Chapter 15 - DNA and RNA

Learning objectives

- To define the terms 'heredity', 'gene' and 'gene expression' and give examples
- To explain the structure and function of chromosomes and the difference between coding and non-coding DNA
- To understand the structure of DNA, including complementary base pairing, and the genetic code
- To describe the process of DNA replication
- To define and describe DNA profiling and give examples of two applications
- To understand the meaning of 'genetic screening', giving examples
- To understand the structure of RNA and how it differs from DNA
- To describe protein synthesis, including the role of messenger RNA
- To describe DNA structure and the process of protein synthesis in detail
- To describe how to isolate DNA from a plant tissue.

Variation

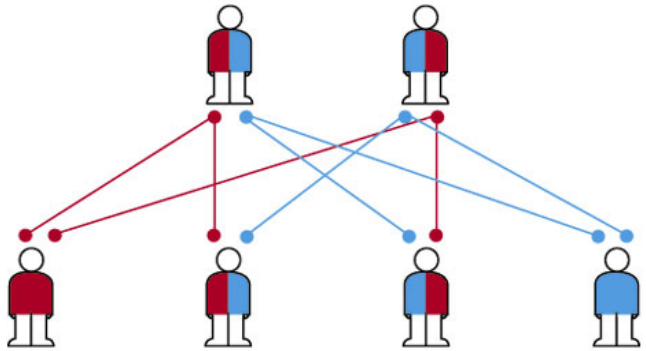
Variation means that individuals in a species have different characteristics to one another.

Acquired Variation - are not inherited. e.g learnt during life

Inherited Variation - are inherited. e.g. passed on through genes.

Heredity

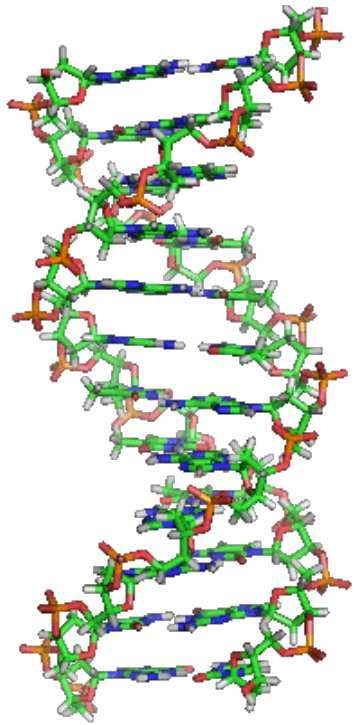
This is the passing on of characteristics from parents to their offspring by means of genes.



Genes

A gene is a section of DNA that causes the production of a protein.

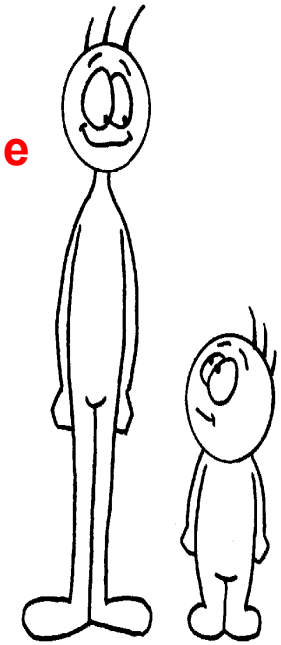
A gene is a section of DNA that makes amino acids stick together in a certain order.
This makes a protein.
The proteins are often enzymes.
Enzymes control reactions in our bodies.



Gene Expression

Gene expression is the precise way that information in the genetic code in a gene is decoded to the cell and used to make a protein.

You may have a gene for being tall but if you don't get the right nutrients you will not grow to be tall.



Characteristics = heredity and environment

Chromosomes

These are about **60% Protein** and **40% DNA**.

Proteins called **Histones** are wrapped around the DNA and keep it tightly coiled up in the nucleus.

Large sections of DNA have genes that are not used.
97% of our DNA is not used anymore. It is called **junk DNA**.
We can use this junk DNA to make DNA profiles to identify people.

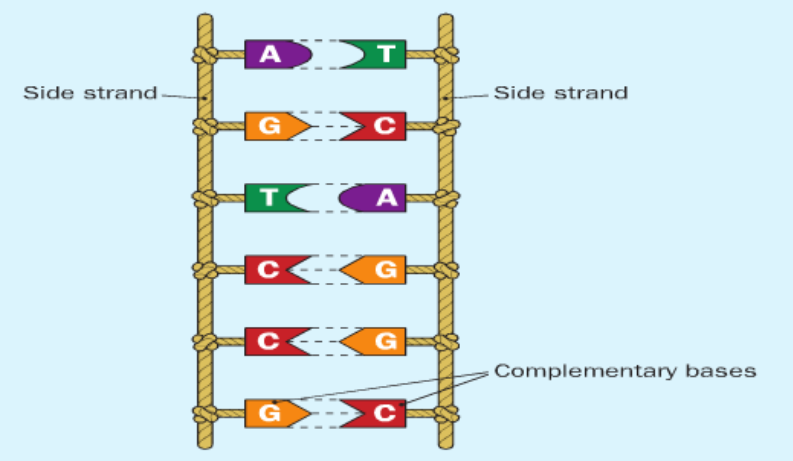
The puffer fish has 8 times more DNA than us.

