Complementary Base Pairs: A and T

DNA contains *complementary base pairs* in which adenine is always linked by two hydrogen bonds to thymine (A–T).
Complementary Base Pairs: G and C

DNA contains *complementary base pairs* in which guanine is always linked by three hydrogen bonds to cytosine (G–C).
The DNA structure is a **double helix** that

- consists of two strands of nucleotides that form a double helix structure like a spiral staircase.
- has hydrogen bonds between the bases A–T and G–C.
- has bases along one strand that complement the bases along the other.
Learning Check

Write the complementary base sequence for the matching strand in the DNA section shown below.

5′—A—G—T—C—C—A—A—T—C—3′
Write the complementary base sequence for the matching strand in the DNA section shown below.

5′—A—G—T—C—C—A—A—T—C—3′

3′—T—C—A—G—G—T—T—A—G—5′
DNA replication involves

- separation of the parent DNA into complementary DNA strands,
- pairing the bases in each strand with new bases to form new complementary strands, and
- producing two new DNA strands that exactly duplicate the original DNA.
Hydrolysis Energy

Energy from the hydrolysis of each nucleoside triphosphate is used to form a phosphodiester bond to each new nucleotide on the complementary strand.
Direction of Replication

During DNA replication,

• an enzyme, helicase, unwinds the parent DNA at several sections,

• DNA polymerase catalyzes the formation of 5′–3′ ester bonds of the leading strand at each open DNA section (called a replication fork),

• the lagging strand (growing in the 3′–5′ direction) is synthesized in short sections called Okazaki fragments, and

• DNA ligase joins the Okazaki fragments to give a single 3′–5′ DNA strand.
Direction of Replication (Continued)
Learning Check

Match the following to their definitions.

1) helicase  
   A. short segments formed by the lagging strand

2) DNA polymerase  
   B. the starting point for synthesis in unwound DNA sections

3) replication fork  
   C. the enzyme that unwinds the DNA double helix

4) Okazaki fragments  
   D. the enzyme that catalyzes the formation of phosphodiester bonds of complementary bases
Solution

Match the following to their definitions.

1) helicase
2) DNA polymerase
3) replication fork
4) Okazaki fragments

A. short segments formed by the lagging strand
B. the starting point for synthesis in unwound DNA sections
C. the enzyme that unwinds the DNA double helix
D. the enzyme that catalyzes the formation of phosphodiester bonds of complementary bases
Types of RNA

RNA

- transmits information from DNA to make proteins.
- has several types as shown below.

**Messenger RNA (mRNA)** carries genetic information from DNA to the ribosomes.

**Transfer RNA (tRNA)** brings amino acids to the ribosome to make the protein.

**Ribosomal RNA (rRNA)** is the most abundant type of RNA; it is combined with proteins to form ribosomes.
# Types of RNA

<table>
<thead>
<tr>
<th>Type</th>
<th>Abbreviation</th>
<th>Percentage of Total RNA</th>
<th>Function in the Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ribosomal RNA</td>
<td>rRNA</td>
<td>80</td>
<td>Major component of the ribosomes; protein synthesis</td>
</tr>
<tr>
<td>Messenger RNA</td>
<td>mRNA</td>
<td>5</td>
<td>Carries information for protein synthesis from the DNA in the nucleus to the ribosomes</td>
</tr>
<tr>
<td>Transfer RNA</td>
<td>tRNA</td>
<td>15</td>
<td>Brings amino acids to the ribosomes for protein synthesis</td>
</tr>
</tbody>
</table>

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Each tRNA

- has a 3'-end with the nucleotide sequence ACC, which is known as the acceptor stem.
- contains an anticodon.
RNA and Protein Synthesis

Protein synthesis involves

- **transcription**, in which mRNA is formed from a gene on a DNA strand.
- **translation**, in which tRNA molecules convert the mRNA information into amino acids to build a protein.
In **transcription**, 

- a section of DNA containing the gene unwinds.
- one strand of DNA is copied, starting at the initiation point, which has the sequence TATAAA.
- an mRNA is synthesized using complementary base pairing, with uracil (U) replacing thymine (T).
- the newly formed mRNA moves out of the nucleus to ribosomes in the cytoplasm.
RNA Polymerase

During transcription,

- **RNA polymerase** moves along the DNA template in the 3′–5′ direction to synthesize the corresponding mRNA.
- the mRNA is released at the termination site.
mRNA Processing: Exons and Introns

In eukaryotes,

• DNA contains **exons** that code for proteins and **introns** that do not code for proteins.
• a pre-RNA is formed that includes the noncoding introns.
• the noncoding introns are removed.
• the exons are joined to form mRNA, which goes to the ribosomes with the information for the synthesis of protein.
Removing Introns from Pre-mRNA
Regulation of Transcription

Transcription is regulated by

• a specific mRNA synthesized when the cell requires a particular protein.
• enzyme induction, in which high levels of a reactant induce the transcription process to provide the necessary enzymes for that reactant.

Within a gene, sections of DNA called operons regulate the synthesis of related proteins.
Lactose Operon and Repressor

- The **lactose operon** consists of a control site and structural genes that produce mRNA for lactose enzymes.
- When there is no lactose in the cell, a regulatory gene produces a repressor protein that prevents the synthesis of lactose enzymes.
- The repressor turns off mRNA synthesis.
Lactose Operon Turned Off

(a) The lactose operon

- Regulatory gene
- Control site
- Lactose operon
- Structural genes

- β-Galactosidase
- Permease
- Acetylase
Lactose Operon and Inducer

In a cell,

- the level of lactose induces the synthesis of the enzymes required for its metabolism.
- lactose combines with the repressor and removes it from the control site.
- RNA polymerase catalyzes the synthesis of the enzymes by the genes in the operon as long as lactose is present.
Lactose Operon Turned On

(c) Transcription turned on

Repressor mRNA

Repressor + Lactose (inducer) → Inactive repressor

mRNA

β-Galactosidase
What is the sequence of bases in mRNA produced from a section of the template strand of DNA that has the sequence of bases: 3′–C–T–A–A–G–G–5′?

1) 5′–G–A–T–T–C–C–3′

2) 5′–G–A–U–U–C–C–3′

3) 5′–C–T–A–A–G–G–3′
Solution

What is the sequence of bases in mRNA produced from a section of the template strand of DNA that has the sequence of bases: 3′–C–T–A–A–G–G–5′?

3′–C–T–A–A–G–G–5′

2) 5′–G–A–U–U–C–C–3′