5.2 Genetic mutations

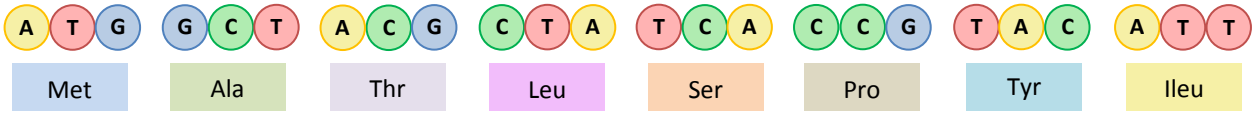
Positive, negative and neutral DNA mutations by substitution, deletion and addition

DNA is a double helix molecule, and its structure is very stable and designed to prevent mistakes in its genetic code. However, despite is marvellous stable structure, sometimes errors get through. DNA **mutations** can occur during DNA replication (before nuclear division), either by **mitosis** or **meiosis**. When a DNA mutation occurs as a cell divides by *mitosis* the mutation is not passed on, but the mutation may contribute to the ageing process or lead to cancer. Mutations within the DNA may well be inherited from cells that have divided by *meiosis* (reproduction of the gametes).

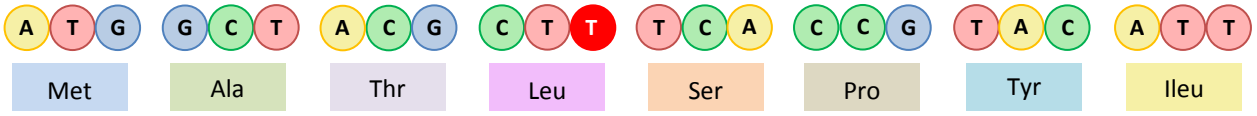
There are three main types of DNA mutation:

- **substitutions** (also known as **point mutations**) involve one base pair replacing another, so only one base has changed
- **insertions** occur where an extra nucleotide base is inserted into the genetic code
- **deletions** occur where one base is removed from the genetic code

Both insertions and deletions cause what is known as a **frameshift**. This is where the inserted or deleted base pair changes the entire coding of the DNA molecule as the triplet codons all change. Take a look at the DNA sequence below:

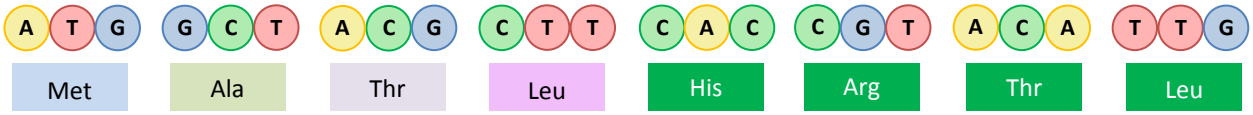


The sequence above is the original DNA sequence, also showing the polypeptide chain it will code for. See what happens when there is a *substitution* mutation:



Substitutions can be **silent mutations**. This means although one base has been changed, the triplet still codes for the same amino acid, and so there is no effect on the polypeptide produced. Sometimes, however, a substitution can change the amino acid the codon codes for. Now see what happens if there is a base *insertion*:

Clearly, the insertion of the guanine base in the fourth codon shown affects the entire polypeptide: it would make no sense, as that's not the polypeptide that should be coded for. The affected amino acids have been highlighted in blue. You can see that an insertion moves every base along one slot, so each triplet is different to what it should be. Now let's take a look at what happens when there is a base *deletion*:



When there's a base deletion, a similar thing happens. Again, all the nucleotide bases shift one spot (just in the opposite direction). Most likely the majority of amino acids coded for will therefore change, as can be seen above with the removal of the adenine from the original sequence. This is a frameshift, as with the insertion.

Silent, neutral and affective mutations

A silent mutation is one where there is a change in the DNA base sequence, but the amino acid coded for remains the same (so there is no effect). However, not all mutations are silent: insertions and deletions are certainly not silent. There are many point mutations that do actually change the structure of a protein, but the same polypeptides are produced, so there has been little effect. These are **neutral mutations**, so long as the resultant differentiation gives the organism no particular advantage or disadvantage.

Some mutations do change the protein structure and actually give the organism an advantage or disadvantage as a result. These are known as *positive* and *negative* (or harmful and beneficial) mutations, respectively.