Transcription and Translation in Prokaryotes

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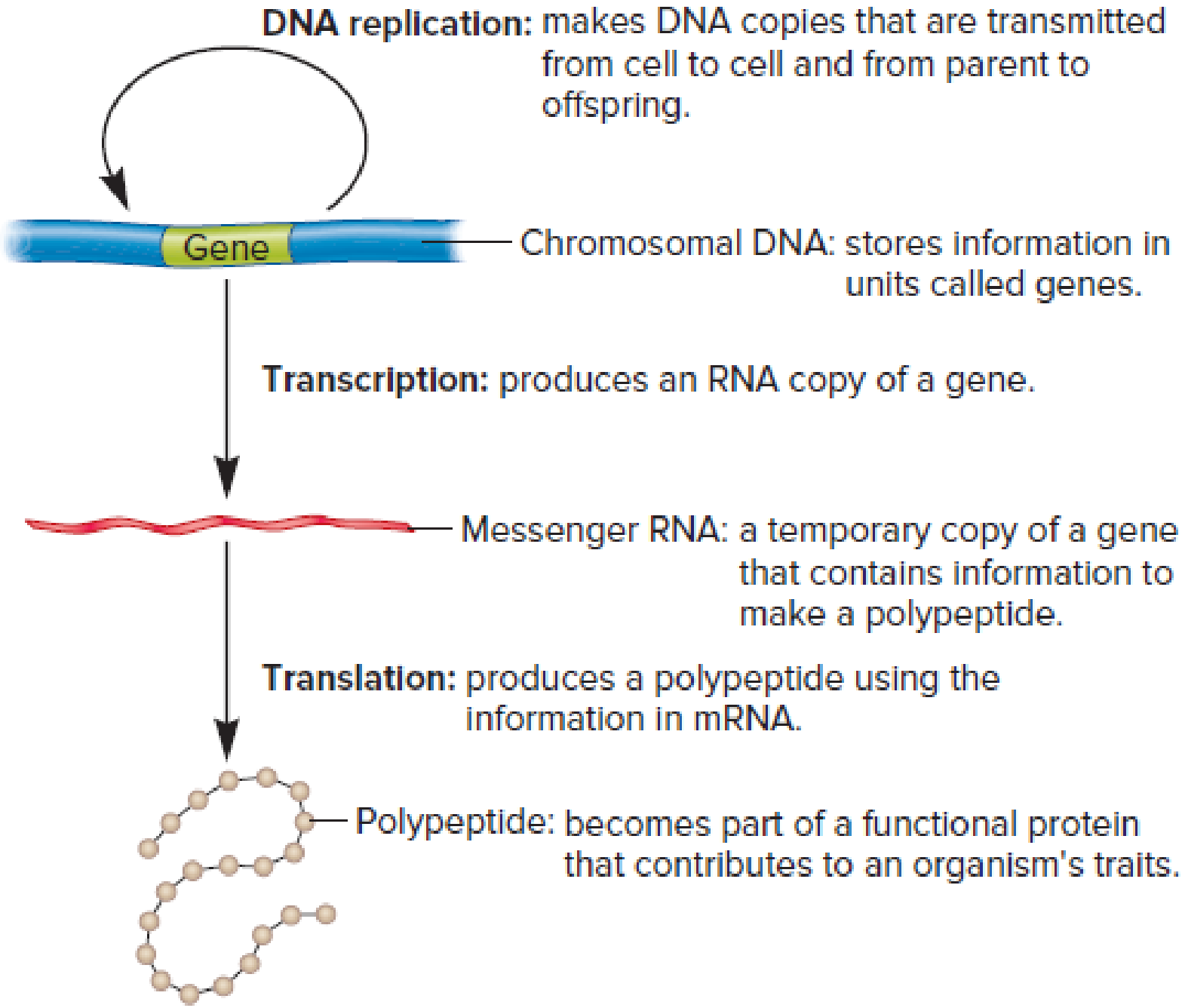
- a **gene** is defined as a segment of DNA that is used to make a functional product, either an RNA molecule or a polypeptide.

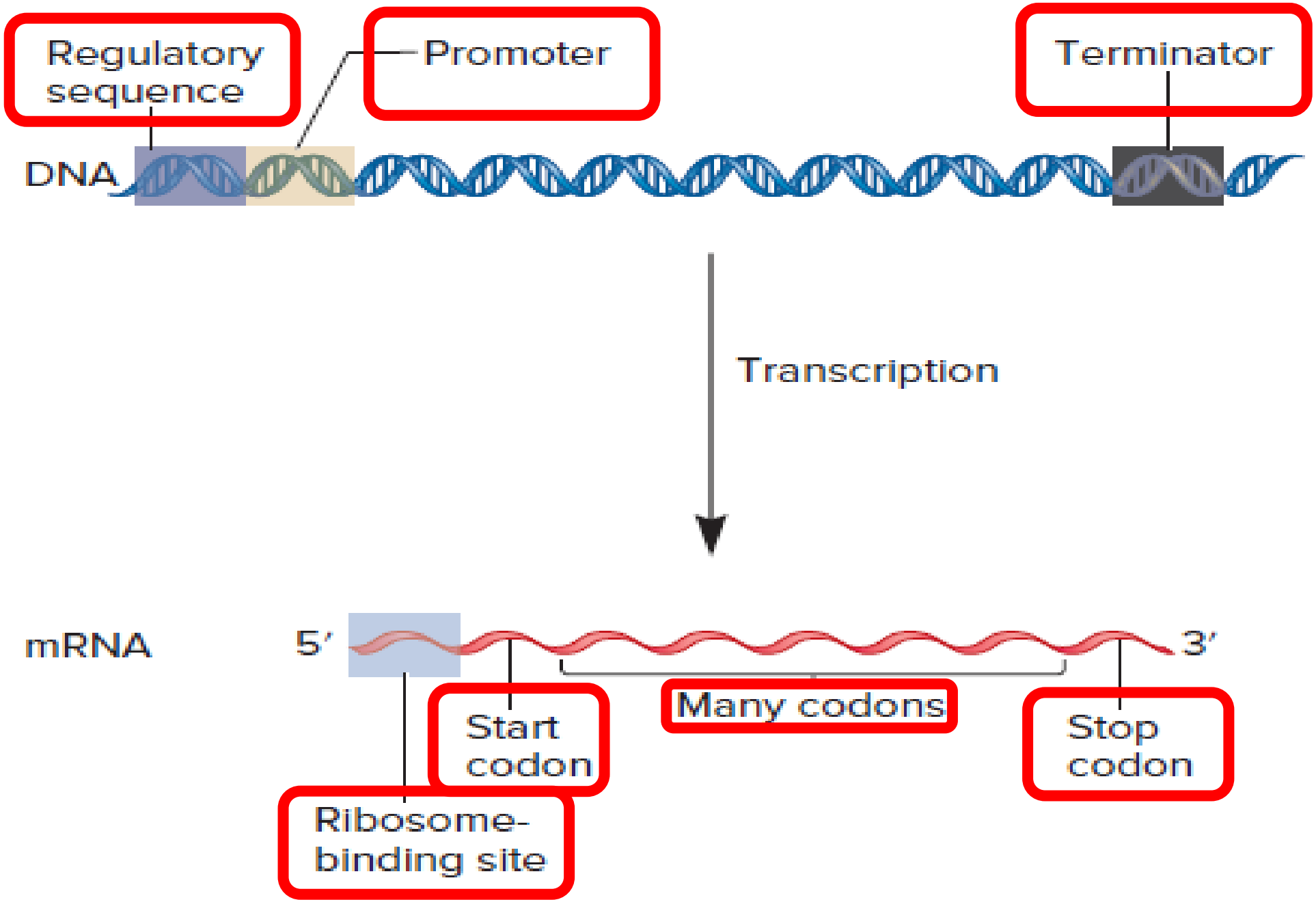
- The first step in this process is called **transcription,** which literally means the act or process of making a copy. In genetics, this term refers to the process of synthesizing RNA from a DNA template.

