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.

- Length of dsDNA helix in mammalian cells
  = Total number of base pairs × Distance between two base pairs

= ~2.2 metres

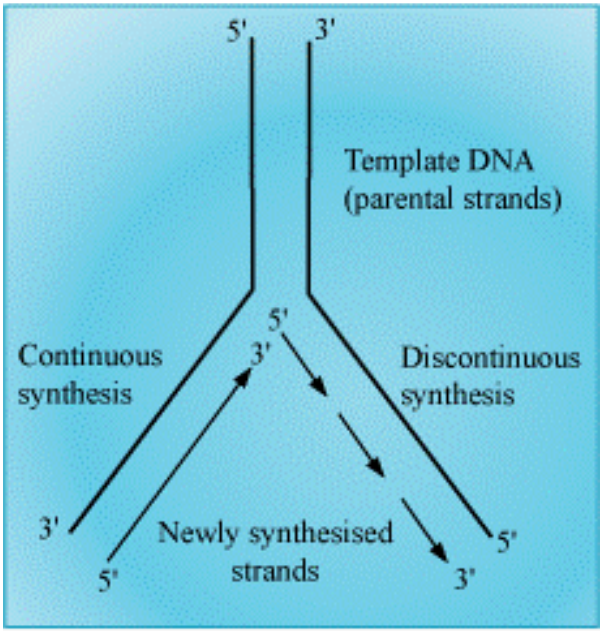
- **Nucleosome** is DNA wrapped around histone octamer.
- Chromatin comprises DNA and basic proteins called histones.
- There are two types of chromatin –

    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.
- **Harshey 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'

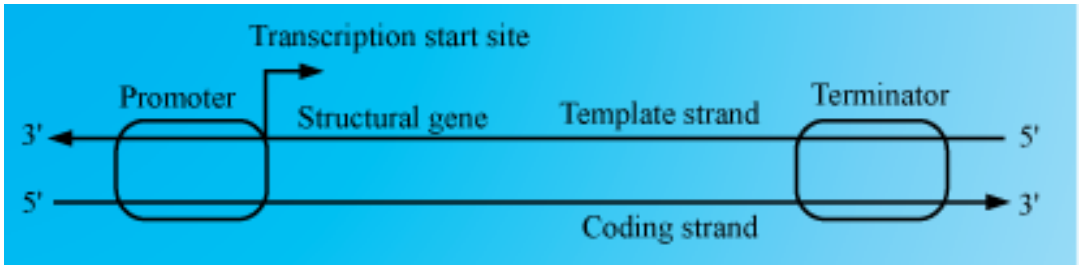


- The generated discontinuous fragments are later on joined by **DNA ligase** to form a continuous DNA strand.

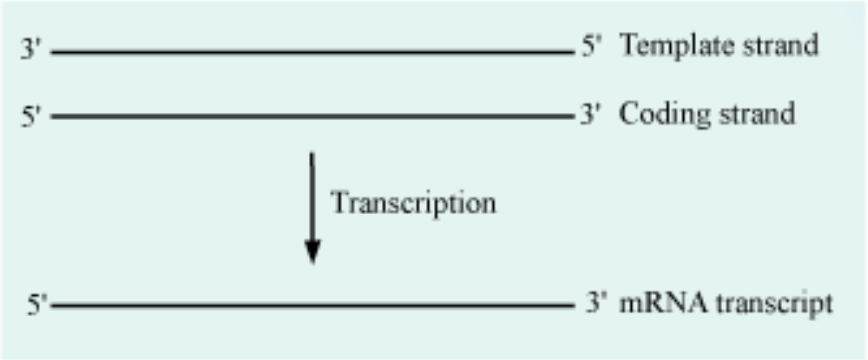
RNA

- 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