

MOLECULAR BIOLOGY

The Relationships of Molecules to Biological Processes

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 Macromolecules

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

- **Macromolecules** are large polymers created from molecular subunits (e.g., nucleic acids build DNA and RNA; amino acids build proteins).
- Genomes consist of nucleic acids (i.e., DNA or RNA) that are preserved and transmitted from one biological process to another; the polypeptides (leading to proteins) are RNA.

DNA
DNA is the genetic, informational molecule in every cellular organism (viruses appear to be exceptions); fragments of DNA or RNA are capable of "living" in test tubes and in the nuclei of eukaryotes, the cytoplasm of prokaryotes, and some cellular organelles (mitochondria, chloroplasts).

- DNA "language" (i.e., the genetic code) is essentially universal; despite different details exist in some single-celled organisms and in some mitochondrial genomes.
- A universal genetic language allows for such phenomena as insertion of human genes into bacteria, which can then produce "human" proteins.

RNA
RNA is found in many forms, most of which are used in protein synthesis.
RNA is the molecule 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
snRNA	Most have noncoding nucleotides, removed
scRNA	Cells nucleus for translation after processing
rRNA (transfer RNA)	Transfers amino acids to ribosomes
rRNA (ribosomal RNA)	Main component of ribosomes
sRNA (small nuclear RNA)	Involved in DNA processing
sRNA (small nuclear RNA)	Involved in RNA processing
ncRNA (noncoding RNA)	Nonprotein-coding nucleotides
dsRNA (double-stranded RNA)	Found in some viruses; used in gene regulation
siRNA (small interfering RNA)	A type of ncRNA
miRNA (micro 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; tumors in liver and breasts.
 - **Energy reserves**: Disulfide bonds in bird eggs for developing embryo.
 - **Homeostasis**: Insulin for blood carbohydrate regulation and cell metabolism.
 - **Enzymes**: Catalysis of chemical reactions.
 - **Transport**: Myoglobin for gas exchange.
 - **Movement**: Muscle fiber components.
 - **Signaling**: Nerve impulse transmission.
 - **Defense**: Antibodies produced for disease defense.

Central Dogma

- **Replication**: DNA is copied from other DNA.
- **Transcription**: RNA is copied from DNA.
 - Transcription 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's information flow; this allows viral RNA to be converted into DNA, thereby allowing the host cell's genome (i.e., viral DNA → 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 nucleic 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).

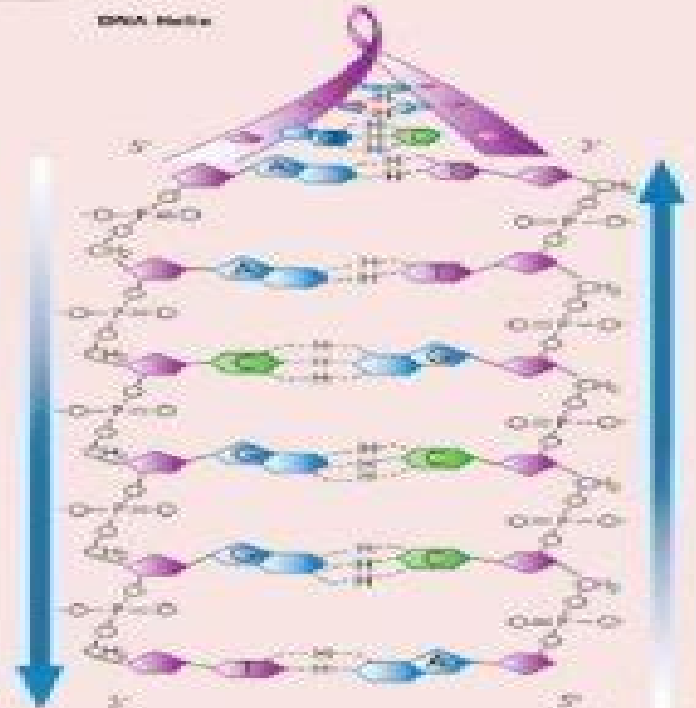
DNA Structure

- 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 (binding A with T or C with G).
- Unfunctionality of each side is opposite (i.e., antiparallel); 3' carbon to 5' carbon in the direction for reference in each nucleotide.

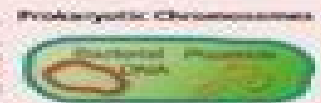
Structure of a Nucleotide



DNA Helix



- **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 plasmids (smaller DNA).
- **Eukaryotic chromosomes** form chromosome complexes.



Molecular Biology Quick Study Academic

Michael Brown



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Synthesizing Systems Anna Darden Copeland, 2007-02-22 The purpose of this dissertation is to introduce a general reading audience to the major themes found in the fiction of Richard Powers with an emphasis on his use of science For Powers science is something more than the accumulation of technical data and the proliferation of theories developed to explain physical phenomena It is an evolving body of knowledge which has important insights to contribute into the conditions which ground human experience The close and often detailed discussions of contemporary issues in science which Powers incorporates into his fiction indicate the extent to which he sees science as an inseparable component in any attempt to understand the complexities of human experience The common ground Powers uses to link the interests of science and those of fiction into a balanced if not always harmonious pursuit of truth is wonder The limitations placed on science during this century do not undermine the ability of science to influence what we can know Nor do these limitations diminish the ability of science to inspire wonder Quite the opposite For Powers the true wonder of the human intellect rests in our remarkable ability to balance observation and interpretation What he discovers again and again in his fiction is that science like literature is a product of the human imagination a way to mediate between the world and our perceptions of it The recognition that science is a cultural practice a body of knowledge thoroughly imbued with the practices and prejudices of its historical surroundings is a necessary first step in mending the rift separating science and literature head and heart The greatest insight of twentieth century science may just be the recognition that there are other ways to access the truth Richard Powers skillful weaving of science and art is a testament that literature offers a unique vantage point from which we might learn something of value about ourselves and the world we inhabit

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