- Protein-encoding genes (also called structural genes) carry the information for the amino acid sequence of a polypeptide. When a protein-encoding gene is transcribed, the first product is an RNA molecule known as messenger RNA (mRNA).

- Central dogma of genetics (also called the central dogma of molecular biology)

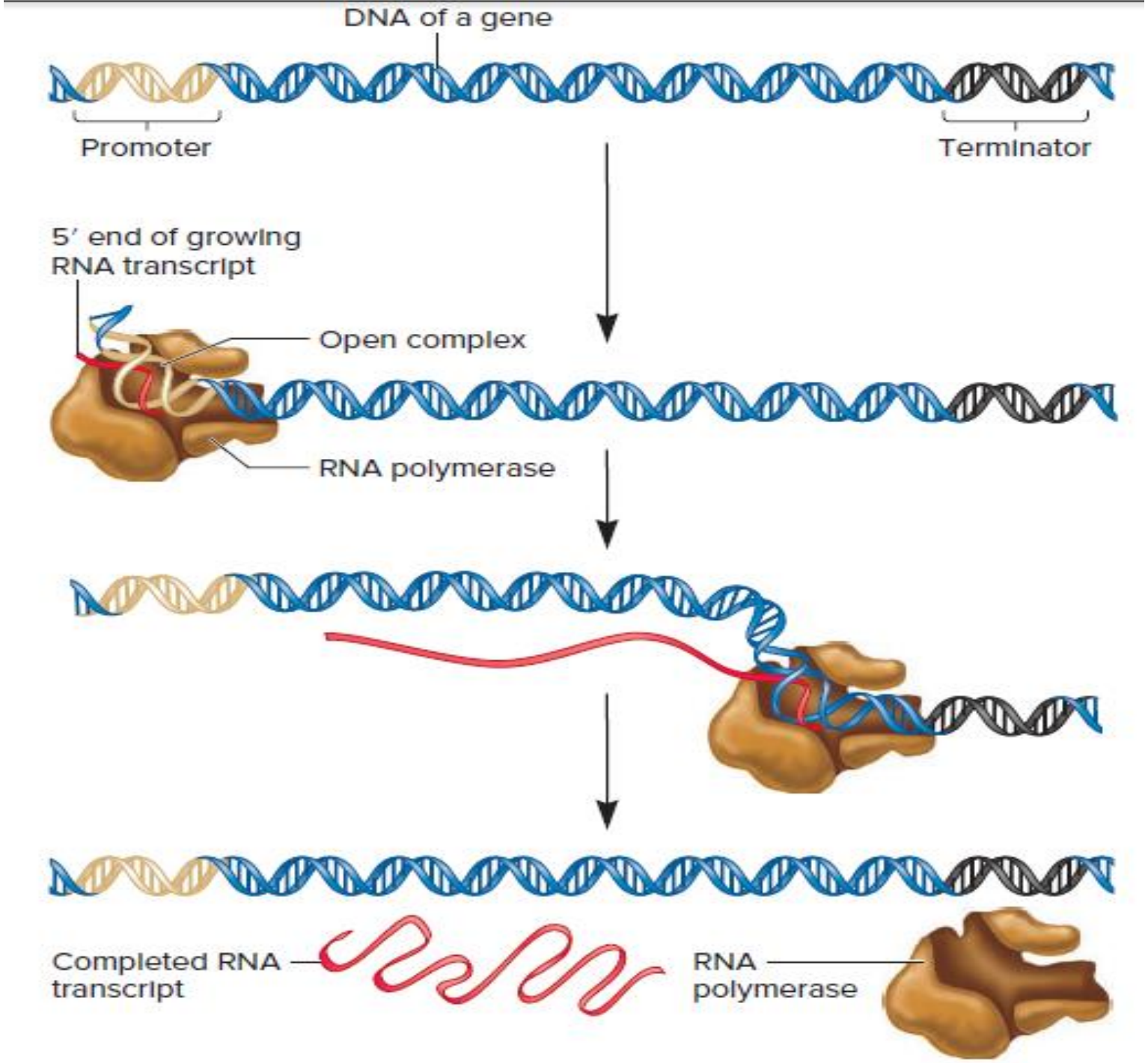
The central dogma of genetics




Regulatory sequence
Promoter
Terminator
DNA
Transcription
mRNA
5′
3′
Start codon
Many codons
Stop codon
Ribosome-binding site

