

Introduction to Molecular Biology

Introduction to Molecular Biology – Study Notes

1. What Is Molecular Biology?

- **Definition:** The branch of biology that examines the molecular mechanisms governing the storage, replication, transcription, translation, and regulation of genetic information.
 - **Core Focus:** DNA, RNA, proteins, and the interactions that control cellular processes.
 - **Historical Milestones**
 - 1953 – Watson & Crick describe the DNA double helix.
 - 1961 – Crick proposes the central dogma (DNA → RNA → Protein).
 - 1970s – Development of recombinant DNA technology.
 - 1990s–2000s – Genome sequencing projects (Human Genome Project).
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2. Central Dogma of Molecular Biology

Step	Description	Key Enzymes / Molecules
Replication	Synthesis of a new DNA strand using an existing DNA template.	DNA polymerases, helicase, primase, ligase
Transcription	Production of RNA (mRNA, rRNA, tRNA, snRNA) from a DNA template.	RNA polymerase, transcription factors
Translation	Decoding mRNA to assemble a polypeptide chain.	Ribosome, tRNA, aminoacyl-tRNA synthetases, initiation/elongation factors

3. DNA – The Genetic Blueprint

- **Structure**
 - Double helix of two antiparallel strands.
 - Sugar-phosphate backbone; nitrogenous bases (A, T, G, C).
 - Major & minor grooves (protein-DNA interaction sites).
- **Key Features**
 - **Genes:** DNA segments that encode functional products (usually proteins or functional RNAs).
 - **Regulatory Elements:** Promoters, enhancers, silencers, insulators.

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- **Chromatin Organization:** DNA wrapped around histone octamers ? nucleosomes ? higher?order structures.
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4. RNA – The Versatile Intermediary

Type	Primary Function	Notable Characteristics
mRNA	Carries coding information from DNA to ribosomes.	5' cap, poly?A tail, intron–exon structure.
tRNA	Delivers specific amino acids to the ribosome.	Cloverleaf secondary structure; anticodon loop.
rRNA	Structural and catalytic components of ribosomes.	Forms the peptidyl transferase center.
snRNA / snoRNA	Involved in splicing and modification of other RNAs.	Associates with spliceosome or snoRNPs.
miRNA / siRNA	Post?transcriptional gene silencing.	Base?pair with target mRNAs ? degradation or translational repression.

5. Proteins – Functional End Products

- **Primary Structure:** Linear amino?acid sequence.
 - **Higher?order Structures:**
 - *Secondary:* ??helices, ??sheets (hydrogen bonding).
 - *Tertiary:* Folding driven by hydrophobic interactions, disulfide bonds.
 - *Quaternary:* Assembly of multiple polypeptide subunits.
 - **Functions:** Enzymes, structural components, signaling molecules, transporters, regulators.
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6. Key Molecular Techniques

Technique	Purpose	Core Principle
PCR (Polymerase Chain Reaction)	Amplify specific DNA fragments.	Thermally cycling DNA polymerase activity.
Gel Electrophoresis	Separate nucleic acids or proteins	