DNA

Deoxyribonucleic Acid is like a **twisted ladder**.
It has 2 strands or sides.
The strands are held together by 2 chemicals (bases).
These bases are called **complementary bases**.

There are 4 bases - A,T,C,G.

A - Adenine **T - Thymine** **C - Cytosine** **G - Guanine**

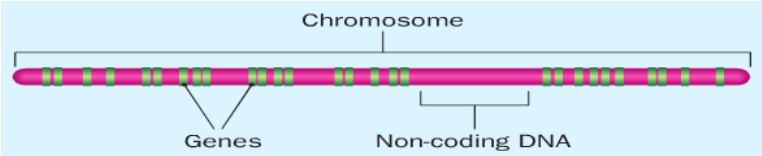


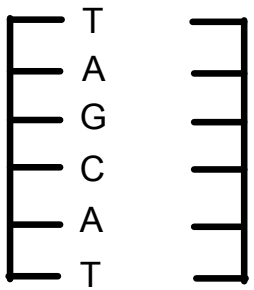
A <u>always</u> attaches to T

C <u>always</u> attaches to G.

The Genetic Code

All the DNA to make a human has 3 billion letters.
If one strand has the sequence **TAGCAT** then the other strand will be.....?





A gene is a list of bases known as a **genetic code**.
A gene works when this code is **expressed**.
This means the code is sent **out of the nucleus** to the cytoplasm.
e.g. CAACGACAA

In the cytoplasm every **three letters** (**triplet, codon**) calls an amino acid.
The amino acids line up in order and form a protein.
e.g. the code CAA = amino acid called **Valine**.
the code CGA = amino acid called **Alanine**.

To isolate DNA from a plant tissue

For this experiment we can use Onion or Kiwi.

We add washing-up liquid to break open the phospholipids in the cell membrane.

We add salt to make the DNA clump together.

We denature enzymes that might destroy the DNA by putting them in a water bath at 60^0C for 15 mins.

We stop DNA breakdown by placing in ice for 5 mins.

We chop up the cell walls and release more DNA by using a blender.

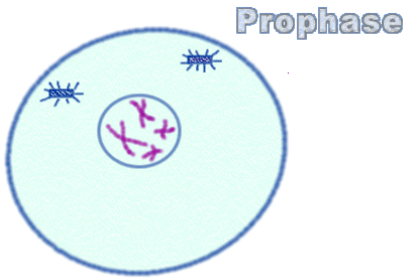
We filter the cells in coffee paper (big pores) and keep the filtrate.

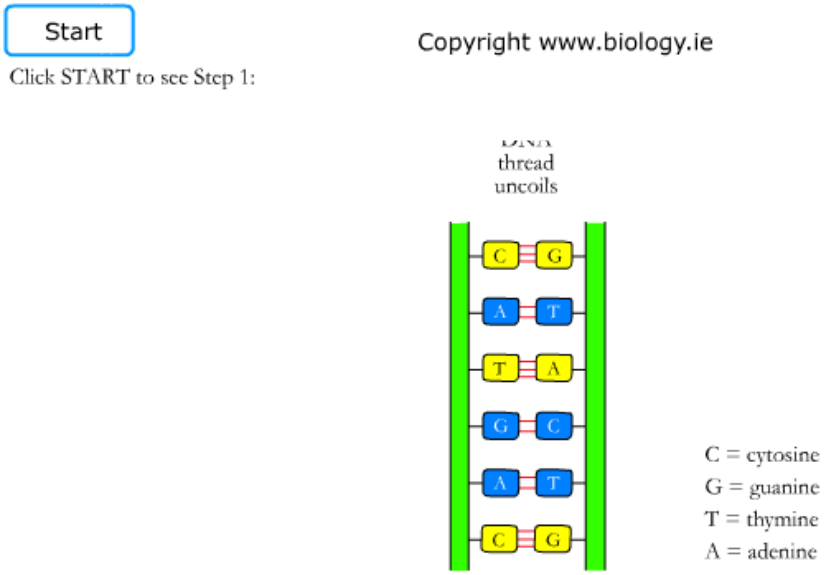
We add an enzyme to break down the **Histone proteins** and release the DNA.

Finally we add ice-cold ethanol to separate out the DNA from the protein.

