Unit 1: DNA & the Genome

Key Area 6: Mutations

Mutations are **changes in the DNA** that can result in **no protein** or an **altered protein** being synthesised.

SINGLE GENE MUTATIONS

A **Single Gene mutation** involves the **alteration of a DNA nucleotide sequence** as a result of:

- **substitution**
- **Insertion**
- **Deletion**

of Nucleotides.

Clue : DIGS

Deletion

Insertion

Gene

Substitution

Substitution Mutations

These involve one DNA nucleotide being swapped/substituted for another.

Missense, Nonsense and Splice-site mutations are all examples of substitution mutations.

Missense mutations result in **one amino acid being changed for another**. This may result in a **non-functional protein** or **have little effect on the protein**.

Example 1

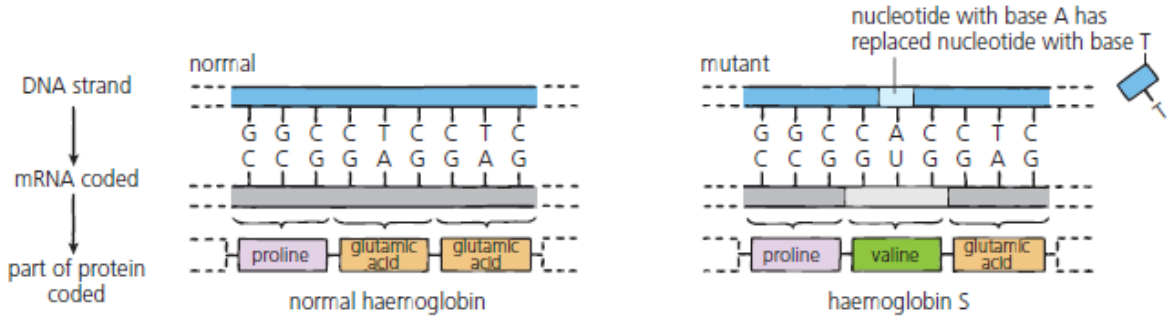
Normal DNA Sequence : …. A T G T C C A T G….

Missense mutation : …. A T G G C C A T G….

This may have **NO EFFECT** on the protein produced if the codon GCC leads to the transcription & translation of an amino acid with similar chemical properties to the amino acid coded for by the original sequence. This means that the folding of the protein produced is unchanged and therefore the protein will have a similar shape & function to the original protein.

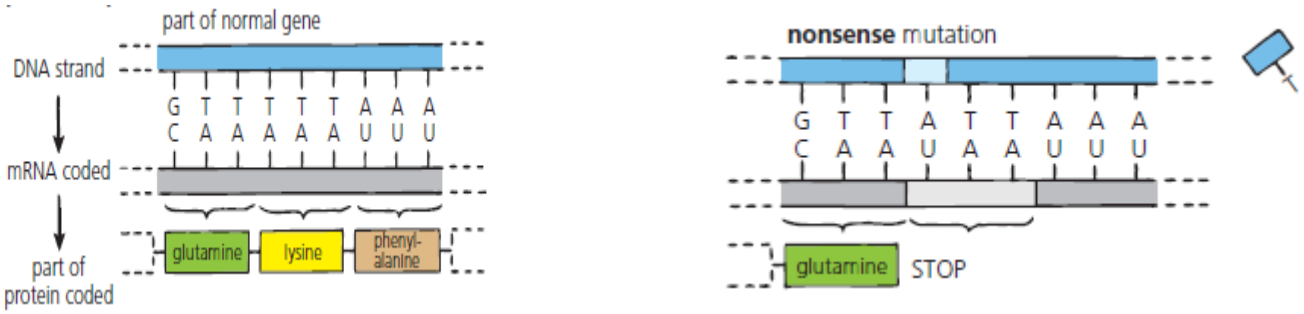
Example 2

Sickle-cell Anaemia



This missense mutation results in a protein which does not function properly since the amino acid (Valine in this case) has **different chemical properties** to the original amino acid (Glutamic Acid).

Nonsense mutations result in a premature STOP CODON being produced which results in a shorter protein.

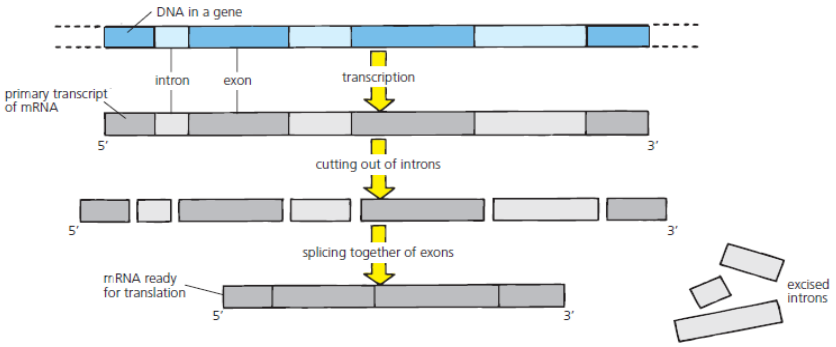


In the above example, substitution of the nucleotide carrying Thymine with a nucleotide carrying Adenine means that during translation, the codon UAA on the mRNA represents a STOP codon and so translation comes to an end, leading to a much shorter protein being produced.

