

2. Gene It's Nature, Expression and Regulation

- A **nucleotide** contains three components –
 1. Nitrogenous base
 2. Pentose sugar
 3. Phosphate group
 - **Nucleoside** contains a nitrogenous base linked to pentose sugar.
 - Two types of nitrogenous bases –
 1. **Purine** – Adenine and guanine
 2. **Pyrimidine** – Cytosine, uracil and thymine
- The nitrogenous bases present in DNA are adenine, cytosine, thymine and guanine. In RNA, thymine is replaced by uracil.
- **Polynucleotide chain** is formed when more than two nucleotides are linked together through 3' – 5' phosphodiester linkages.

DNA (Deoxyribonucleic acid)

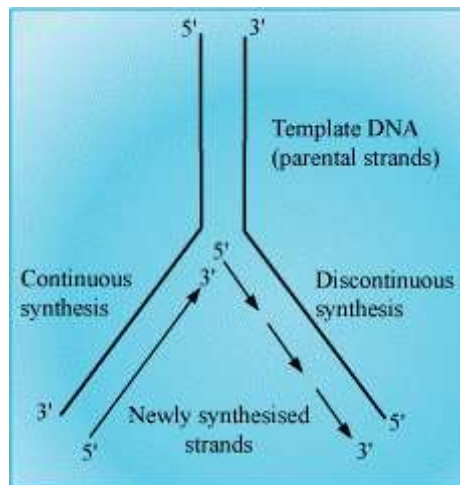
- DNA is a double-helical structure with anti-parallel strands. Both strands are complementary to each other.
- Double-helix DNA structure was proposed by **James Watson and Francis Crick**.
- Adenine always pairs with thymine, with two hydrogen bonds while guanine pairs with cytosine, with three hydrogen bonds.
- **Griffith** worked on *Streptococcus pneumonia* and found that certain transforming principles got transferred from the heat-killed S strains of bacteria to the live R strain, and made them virulent.
- **Avery, MacLeod and McCarty** concluded that DNA, and not the protein, is the genetic material that leads to bacterial transformation.
- **Hershey and Chase** conducted experiment on bacteriophage and confirmed that DNA is the genetic material in these viruses.
- Presence of 2' OH group on RNA makes it easily degradable; hence, less stable. Therefore, DNA is structurally more stable than RNA, and hence, is used as genetic material.
- Length of dsDNA helix in mammalian cells
$$= \text{Total number of base pairs} \times \text{Distance between two base pairs}$$
$$= \sim 2.2 \text{ metres}$$
- **Nucleosome** is DNA wrapped around histone octamer.
- Chromatin comprises DNA and basic proteins called histones.

- There are two types of chromatin –

1. **Euchromatin:** Loosely packed chromatin that is transcriptionally active
2. **Heterochromatin:** Densely packed chromatin that is transcriptionally inactive

DNA Replication

- DNA replicates itself by the process of replication.
- The enzyme required for the replication is DNA-dependent DNA polymerase. It catalyses polymerisation only in the 5' → 3' direction.
- The process of DNA replication is discontinuous on the template strand with polarity 5' → 3'



- The generated discontinuous fragments are later on joined by **DNA ligase** to form a continuous DNA strand.
- **Process of transcription**
 - It involves three steps: initiation, elongation and termination.
 - The enzyme involved in transcription is DNA-dependent RNA polymerase.
 - The enzyme RNA polymerase associates with the initiation factor (σ) and the termination factor (ρ) to respectively initiate and terminate the process of transcription.
 - In eukaryotes, there are three types of RNA polymerase in the nucleus –
 - **RNA polymerase I:** Transcribes rRNAs
 - **RNA polymerase II:** Transcribes precursor of mRNA, i.e., hnRNA
 - **RNA polymerase III:** Transcribes tRNA 5srRNA, snRNAs

RNA

- There are three types of RNA –
 - **Messenger RNA (mRNA):** Provides template to initiate translation
 - **Transfer RNA (tRNA):** Brings amino acids to mRNA; also known as adapter molecule
 - **Ribosomal RNA (rRNA):** Has structural and catalytic role during translation

Translation

- It is the process of polymerisation of amino acid sequence to synthesise a polypeptide chain.
- **It involves three steps** –
 - **Initiation:** It involves binding of ribosome to mRNA.
 - **Elongation:** Amino acylated tRNA binds to appropriate codon in mRNA. Ribosomal RNA acts as a catalyst for peptide bond formation.
 - **Termination:** A release factor binds to the stop codon and terminates the process of translation.

Genetic code

- It is the order of nucleotides in a DNA molecule.
- Features of genetic code –
 - Triplet
 - Universal
 - Degenerate
 - Non-ambiguous
 - Commaless
 - Initiation codon is AUG (Methionine) and termination codons are UAA, UGA and UAG.
- **Codon:** It is the triplet nucleotide base present on mRNA.

Lac Operon

- It contains four different genes –
 - Regulator gene: *i* gene
 - Operator gene
 - Promoter gene
 - Structural gene: *z*, *y* and *a*
- In the presence of inducers such as lactose, proteins are synthesised.

Repressor is converted into inactive form



Repressor leaves the operator



Transcription starts at the promoter region



Synthesis of proteins

- In the absence of inducers, proteins are not synthesised.

Repressor is in its active form



Repressor binds to operator



**Prevents RNA polymerase from binding to
the operator region**



No gene transcription

- Regulation of lac operon by repressor is negative regulation.