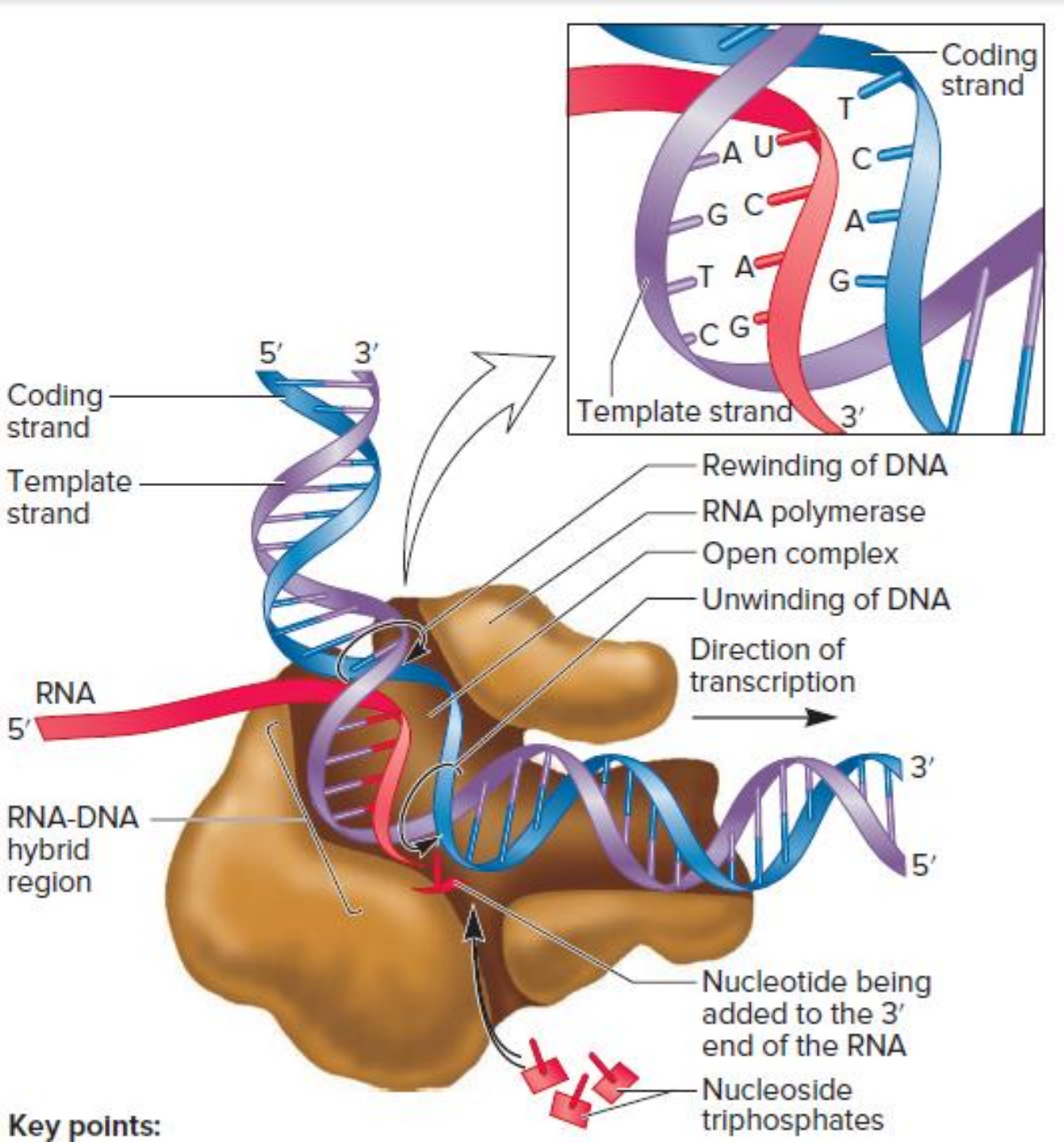
Stages of Transcription:

