

Molecular Basis of Inheritance

- 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)

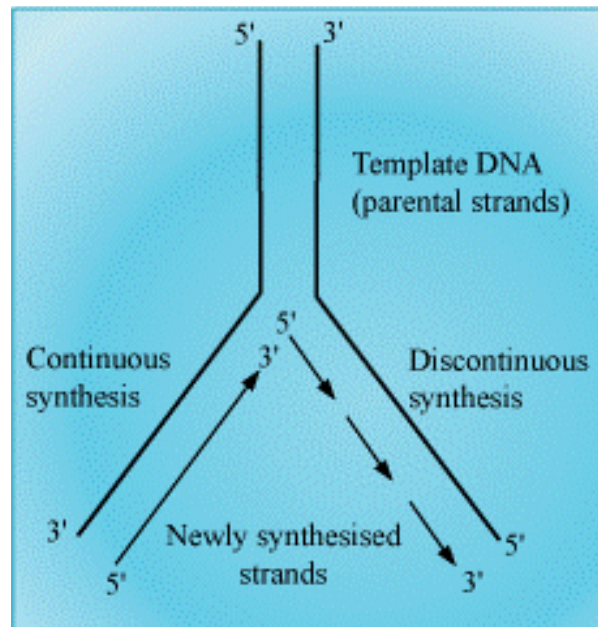
- DNA is a double-helical structure with anti-parallel strands. Both strands are complementary to each other.
 - Double-helix DNA structure was proposed by **James Watson and Francis Crick**.
 - Adenine always pairs with thymine, with two hydrogen bonds while guanine pairs with cytosine, with three hydrogen bonds.
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- Length of dsDNA helix in mammalian cells
$$= \text{Total number of base pairs} \times \text{Distance between two base pairs}$$

= ~2.2 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
- **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.

DNA Replication

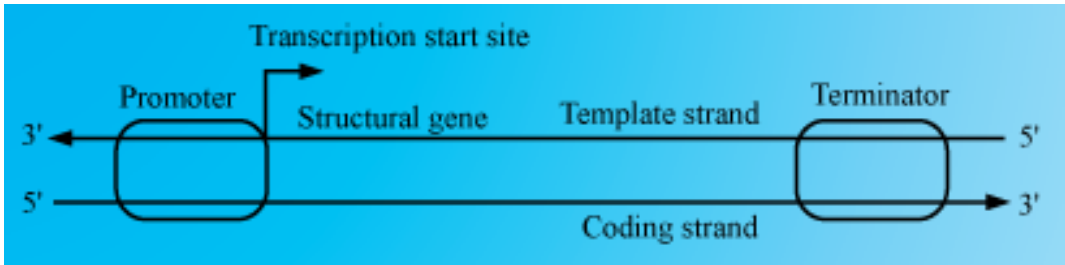
- DNA replicates itself by the process of replication.
- The enzyme required for the replication is DNA-dependent DNA polymerase. It catalyses polymerisation only in the 5' → 3' direction.
- The process of DNA replication is discontinuous on the template strand with polarity 5' → 3'



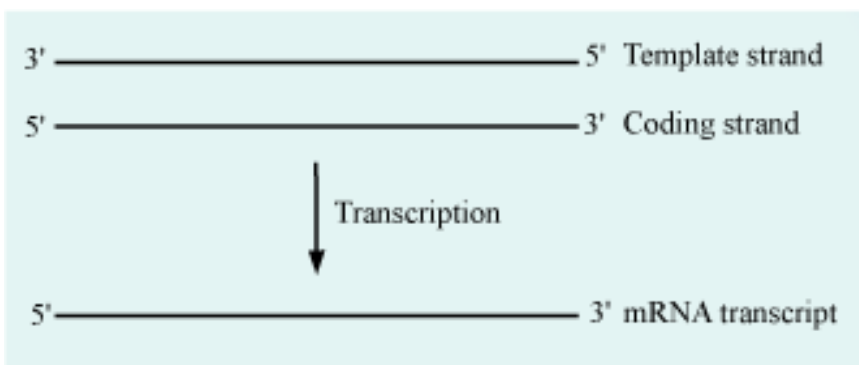
- The generated discontinuous fragments are later on joined by **DNA ligase** to form a continuous DNA strand.

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
- **Transcription** is the process of transferring genetic information from DNA to RNA. Only one DNA strand is copied into mRNA.
- A **transcription unit** extends from the promoter to the terminator region.



- Transcription of the DNA template strand produces an RNA transcript with the same sequence as a non-template strand (coding strand).



- Eukaryotic gene is monocistronic while prokaryotic gene is polycistronic.
- Eukaryotic gene is made up of coding sequences (exons) and non-coding sequences (introns).
- **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

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.

Mutation

- It is the sudden change in genotype due to the alteration in DNA sequences.
- **Mutation and recombination** brings variation in DNA.
- **Point mutation** arises due to the change in a single base pair in DNA; for example, sickle-cell anaemia.
- **Frame shift mutation** arises due to deletion and insertion of base pairs.
- **Mutagens** are factors that induce mutations; for example, UV radiation.
- Inheritable mutations can be studied by pedigree analysis

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.

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.

DNA fingerprinting

- It is the technique to find variations in an individual at DNA level. It is based on the principle of DNA polymorphism.
- DNA fingerprinting was developed by Alec Jeffreys.

- **Polymorphism:** It is the variation at DNA level due to mutation. These variations accumulate and give rise to new species.
- **Application of DNA fingerprinting –**
 - Forensic science
 - Genetic biodiversity
 - Evolutionary biology