

Molecular Biology (Quick Study: Academic)

Inc. BarCharts

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Levels of Organization

1. Multicellular organisms
2. Organ systems (Groups of different tissue types working together)
3. Tissues (Groups of different cell types working together)
4. Cells (Basic functional unit of life, which includes single-celled organisms)
5. Molecular (Molecular structure and function that ultimately determine the biology of the organism)

Major Biomolecules

Major biomolecules are **deoxyribonucleic acid (DNA)**, **ribonucleic acid (RNA)**, and **proteins**. These are studied in the fields of cell biology, genetics, molecular genetics, and biochemistry. **Genomics** is the study of the functions of genes.

- **Biomolecules** are large polymers created from monomer subunits (e.g., **nucleic acids** build DNA and RNA; **amino acids** build proteins).
- **Genes** consist of nucleic acids (i.e., DNA or RNA) that are preserved and transmitted across several biological processes by coding for polypeptides leading to proteins or RNA.

DNA

- DNA is the genetic, informational molecule in every cellular organism (viruses appear to be molecular fragments of DNA or RNA and are capable of "living" in host cells) and is found in the nuclei of eukaryotes, the cytoplasm of prokaryotes, and some cellular organelles (mitochondria, chloroplasts).
- DNA is a "template" (i.e., the **genetic code**) is essentially universal; slight differences exist in some single-celled organisms and in some mitochondrial genomes.
- A common genetic language allows for such phenomena as insertion of human genes into bacteria, which can then produce "transgenic" proteins.

RNA

- RNA is found in many forms, most of which are used in protein synthesis.
- RNA is the molecular of inheritance in some viruses.
- Some RNA molecules (e.g., **ribozymes**) have enzymatic functions.

Major RNA Types & General Functions

RNA Type	Function
mRNA (messenger RNA)	Carries coded genetic message from DNA.
rRNA (ribosomal RNA)	Must have remaining nucleotides removed.
tRNA (transfer RNA)	Each nucleotide for translation after processing.
rRNA (ribosomal RNA)	Transfer genetic code to ribosome.
rRNA (ribosomal RNA)	Main component of ribosome.
sRNA (small nuclear RNA)	Involved in DNA processing.
sRNA (small nuclear RNA)	Involved in DNA processing.
sRNA (small nuclear RNA)	Non-protein-coding nucleotides.
sRNA (small nuclear RNA)	Found in some viruses, used in gene regulation.
sRNA (small nuclear RNA)	A type of sRNA.
sRNA (small nuclear RNA)	Short nucleotide sequence; used in gene regulation.

Proteins

- Proteins are coded for by genes; **proteomics** is the study of proteins, which are essential to nearly all cellular functions, including:
 - Structure: Cell cytoskeleton; keratin in hair and feathers.
 - Energy reserves: Ovalbumin in bird egg for developing embryo.
 - Hormones: Insulin for blood carbohydrate regulation and cell metabolism.
 - Enzymes: Catalysts of chemical reactions.
 - Transport: Hemoglobin for gas exchange.
 - Movement: Muscle fiber components.
 - Biogenic: Some synaptic transmission.
 - Defense: Antibodies produced for immune defense.

Central Dogma

- **Replication:** DNA is copied from other DNA.
- **Transcription:** RNA is copied from DNA.
- **Translation:** Proteins are synthesized from RNA.
- **Reverse transcription:** Retroviruses, a group of RNA viruses, possess a special enzyme called **reverse transcriptase**, which allows the viral genome to go in the reverse direction of the central dogma: information flows from viral RNA to be converted into DNA, thereby altering the host cell's genome (i.e., viral RNA → host DNA).

DNA & RNA Structure

Nucleotides are the components of nucleic acids, which are made of three subunits:

- **Sugar** (deoxyribose in DNA; ribose in RNA)
- **Phosphate**
- **Nitrogenous base** (five possible bases)

- In DNA, the major acid of chromosomes, four nitrogenous bases are found: **adenine (A)**, **guanine (G)**, **cytosine (C)**, and **thymine (T)**.
- RNA consists of similar bases, except **uracil (U)** replaces thymine (T).

DNA Structure

- DNA is a double helix molecule.
- Shape is similar to a spiral staircase or twisted ladder, with the sides formed by repeating sugar-phosphate groups from each nucleotide, and the horizontal rungs (i.e., steps) formed by hydrogen bonds involving A with T or C with G.
- Directionality of each side is opposite (i.e., antiparallel); 3' carbon to 5' carbon in the direction for reference in each nucleotide.

Prokaryotic Chromosomes

- Prokaryotic chromosomes are typically small and circular; packaged by DNA-binding proteins into a nucleoid (not a nucleus, as there is no membrane directly surrounding the DNA); may have additional copies and plasmids (small DNA).
- Prokaryotic chromosomes form chromosome complexes.

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#296317 in Books 2012-05-31 2012-05-31 Original language: English PDF # 1 .6 x 11.00 x 8.50l, .15 Binding: Pamphlet 6 pages | File size: 19.Mb

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