Replication of DNA

From **Mitosis** we learnt that the cell nucleus divides by PMAT.
Before a cell can divide the nucleus must first divide.
Proteins called **Histones** hold the chromosomes tightly bound.
For a nucleus to divide the **chromosomes have to be copied** to make an extra set for the new cell.
DNA is copied during **Interphase.**

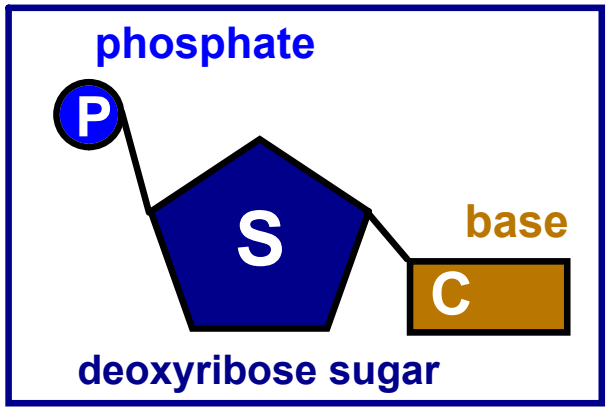


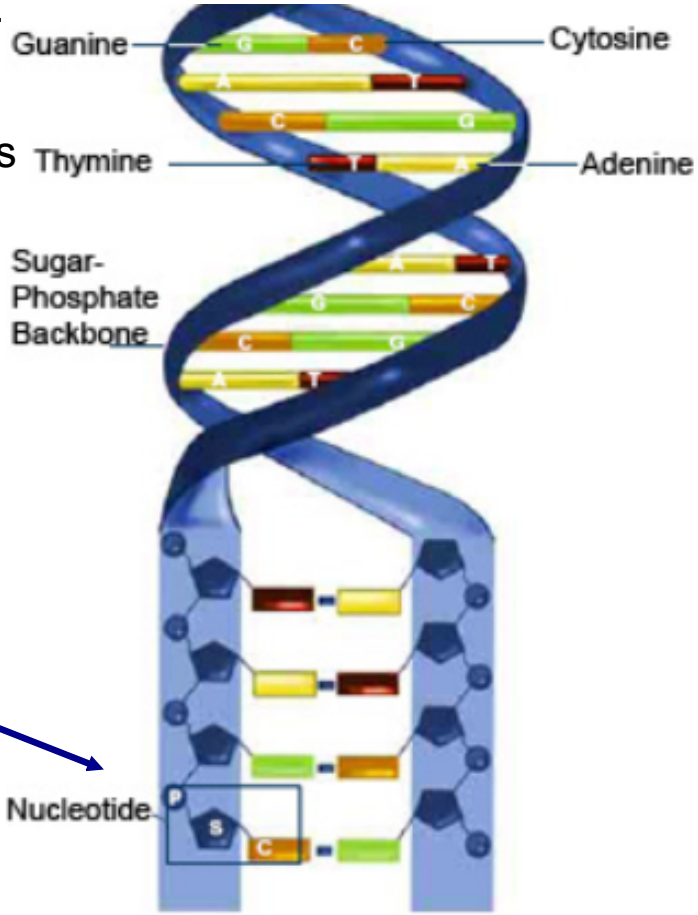


Nucleotides

Nucleotide is the name given to the section of DNA that contains the phosphate, sugar and nitrogen base.

Each base (A,T,C,G) has a Sugar and P attached. These connect to other nucleotides to form the strands of the DNA ladder.