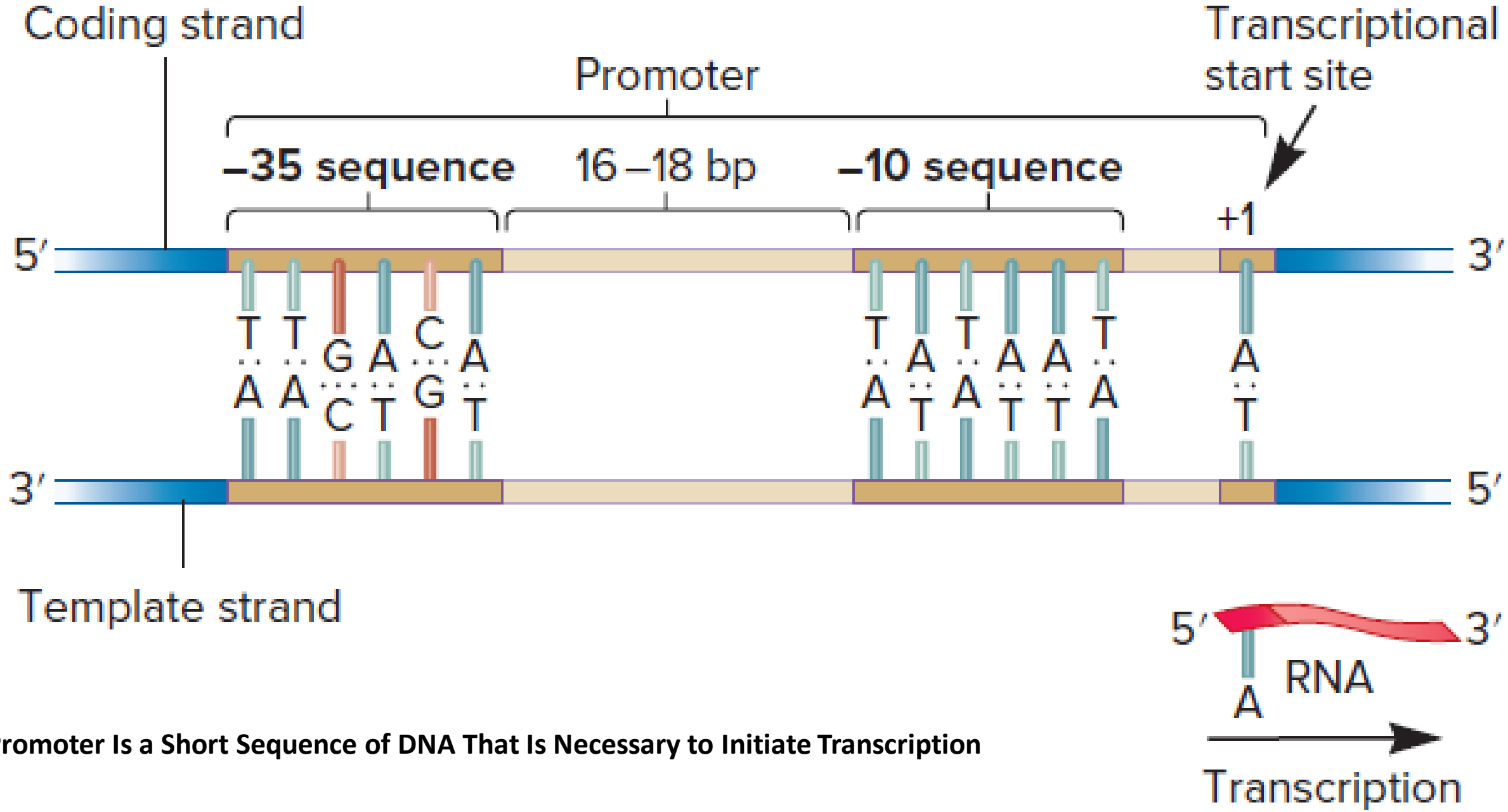
Initiation,
Elongation,
Termination



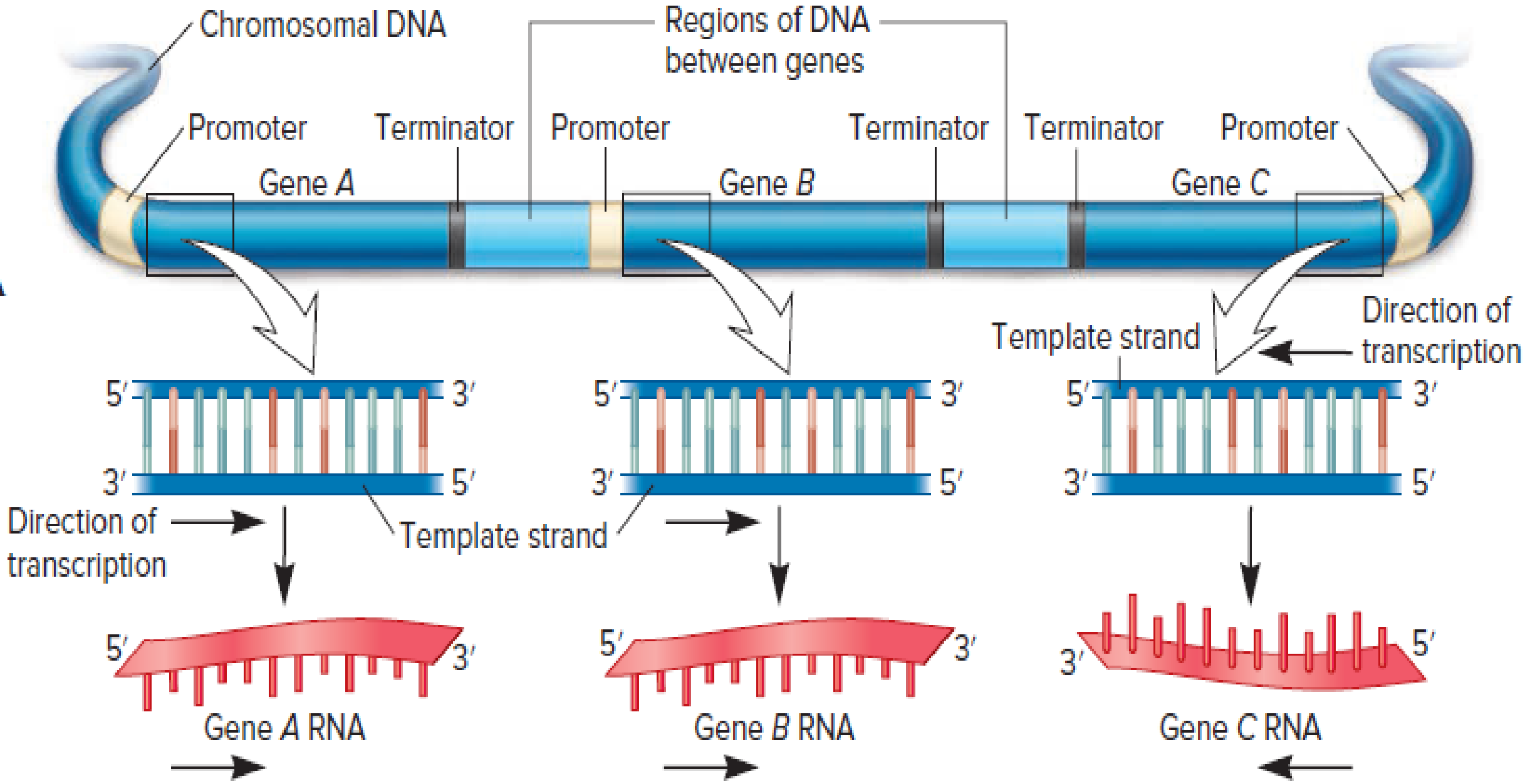
Key points:

- RNA polymerase slides along the DNA, creating an open complex as it moves.
- The DNA strand known as the template strand is used to make a complementary copy of RNA, resulting in an RNA-DNA hybrid.
- RNA polymerase moves along the template strand in a 3 to 5 direction, and RNA is synthesized in a 5 to 3 direction using nucleoside triphosphates as precursors.
- The complementarity rule is the same as the AT/GC rule except that U is substituted for T in the RNA.



