Eukaryotic Gene Expression

Gene Expression: The process in which the information within a gene is used, first to synthesise RNA, through transcription, and then to a protein, through translation, eventually to affect the phenotype of an organism.

Central Dogma of Molecular Biology: The principle of directional informational flow from DNA to RNA to protein.

Transcription: The process, in which a complementary RNA copy is made under the direction of the template strand of a specific region of the DNA molecule, catalysed by the enzyme RNA polymerase.

Translation: The process, in which a polypeptide chain is synthesised by ribosomes using genetic information encoded in an mRNA template

DNA → pre-mRNA → mature mRNA ——tRNA & rRNA——→ polypeptide

Gene: A section of the DNA that contains the information in the form of a specific sequence of nucleotides to direct the synthesis of one polypeptide chain or RNA. It is a unit of inheritance located in the locus on the chromosome which specifies a particular character of an organism.

Characteristic	**RNA**	**DNA**
Substituent	Made of polynucleotides, basic units: phosphate group, pentose sugar, nitrogenous base	
Bond	Have a sugar-phosphate backbone joined by phosphodiester bonds	
Synthesis	Polymerised through condensation synthesis	
	Synthesised by complementary base pairing of nucleotides using a template	
Nitrogenous bases	A, G, U, C	A, G, T, C
Size & mass	Smaller molecular mass (20k to 2000k Da)	Larger molecular mass (100k to 150000k Da)
No. of subunits	1 polynucleotide chain	2 polynucleotide chains
3D structure	Almost always single-stranded, helical molecule, which can be folded into a complex tertiary structure eg. tRNA	Always a double-stranded helical molecule which forms a double helix. Coiled around histone proteins
Monomers	Ribonucleotides	Deoxyribonucleotides
Pentose sugar	OH group attached on 2'Carbon	H attached on 2' Carbon
Chemical stability	Less stable – more reactive partly due to ribose having an additional reactive 2' OH group	More stable – more resistant to spontaneous enzymatic breakdown due to deoxyribose lacking 2'OH group
Purines : pyrimidines	A: U ≠ G:C ≠ 1:1 (Ratio cannot be predicted as RNA is single-stranded, without a complementary strand)	A:T = G:C = 1:1 (Chargaff's rule)
Basic forms	Several basic forms: messenger RNA, transfer RNA, ribosomal RNA, small nuclear RNA, small interfering RNA	Only one basic form

		are removed and the **remaining group is added to the free 3' OH group of the growing RNA** chain via **phosphodiester bond**
	Re-annealing of DNA and proofreading	• **RNA polymerase reanneals the unwound DNA** behind it, **dissociating the growing RNA** chain from the template • It carries out **proofreading functions** and is responsible for the **removal** of incorrectly inserted ribonucleotides
Termination		• **RNA polymerase** transcribes a **terminator sequence** in the DNA • Triggers the **release of the RNA chain** and **dissociation of the RNA polymerase** from the DNA • Transcribed terminator codes for a polyadenylation sequence (AAUAAA)

Exons: protein-coding sequence in the gene

Introns: long sequences of nucleotides inserted between exons that do not code for any portion of the polypeptide, ie. are non-coding sequences

Post-transcriptional Modification		
Modification	**Process**	**Function**
Addtion of 5' Methylguanosine cap	The 5' end of the new pre-mRNA molecule is modified by **addition of** a cap that consists of a **methylated guanine (G) nucleotide/ methylguanosine triphosphate**	• **Protects mRNA** from **degradation** by nucleases and phosphatises that degrade the RNA from the 5'end during its transport from the nucleus to the cytoplasm • 5' cap signals **the 5' end** of the mRNA which serves as the **assembly point to recruit the small subunit of the ribosome** for translation to begin • Helps **distinguish mRNAs** from the other types of RNA molecules
Addition of 3' poly(A) tail	Immediately after the pre-**mRNA is cleaved by an endonuclease** at a site 10-35 nucleotides after the AAUAAA poly(A) sequence, the 3' end of the pre-mRNA is modified by **addition of a series of ~200 adenine (A) nucleotides**, referred to as the **poly(A) tail**. Catalysed by **poly(A)-polymerase**	• 3' poly(A) tail **protects the mRNA from degradation by nucleases** • Make mRNA a more **stable template** for translation • Required to **facilitate the export** of mRNA out of the nucleus via **nuclear pores**
RNA splicing	RNA splicing occurs after the release of pre-mRNA from RNA polymerase, during which, **introns are removed** while **remaining exons are spliced/ligated** together to form **mature mRNA**. Requires hydrolysis of ATP	• Provides for variation as different combination of exons could results in different types of polypeptides synthesised

Genetic code:

- consists of information in the form of **3 nucleotide bases** called **codons of mRNA**
- also the **triplet bases** in the **non-template/non-transcribed strand of DNA**