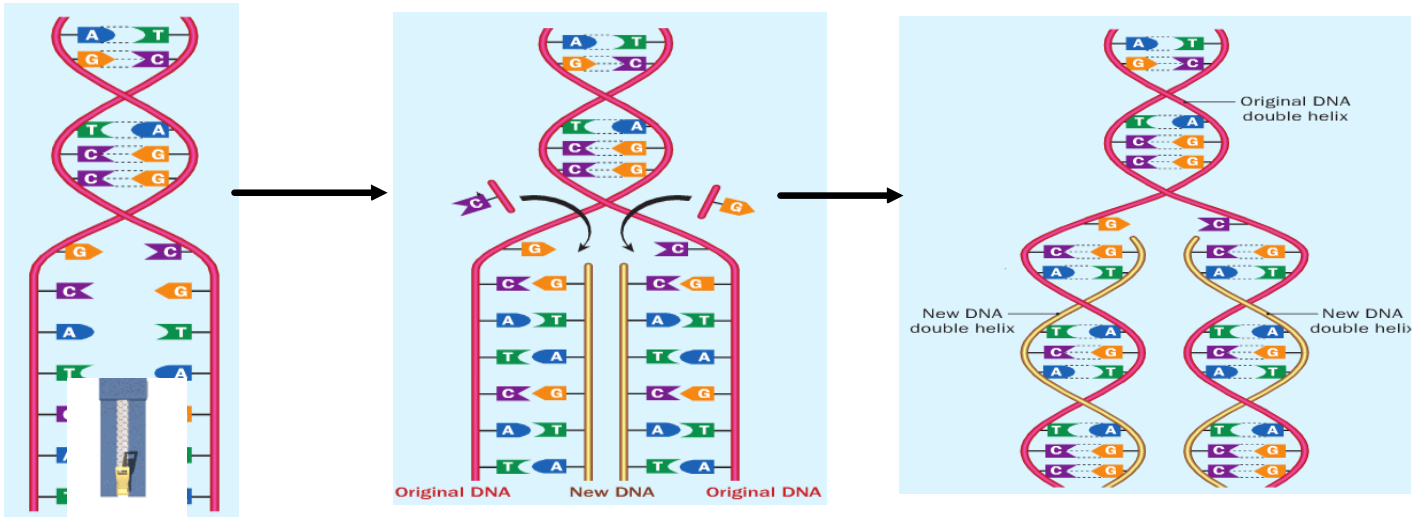


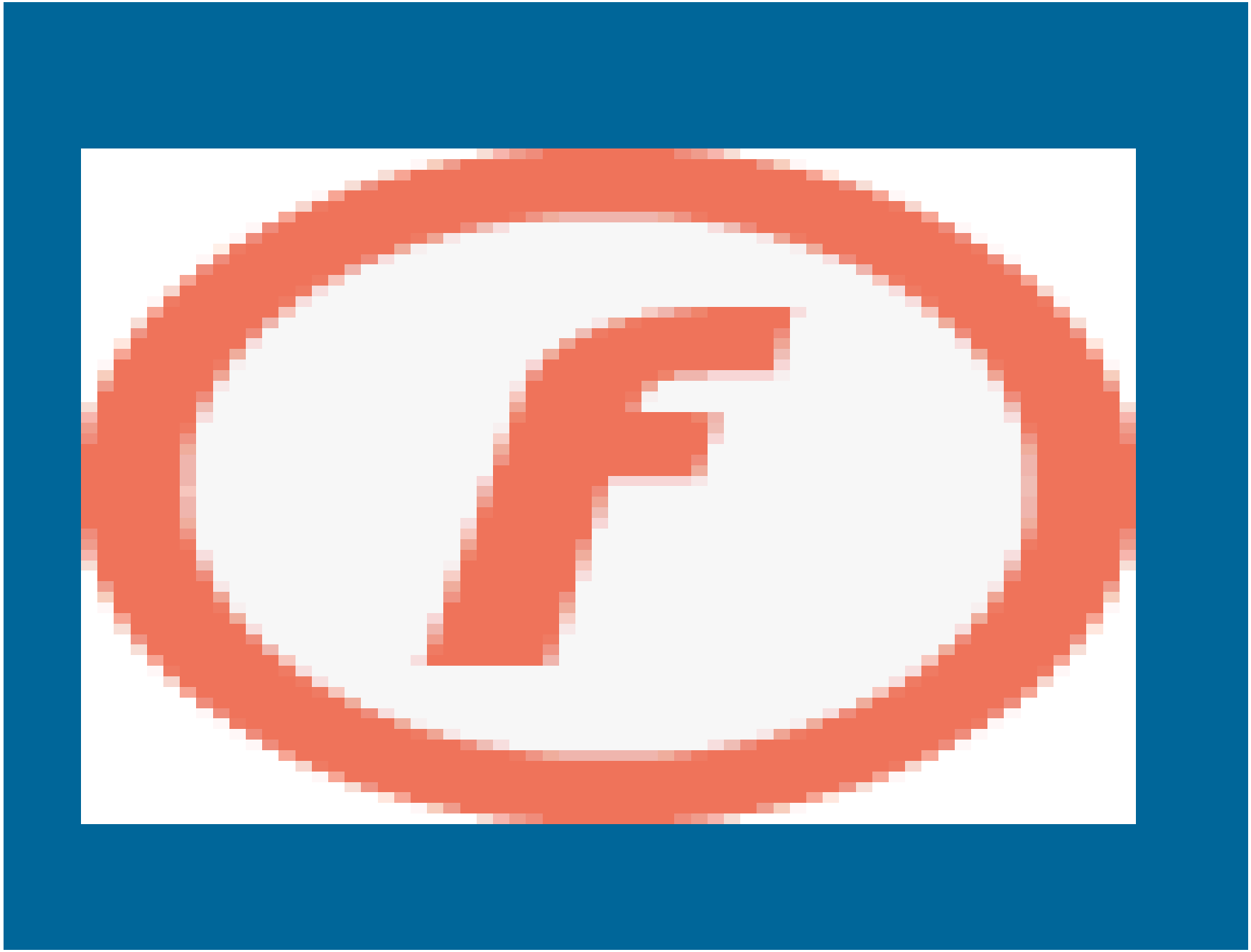


Replication of DNA

Steps in Replication

1. The DNA uncoils.
2. An enzyme breaks the bond between the base pairs.
3. DNA bases from the cytoplasm enter the nucleus.
   They attach to exposed DNA bases on the strands.
4. Each new strand is half old and half new.
   Each strand is an exact copy of the original DNA strand.
5. All DNA strands rewind up to form a double helix shape.

