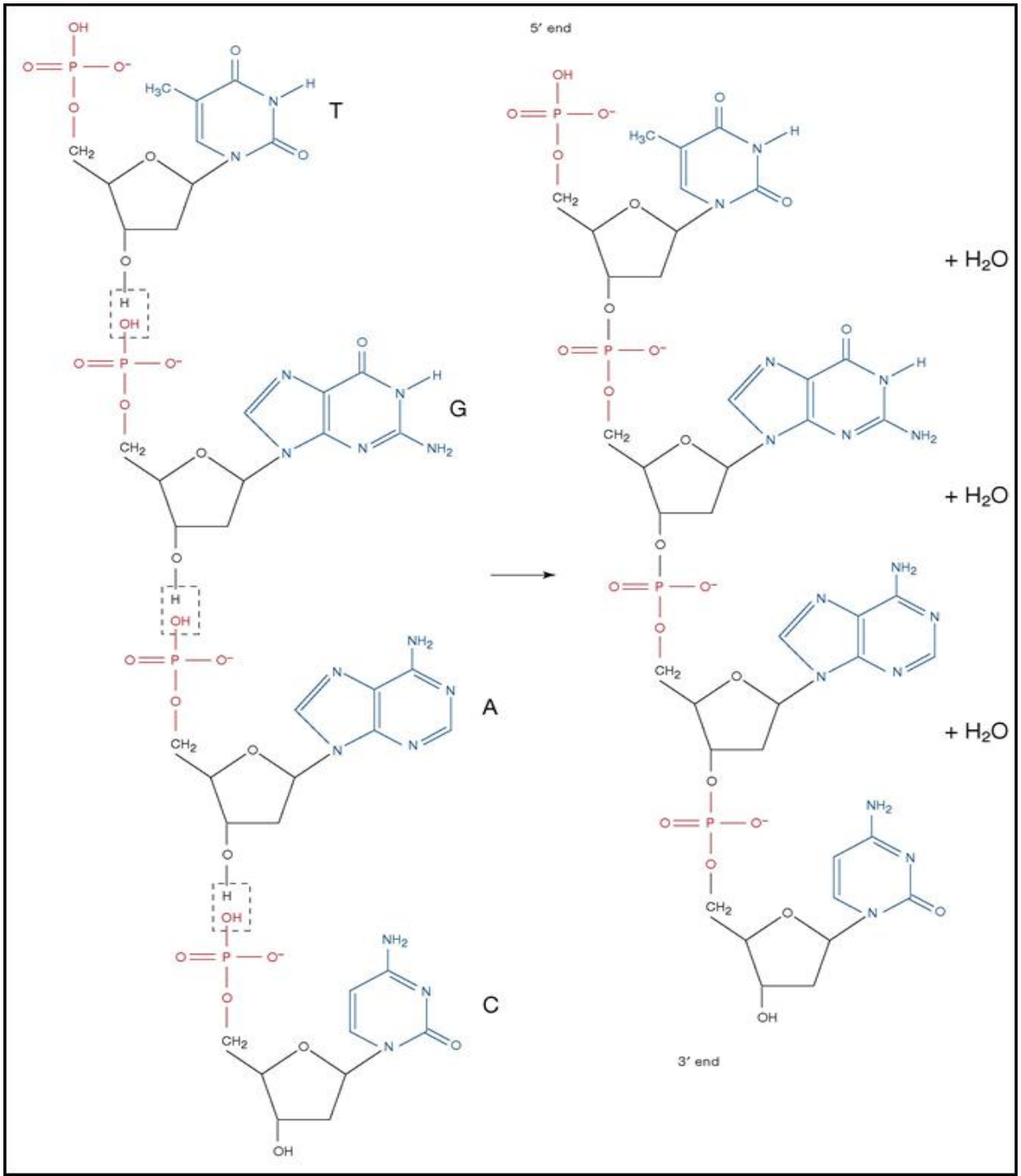
- DNA is a condensation polymer constructed from 4 monomers known as nucleotides.

- Each nucleotide consists of a phosphate group, a deoxyribose sugar group and one of 4 bases: adenine (A), cytosine (C), guanine (G) and thymine (T).

- Adenine and guanine are derivatives of the organic compound purine. Cytosine and thymine are derivatives of pyrimidine.

The structure of DNA

The base forms a covalent bond to the carbon atom, C_1, the phosphate group bonds to C_5 and a water molecule is produced when each bond is formed. This is via a condensation reaction


5′ end
T
G
A
C
+ H2O
+ H2O
+ H2O
3′ end

Primary structure of the polymer

- Covalent bonds are responsible for producing the primary structure of DNA.

- One end of the DNA strand has a hydroxyl group and is called the 3’ end. The end of the polymer with the phosphate group is called the 5’ end.

- The base is bonded to the C by condensation reaction. It is the sequence of bases along the sugar-phosphate backbone that forms it primary structure and is the basis for the genetic code.

Secondary structure of the polymer:

- Hydrogen bonding is responsible for the maintenance of the secondary structure.

- Base pairs fit together like a jigsaw. A pairs with T and G and C pair together.

- Two hydrogen bonds form between A and T and 3 hydrogen bonds form between G and C.

Secondary structure of the polymer cont....

The secondary structure of DNA is a DNA polynucleotide strands held together by hydrogen bonding between the bases A and T and G and C. The structure twists around to form a right handed double helix. The pairing of the bases is referred to complimentary base pairing.

Tertiary structure of the polymer:

- The phosphate groups in the backbone of the double helix give DNA molecule a negative charge. And this enables the molecule to interact with a group of proteins called histones.

- The DNA molecule wraps around the histones and become supercoiled and tightly and efficiently packaged.

Task

Draw Figure 13.8, page 208

Replication

- This is the division of plant and animal cells that generates an exact copy of their DNA.