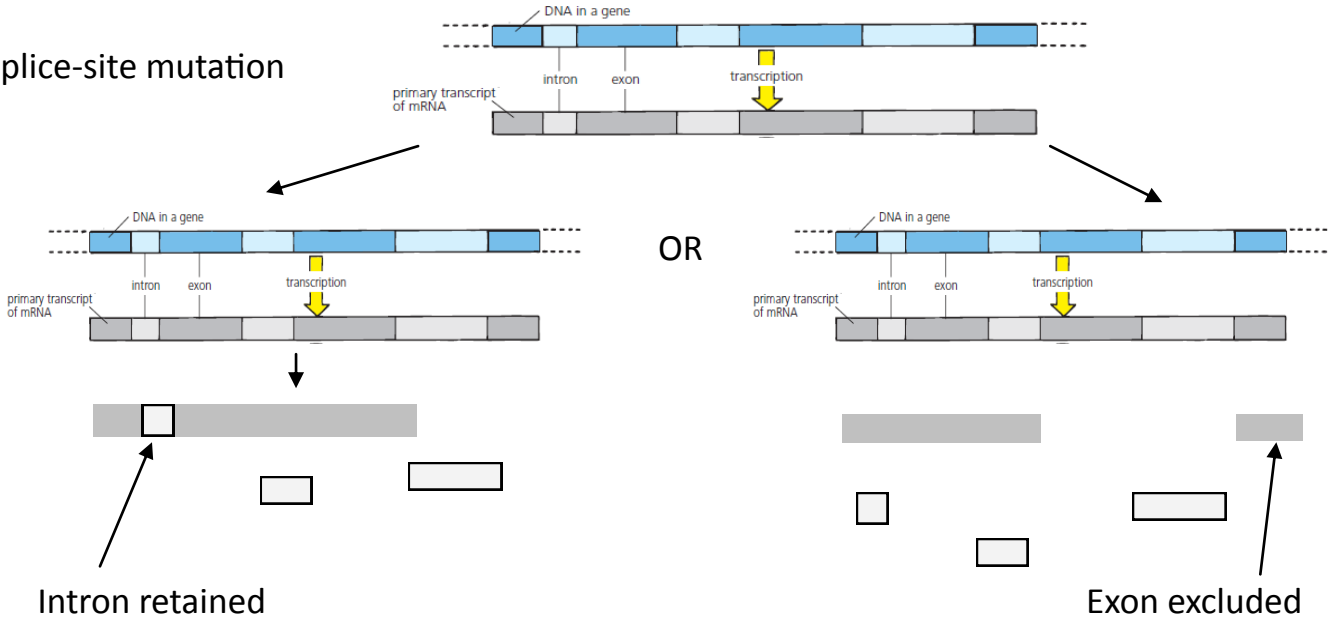
Splice-site mutations result in some **INTRONS being RETAINED** and/or some **EXONS not being INCLUDED** in the mature mRNA transcript.

E.g

Normal



Splice-site mutation



Intron retained

Exon excluded

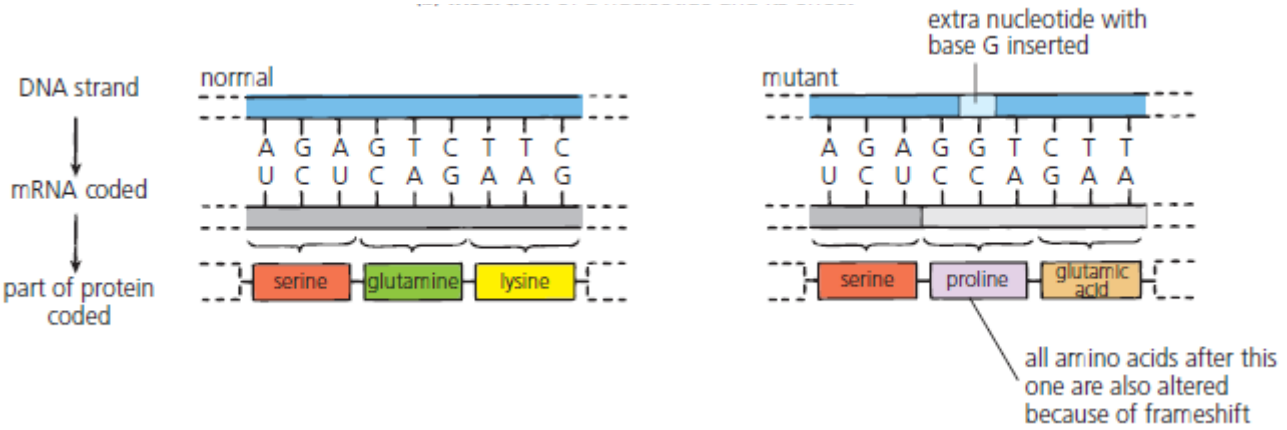
Insertion Mutations involve an extra **DNA nucleotide** being **added/inserted** into the DNA sequence.