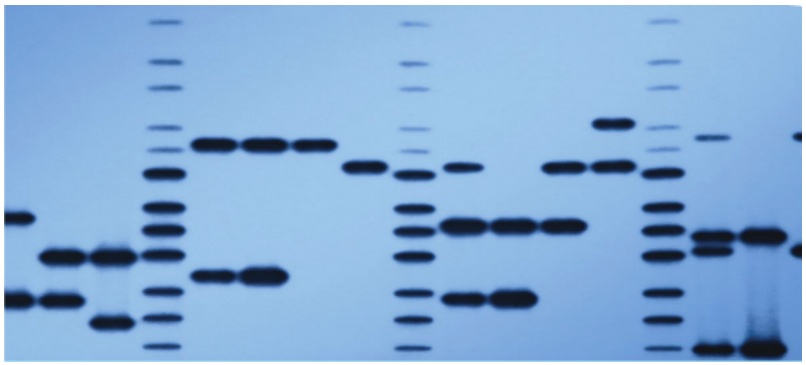




DNA Profiling

This is also known as DNA finger-printing.
It is a method of making a unique pattern of bands from the DNA of a person. This can then be used to tell different people apart by using their DNA.

The pattern is made using **Gel Electrophoresis**.
An electric current is used to separate DNA into a pattern on a gel. Even a small amount of DNA can be copied to create more for testing.



How it works

Steps in making a DNA Profile

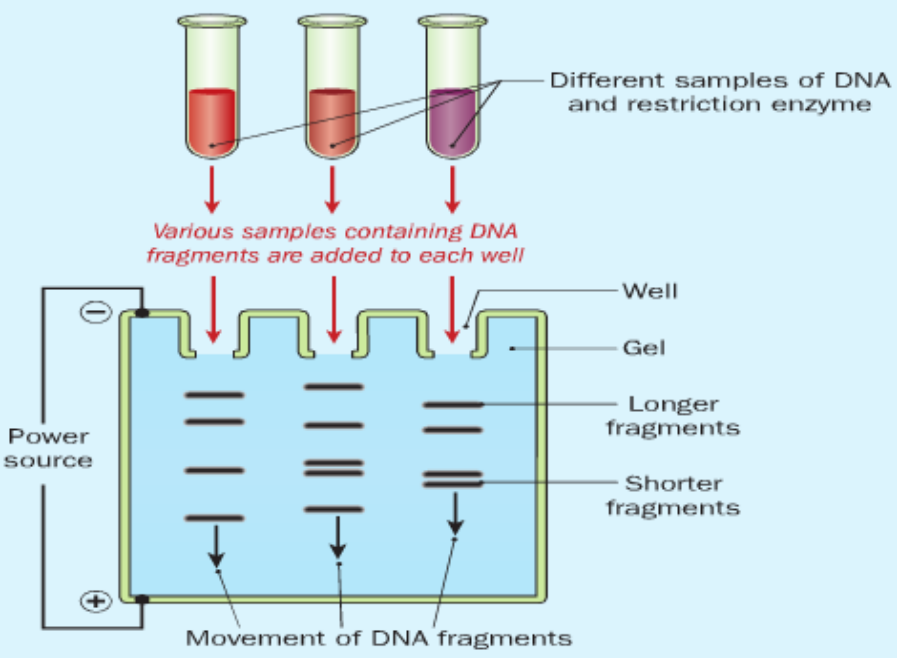
Step 1.
DNA is released.
It is released from cells as in the experiment we did earlier.

Step 2.
DNA is cut into fragments.
Enzymes called restriction enzymes cut the DNA at certain places. This cuts the DNA into different length strands. It always cuts between the same letters in the ATCG code.
e.g. one enzyme always cuts at the code GAATTC.

Step 3.

DNA fragments are separated.

The DNA is injected into wells on a sugar **gel**.
An electric current is passed through the gel and the **negatively** charged DNA moves from one end to the other. The larger pieces don't move very far while the short pieces can move further in the gel.
This leaves a pattern of lines or **bands** on the gel.



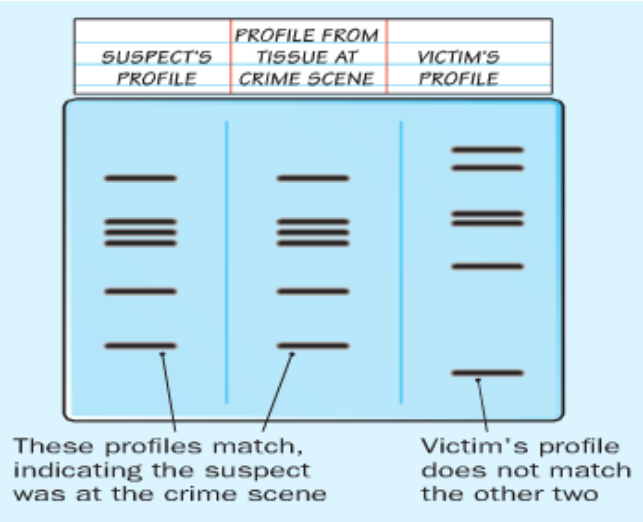
Step 4.