- The DNA double helix partially unwinds, as hydrogen bonds between the 2 DNA strands are broken. Enzymes catalyse this process.

Replication cont...

The bases exposed on the separated strands then act as a template to which each new nucleotide attach by hydrogen bonds between the complimentary pairs. These undergo condensation reactions catalysed by the enzyme DNA polymerase to form 2 exact copies.

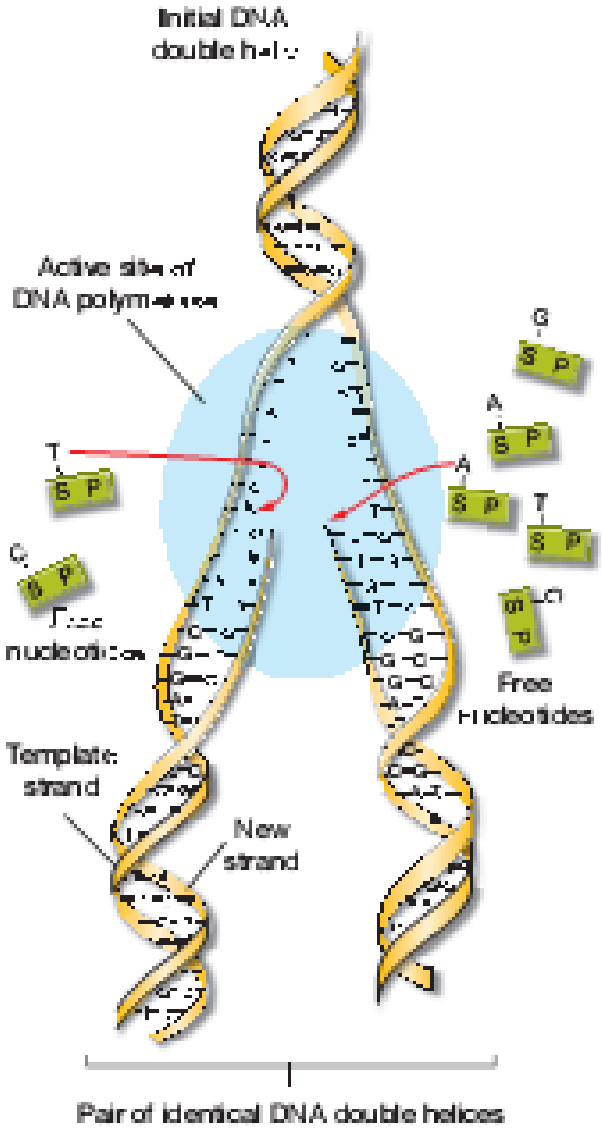


Figure 13.10
Replication of DNA is possible because of the hydrogen bonds between complementary bases (A–T, C–G) that break and then re-form.

13.3 How does DNA control biochemical processes?

- Alleles are alternate sequences of nucleotides on specific positions on a given chromosome.

- The sequence of nucleotides in DNA directs the sequence of amino acids in proteins.

- A triplet code is a sequence of 3 DNA bases codes for a particular amino acid.

13.3 How does DNA control biochemical processes? Cont…

- Messenger RNA decodes the information on DNA in the nucleus and transfers it to the ribosomes where protein synthesis occurs.

- Transfer RNA decodes this information and selects the amino acids.

- DNA $\xrightarrow{\text{transcription}}$ mRNA $\xrightarrow{\text{translation}}$ tRNA → proteins.

- A change in a DNA base can lead to a variation in the amino acid sequence in a protein which can result in a major health concern.

13.3 How does DNA control biochemical processes? Cont…

- Sickle cell anaemia: is an inheritable disease in which the RBC deform into a sickle shape when oxygen concentration is low. A gene on chromosome 11 doesn't code properly so a thymine is replaced with an adenine.

- Cystic fibrosis: an inheritable disease caused by a tiny error in the DNA sequence of a coding allele on chromosome 7 which means 1 amino acid is omitted from the polypeptide.

13.4 Forensic Application.

- Except for identical twins, your DNA sequence is unique.

- Electrophoresis: is an analytical technique used in creating a DNA fingerprint.

- Best for the separation and qualitative analysis of very large molecules that have an overall charge, such as DNA and proteins.

Forensic Application cont...

- The sample goes into a gel that has an electrolyte so it can conduct an electric charge.

- The separated components are visible by adding a dye, adding radioactive probes that bind to them or shining lasers into fragments that have a fluorescent dye in their structure.

DNA profiling

- Scientist are interested in the non-coding section of DNA. It varies greatly between people.

- We use DNA profiling to provide experimental data in court cases, identifying bodies in natural disasters and identifying species of plants and animals.

Forensic techniques

- DNA profiling involves the isolation of a sample of DNA and treating this with a restriction enzyme.

- Restriction enzymes act like molecular scissors, cutting DNA molecules everywhere a particular base sequence is found. They are specific.

- Thousands of DNA fragments are made then they are duplicated, separated, blotted to a medium, labelled with radioactive piece of DNA and exposed to x-ray.

PCR:
polymerase chain reaction

- A technique that takes advantage of DNA's ability to produce an identical replica molecule.

- You alternately heat and cool a sample to make millions of copies. Which means forensic scientists can gather evidence from a small sample of DNA.

PCR Cont…

3 cycles:

- Denaturation: Heat to 95^{o}C to break hydrogen bond between DNA strands.
- Annealing: Cooled to 55^{o}C, primers bond to the ends of the bit to be copied.
- Elongation: Heated to 72^{o}C complementary base pairs are added to the single strand DNA to make double strand DNA. Catalysed by polymerase and involves forming hydrogen bonds.

Task

Worksheet DNA Structure and Function – SWB pg 104