TRANSCRIPTION

Content Statements:

D1.2.1 Transcription as the synthesis of RNA using a DNA template

D1.2.2 Role of hydrogen bonding and complementary base pairing in transcription

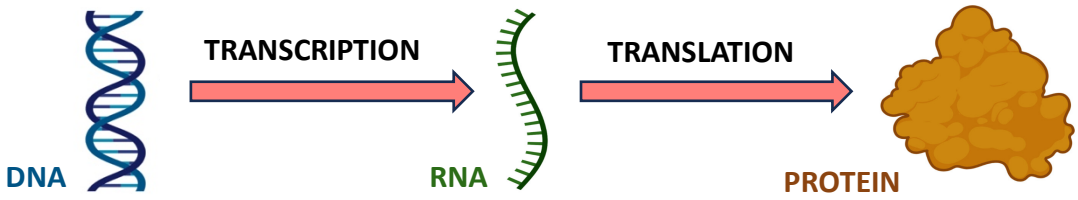
D1.2.3 Stability of DNA templates

D1.2.4 Transcription as a process required for the expression of genes

CENTRAL DOGMA

The central dogma of molecular biology describes the flow of genetic information within living organisms:

- **DNA** is a cell's genetic 'blueprint' and is organised into instructions (or *genes*) that encode specific traits
- **RNA** is a temporary 'photocopy' of a gene, which is made via *transcription* and sent to the ribosomes
- **Proteins** are synthesised by the ribosomes via *translation* and carry out the encoded cellular functions



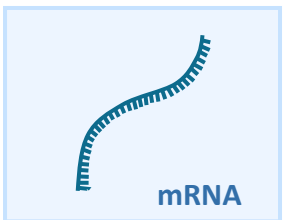
GENES

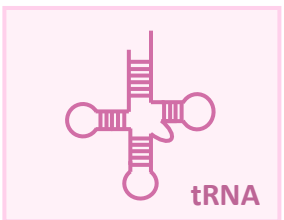
Genes are sequences of DNA that encode a specific characteristic (via the production of RNA or protein). They function as the basic units of inheritance. Genes can be categorised as either structural or regulatory. A gene is composed of three key sections. The **promoter** is the site to which the enzyme RNA polymerase will bind – it is responsible for initiating transcription. The **coding sequence** is the region of DNA that is transcribed into RNA, while the **terminator** sequence functions to stop transcription by RNA polymerase.

TYPES OF RNA

There are three main types of RNA that are encoded by genes and involved in the synthesis of proteins:

- **Messenger RNA** (mRNA) is the transcript copy of a DNA instruction (it encodes the protein sequence)
- **Transfer RNA** (tRNA) carries the protein subunits (amino acids) to the mRNA transcript for assembly
- **Ribosomal RNA** (rRNA) acts to provide the catalytic activity for combining the amino acids together

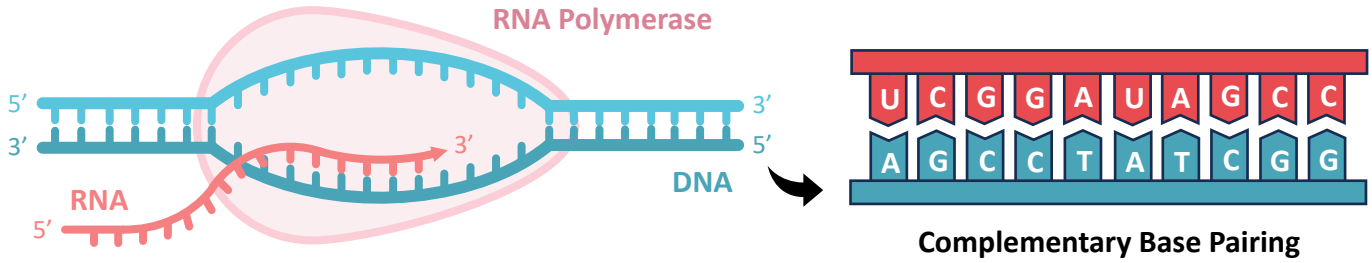




Proteins are translated from an **mRNA** sequence while **tRNA** and **rRNA** play supporting roles

TRANSCRIPTION

Transcription is the process by which a DNA sequence (gene) is copied into complementary RNA sequences by **RNA polymerase**. This enzyme binds to the promoter and then separates the double-stranded DNA of the coding sequence (by breaking the hydrogen bonds between base pairs). **Free RNA nucleotides** then align opposite their complementary base partner and RNA polymerase joins them together with covalent bonds (between the sugar-phosphate backbone). When the enzyme reaches the terminator sequence the synthesised RNA transcript is released and the double helix reforms. Transcription occurs in the nucleus.



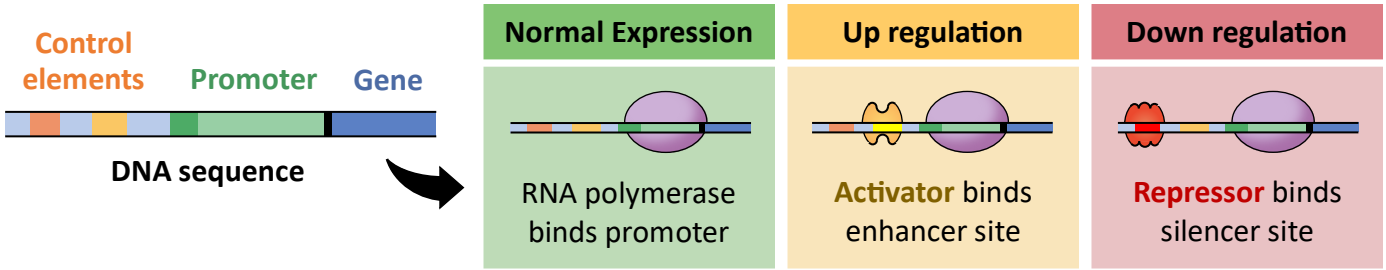
The RNA transcript has a sequence that is **complementary** to the DNA template. This is because the DNA bases can form hydrogen bonds with particular RNA nucleotides. Adenine always pairs with uracil via two hydrogen bonds, while guanine and cytosine always pair via three hydrogen bonds. This system of base pairing ensures that the RNA transcript is always a correct and reliable copy of the genetic instructions.

GENE EXPRESSION

The expression of genes is coordinated by **transcription factors**, which are produced by regulatory genes. Transcription factors either mediate or impede the binding of RNA polymerase to the promoter, and hence function to help switch genes on and off. There are two main types of transcription factors:

- **Activator proteins** bind to enhancer sites and essentially function to increase transcription rates
- **Repressor proteins** bind to silencer sites and essentially function to decrease transcription rates

The presence of certain transcription factors may be tissue-specific, leading to the differentiation of cells and tissues. Additionally, **chemical signals** can moderate the activity of transcription factors and hence change gene expression (e.g. hormones may activate target tissues by altering gene expression patterns). The study of changes in organisms as a result of variations in gene expression levels is called **epigenetics**.



CELL DIFFERENTIATION

All cells in a multicellular organism contain the same genetic instructions. The totality of DNA sequences (both genes and non-coding DNA) within a cell or organism is called the **genome**. However, different genes may be activated in certain tissues, leading to the production of different proteins. The totality of proteins expressed within a cell or organism at a particular time is called the **proteome**. Because different cell types express different genes and produce different proteins, they may differ in both morphology and function.