Patterns are compared.

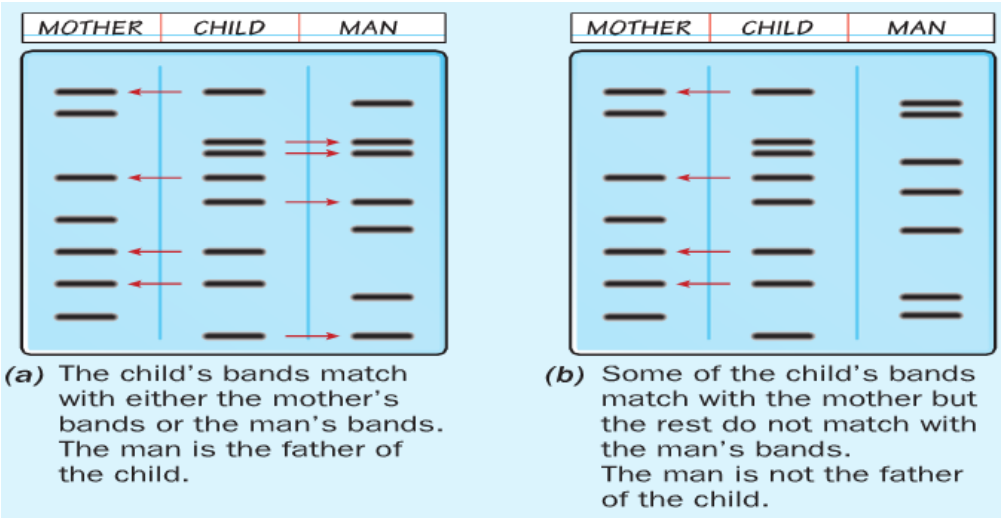
Because the restriction enzymes cut the DNA at certain places your DNA always makes the same pattern. A photograph of the gel is taken and the bands of different DNA can be compared.

Only identical twins will have the same DNA pattern.

CRIME SUSPECTS

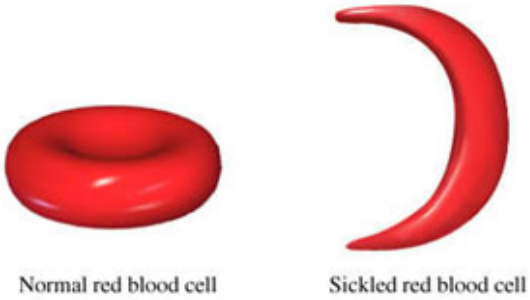


PATERNITY TESTS



Genetic Screening

This is where DNA is tested for a presence or absence of a particular gene or an altered gene.



Genes can have mistakes made by replication or by a **mutation**.

Adult screening - **Cystic fibrosis** or Sickle-cell anaemia.

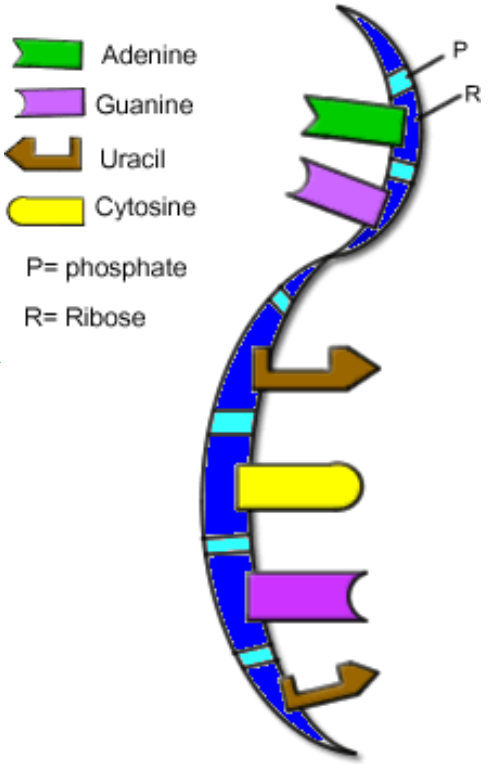
Foetal screening - cells can be removed from the placenta or fluid.

Genetic Counselling - couples with a history of genetic disorders in their family can receive advice and tests to let them make informed decisions about having children.