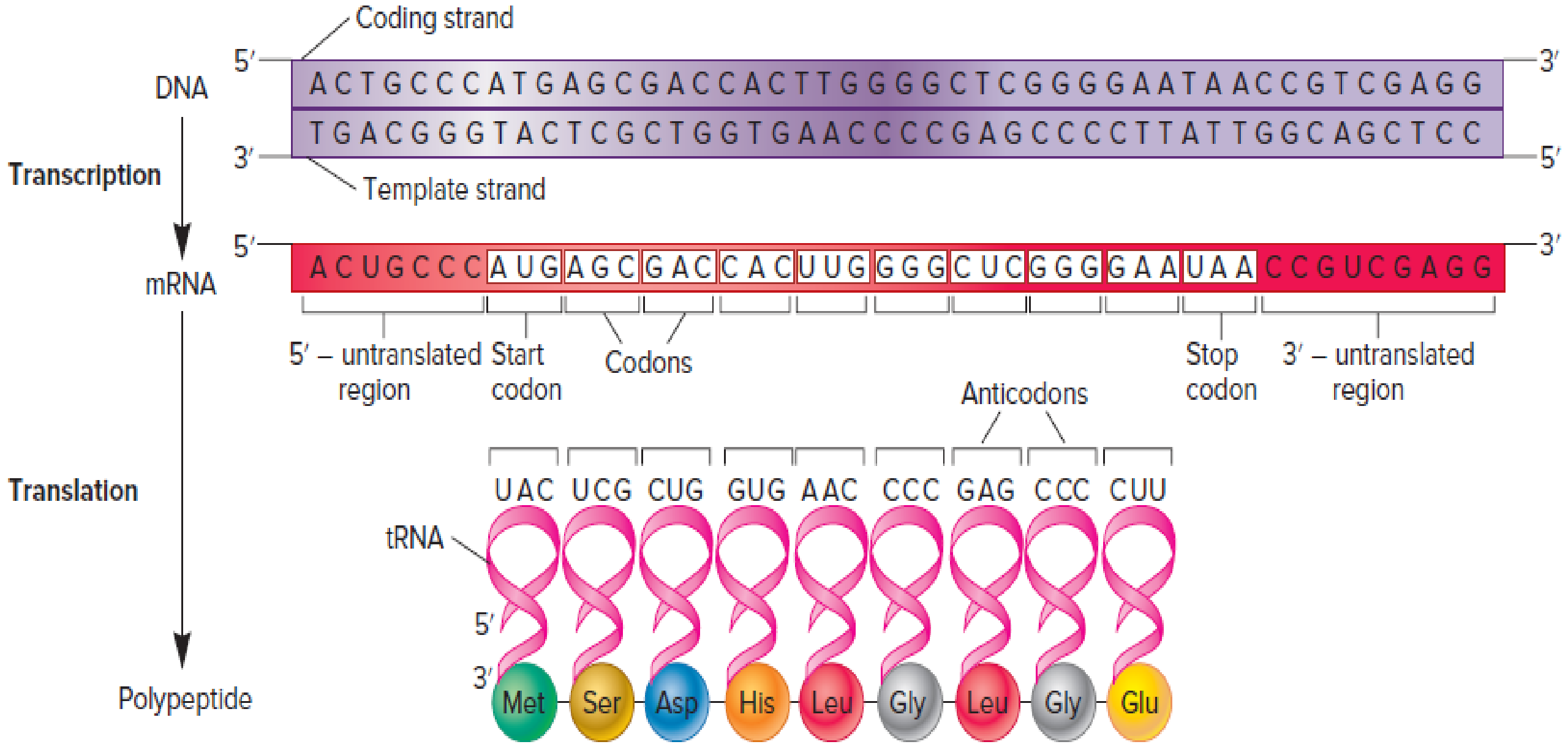


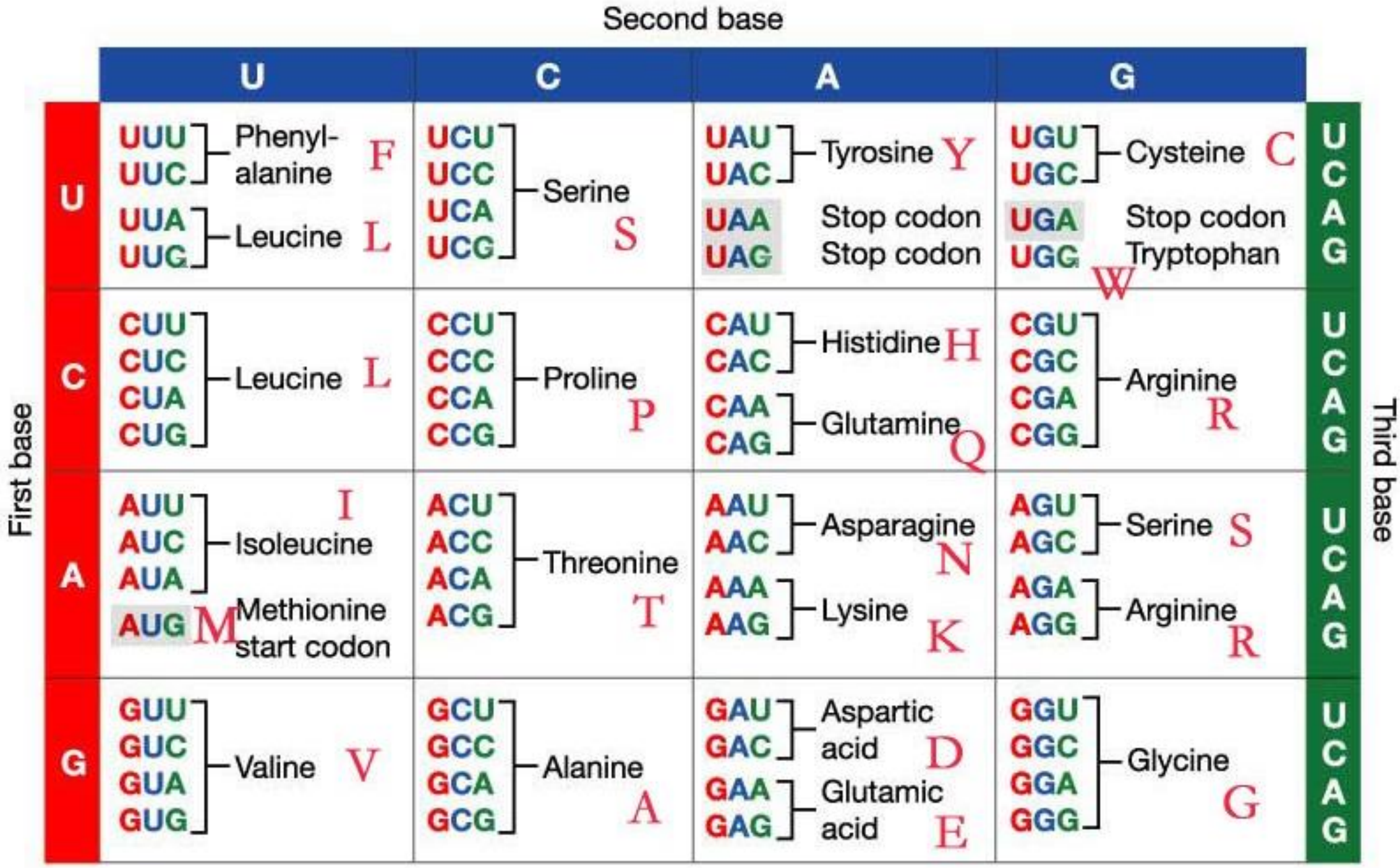
A Promoter Is a Short Sequence of DNA That Is Necessary to Initiate Transcription