Deletion Mutations involve a **DNA nucleotide** being **left out/deleted** from the DNA sequence.

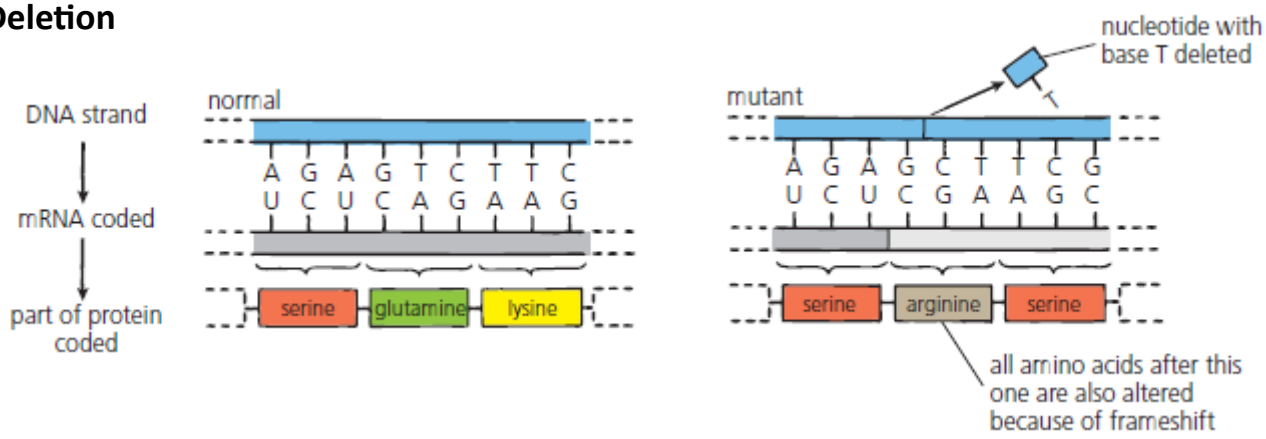
Both **Insertion and Deletion** mutations result in a **Frame-shift**.

Frame-shift mutations cause **ALL** of the **codons** and all of the **amino acids** after the mutations to be changed. This has a major effect on the structure of the protein produced.

Insertion



Deletion



CHROMOSOME MUTATIONS

A Chromosome mutation involves a change in the **structure** or **number** of **chromosomes**.

There are 4 types of chromosome mutations:

- **Deletion**
- **Inversion**
- **Translocation**
- **Duplication**

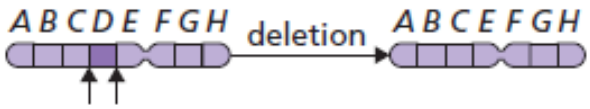
Clue : DICTD

Where C stands for Chromosome

The **substantial changes** in chromosome mutations often make them **lethal**.

Deletion

This is where a **section of chromosome is removed**.

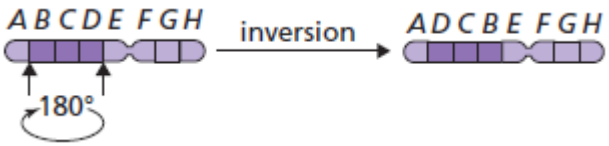


Each letter represents a GENE.

So, in this case Gene D has been deleted.

Inversion

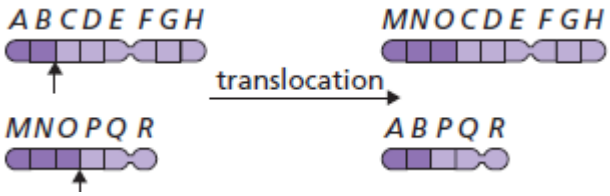
This is where a **section of chromosome is reversed**.



The chromosome breaks in 2 places and a set of genes rotates through 180^{o}

Translocation

This is where a **section of a chromosome is added to a different chromosome**, **not it's homologous partner**.



Duplication

This is where a **section of a chromosome** is **added from it's homologous partner**.

Some duplications can be highly detrimental whilst others can be important in evolution.

IMPORTANCE OF MUTATIONS & GENE DUPLICATIONS IN EVOLUTION

Duplication allows potential beneficial mutations to occur in a duplicated gene whilst the original gene can still be expressed to produce it's protein.