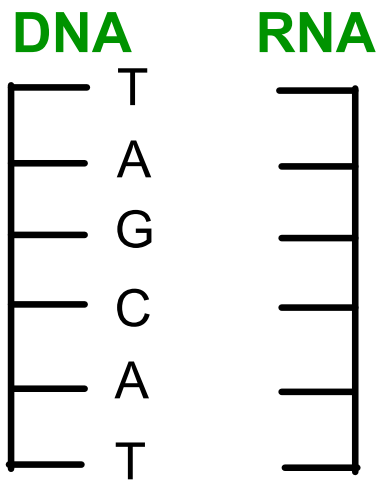
RNA - Ribonucleic acid

RNA is different to DNA as it has 4 bases A,U,G,C.
Uracil is there instead of Thymine.

Differences between DNA and RNA	
DNA	**RNA**
1 The bases are AT GC (thymine)	The bases are AU GC (uracil)
2 Double-stranded (i.e. double helix)	Single-stranded
3 Found in the nucleus	Found in the nucleus and cytoplasm

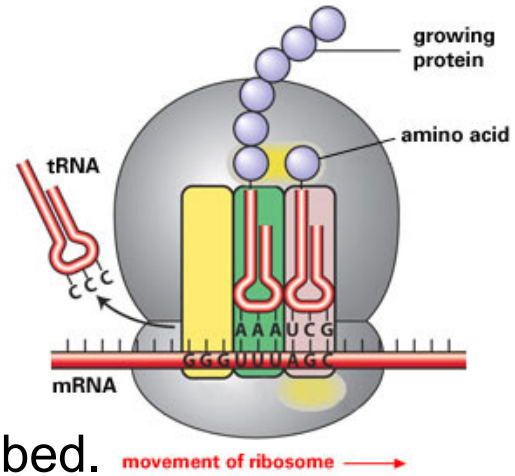


If a DNA strand is this, then the RNA bases (nucleotides) will attach on in the following way.



Protein Synthesis

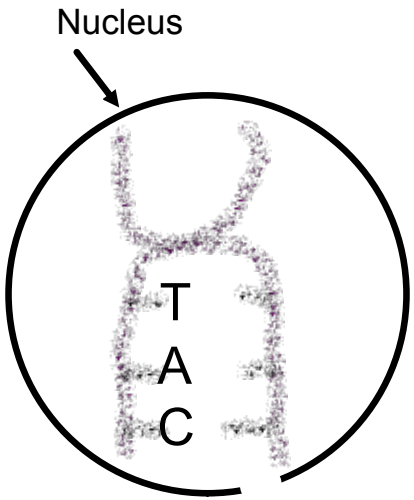
DNA has a code that makes a **protein**.
Proteins are made in **ribosomes** in the **cytoplasm**.
DNA cannot leave the cell nucleus.
RNA is used as a **messenger** to carry the code to the ribosome in the cytoplasm.

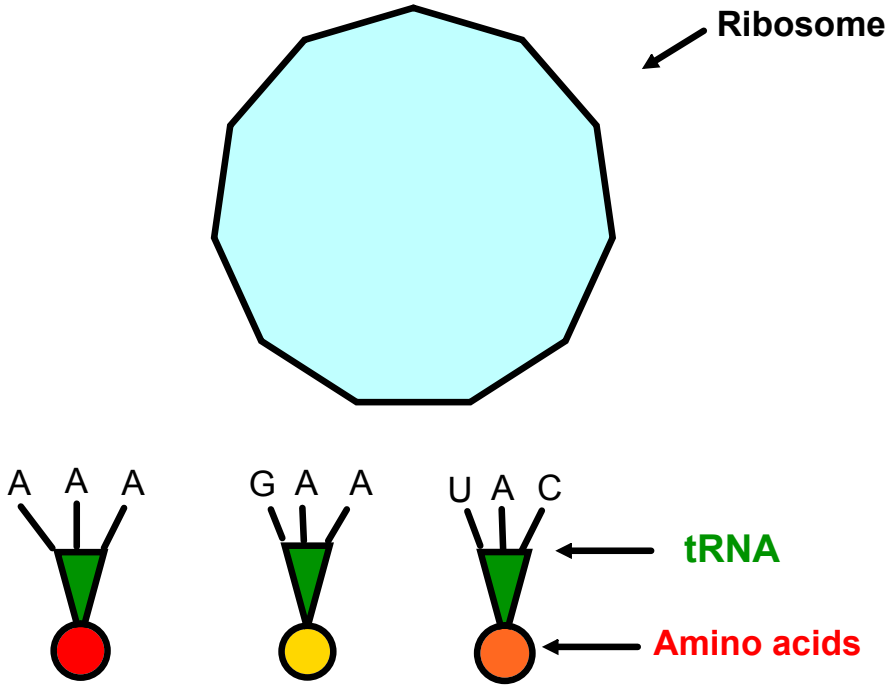


The RNA must first **copy the code** from the DNA.
This is called **Transcription** - as the code is transcribed.
Once the code is copied the **mRNA** (messenger RNA) moves out to the cytoplasm and to the Ribosome.