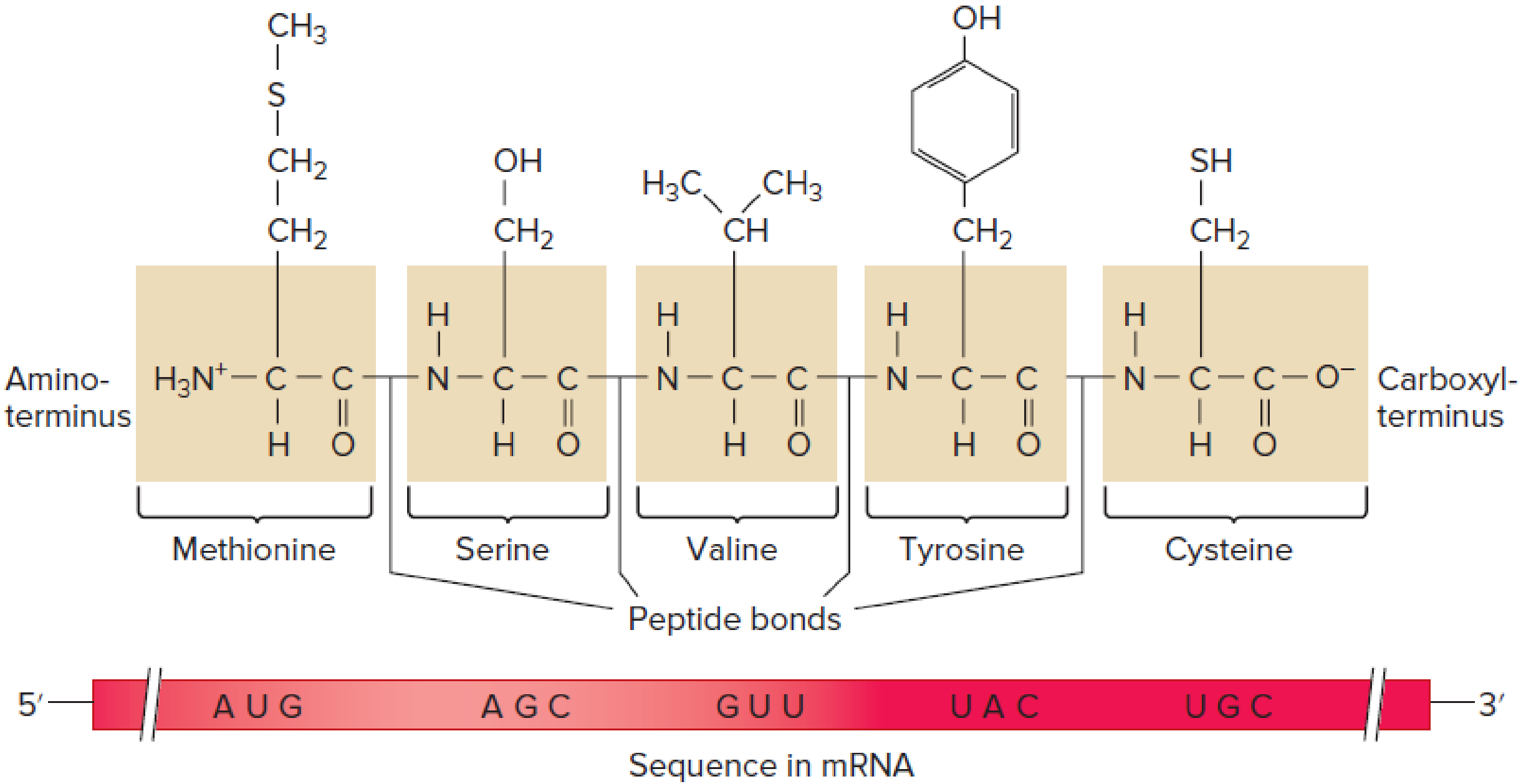

Chromosomal DNA
Regions of DNA between genes
Promoter
Terminator
Promoter
Terminator
Terminator
Promoter
Gene A
Gene B
Gene C
Template strand
Direction of transcription
5′
3′
3′
5′
Direction of transcription
Template strand
Gene A RNA
Gene B RNA
Gene C RNA

Translation of mRNA

- Is the process in which the sequence of codons within mRNA provides the information to synthesize the sequence of amino acids that constitute a polypeptide.
- One or more polypeptides then fold and assemble to create a functional protein.