The ribosome **'reads'** the mRNA code.
It reads it three letters at a time. Each triplet of letters matches three letters of **tRNA** (transfer RNA). This carries (transfers) a certain **amino acid** to the ribosome.
This is called **Translation**.
The amino acids then join to form a **protein**.

Protein Synthesis





Transcription/Translation Overview

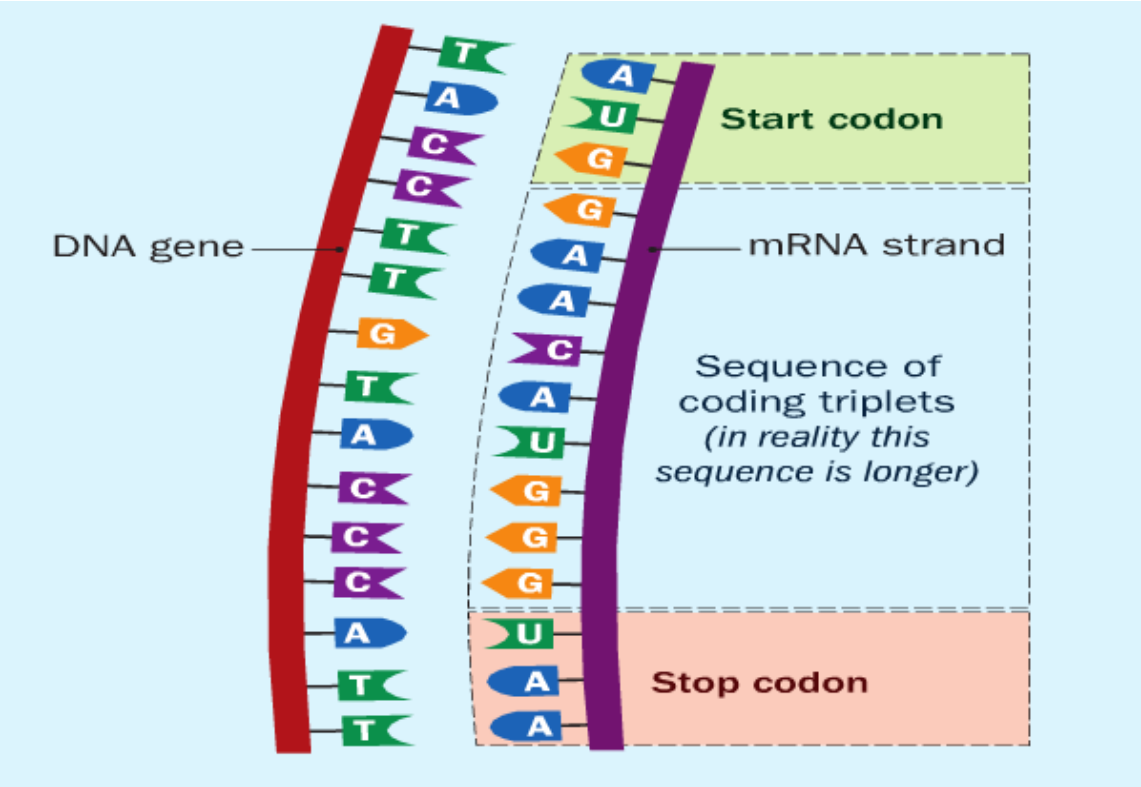
Developed by: Patty Hain and
Nathan Wambaugh

Translation Detail

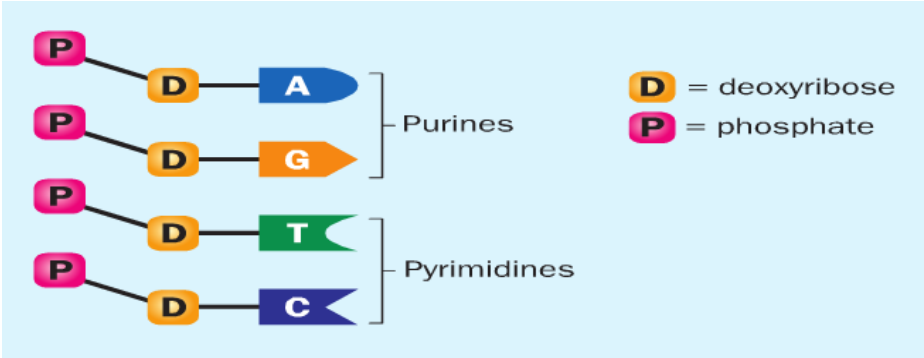
Developed by: Deana Namuth,
and Nathan Wambaugh

Codons

The **start** codon tells the ribosome to start reading the code.
The **stop** codon tells the ribosome that there is no more code to read.
The tRNA (transfer RNA) has 3 letters called **anticodons** that match up with the 3 letters (codons) on the mRNA.



Detailed Structure of DNA - Higher Level



The **Purines** are A and G
The **Pyrimidines** are T and C

A and T are joined by a **double** hydrogen bond
C and G are joined by a **triple** hydrogen bond