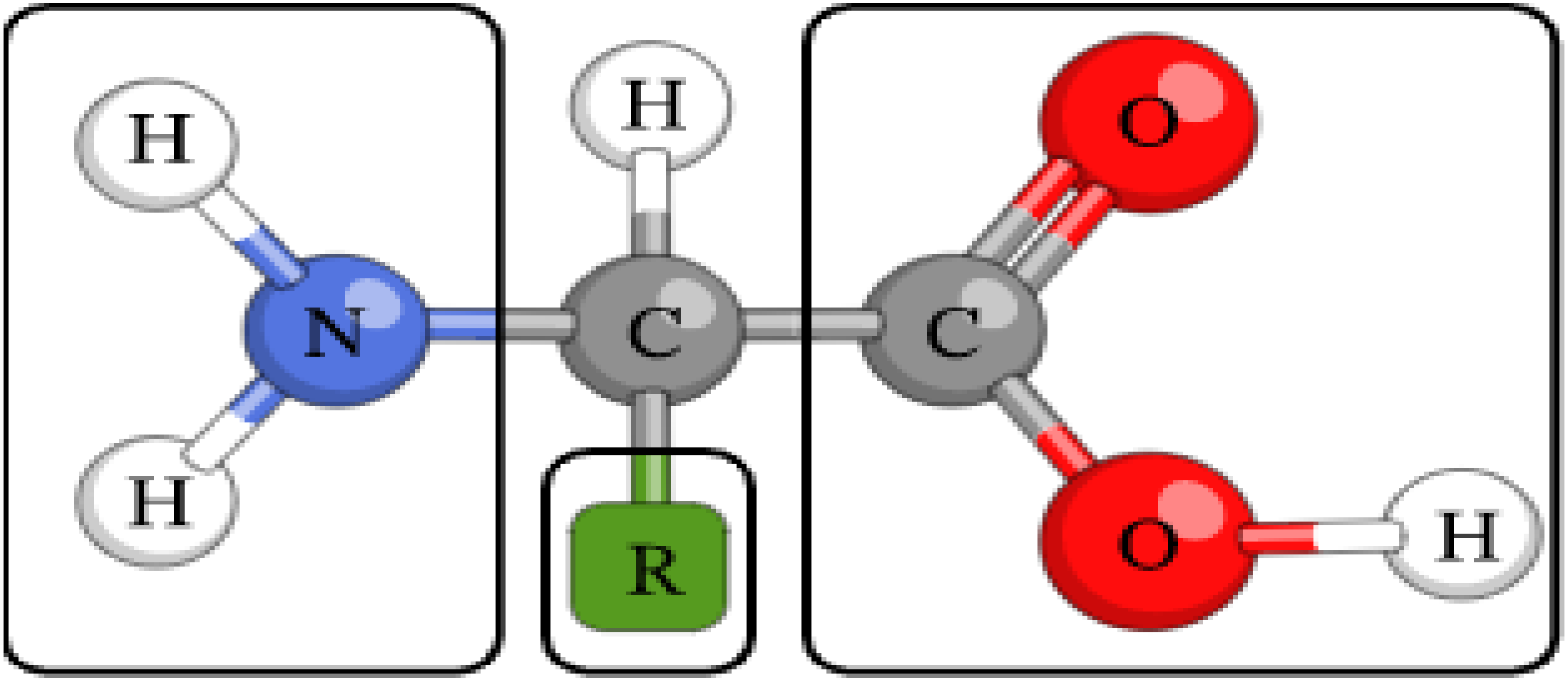

Coding strand
5′
3′
DNA
A C T G C C C A T G A G C G A C C A C T T G G G G C T C G G G G A A T A A C C G T C G A G G
T G A C G G G T A C T C G C T G G T G A A C C C C G A G C C C C T T A T T G G C A G C T C C
3′
5′
Transcription
Template strand
5′
3′
mRNA
A C U G C C C A U G A G C G A C C A C U U G G G G C U C G G G G A A U A A C C G U C G A G G
5′ – untranslated region
Start codon
Codons
Stop codon
3′ – untranslated region
Anticodons
Translation
U A C U C G C U G G U G A A C C C C G A G C C C C U U
tRNA
5′
3′
Polypeptide
Met
Ser
Asp
His
Leu
Gly
Leu
Gly
Glu


Second base
U
C
A
G
First base
Third base
U
C
A
G
UUU UUC Phenyl-alanine F
UUA UUG Leucine L
UCU UCC UCA UCG Serine S
UAU UAC Tyrosine Y
UAA Stop codon
UAG Stop codon
UGU UGC Cysteine C
UGA Stop codon
UGG Tryptophan W
CUU CUC CUA CUG Leucine L
CCU CCC CCA CCG Proline P
CAU CAC Histidine H
CAA CAG Glutamine Q
CGU CGC CGA CGG Arginine R
AUU AUC AUA Isoleucine I
AUG Methionine start codon M
ACU ACC ACA ACG Threonine T
AAU AAC Asparagine N
AAA AAG Lysine K
AGU AGC Serine S
AGA AGG Arginine R
GUU GUC GUA GUG Valine V
GCU GCC GCA GCG Alanine A
GAU GAC Aspartic acid D
GAA GAG Glutamic acid E
GGU GGC GGA GGG Glycine G


Amino-terminus
Carboxyl-terminus
Methionine
Serine
Valine
Tyrosine
Cysteine
Peptide bonds
5′
A U G
A G C
G U U
U A C
U G C
3′
Sequence in mRNA

Polypeptide

- There are 20 different amino acids that are most commonly found within polypeptides.
- Each amino acid contains a unique **side chain,** or **R group,** that has its own particular chemical properties. For example, aliphatic and aromatic amino acids are relatively nonpolar, which means they are less likely to associate with water.
- These hydrophobic (meaning “water-fearing”) amino acids are often buried within the interior of a folded protein. In contrast, the polar amino acids are hydrophilic (“water-loving”) and are more likely to be on the surface of a protein, where they can favorably interact with the water in surrounding cell or tissue fluids.
- The chemical properties of the amino acids and their sequences in a polypeptide are critical factors that determine the unique structure of that polypeptide.

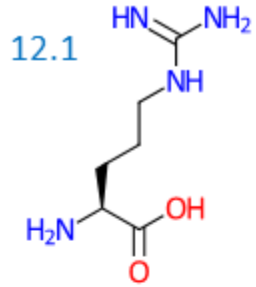


Amino group

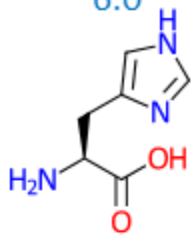
Side chain

Carboxyl group

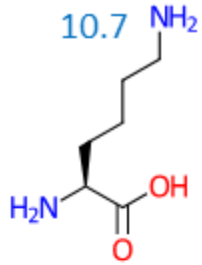
Positively charged



Arginine
Arg **R**

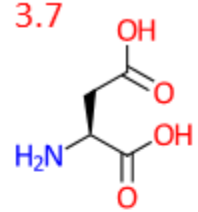


Histidine
His **H**

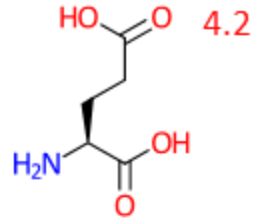


Lysine
Lys **K**

Negatively charged

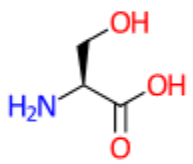


Aspartic Acid
Asp **D**

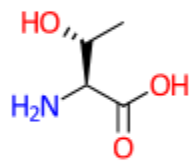


Glutamic Acid
Glu **E**

Polar uncharged

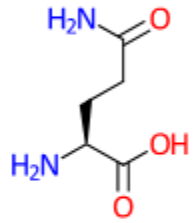


Serine
Ser **S**



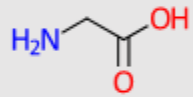
Threonine
Thr **T**

Asparagine
Asn **N**

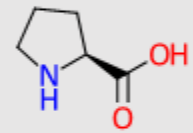


Glutamine
Gln **Q**

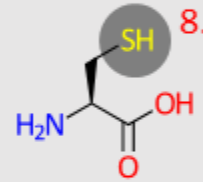
Special cases



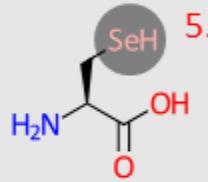
Glycine
Gly **G**



Proline
Pro **P**

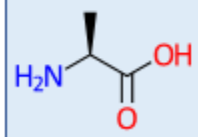


Cysteine
Cys **C**

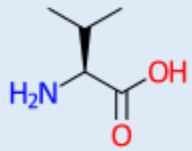


Selenocysteine
Sec **U**

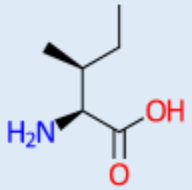
Hydrophobic



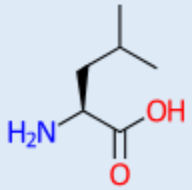
Alanine
Ala **A**



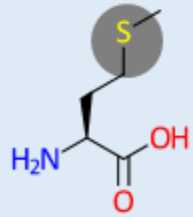
Valine
Val **V**



Isoleucine
Ile **I**

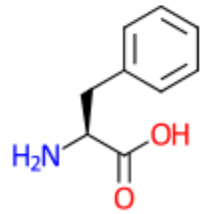


Leucine
Leu **L**

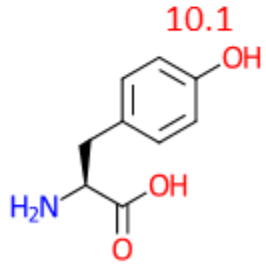


Methionine
Met **M**

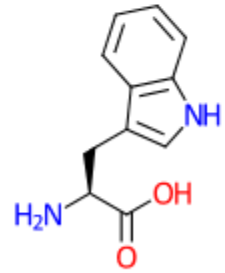
Hydrophobic



Phenylalanine
Phe **F**



Tyrosine
Tyr **Y**

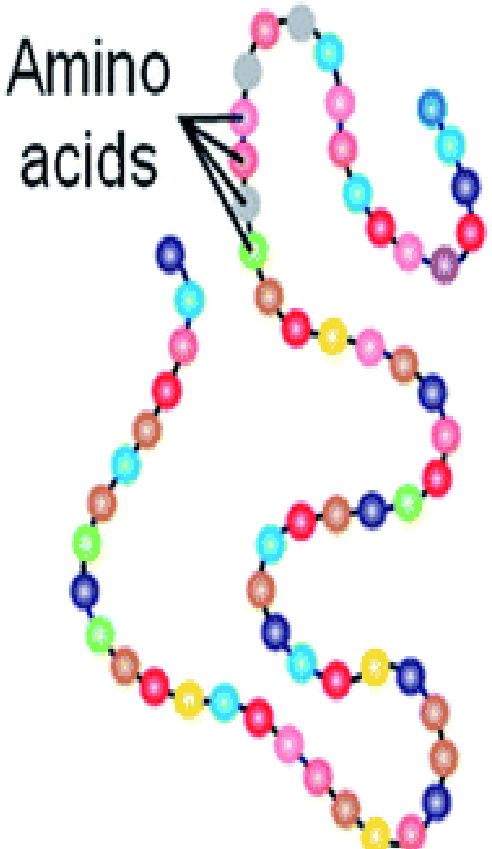


Tryptophan
Trp **W**

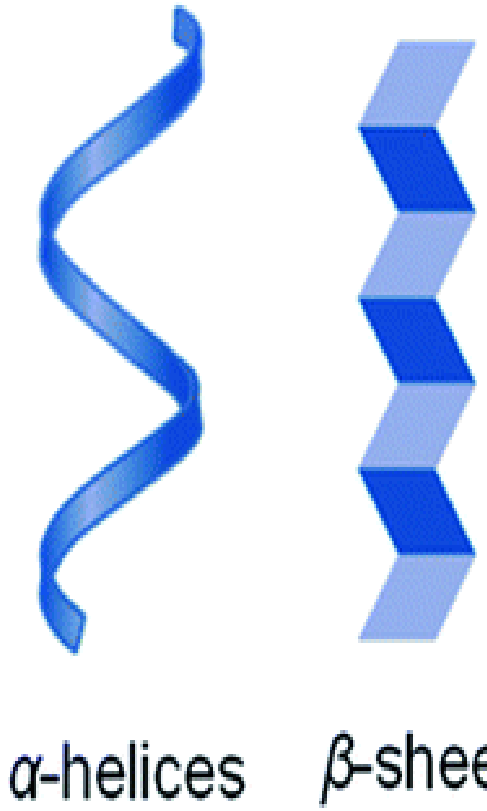
Thomas Ryckmans 2021

Protein structure

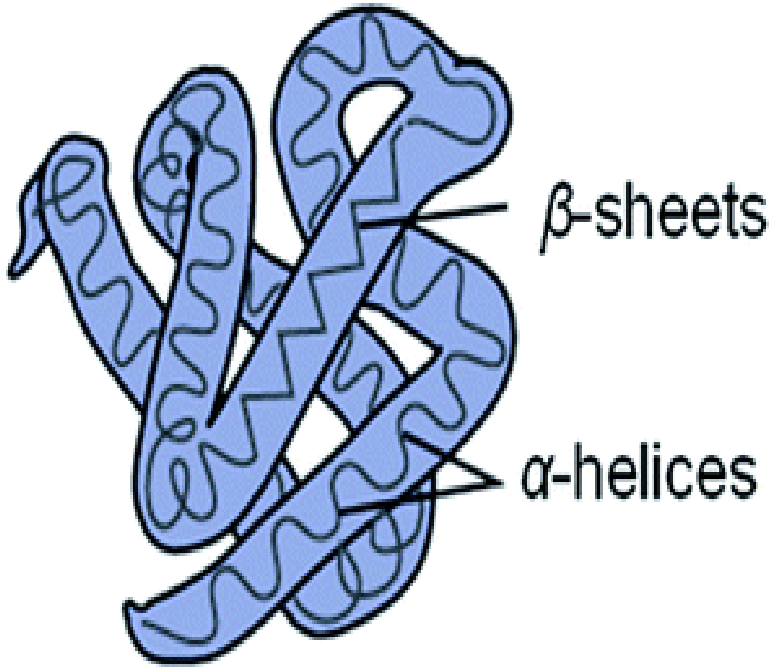
Primary structure



Secondary structure



Tertiary structure



Quaternary structure