BIO102-Foundations of Biology (I)

Transcription: DNA to RNA

INDRAPRASTHA INSTITUTE *of*
INFORMATION TECHNOLOGY **DELHI**

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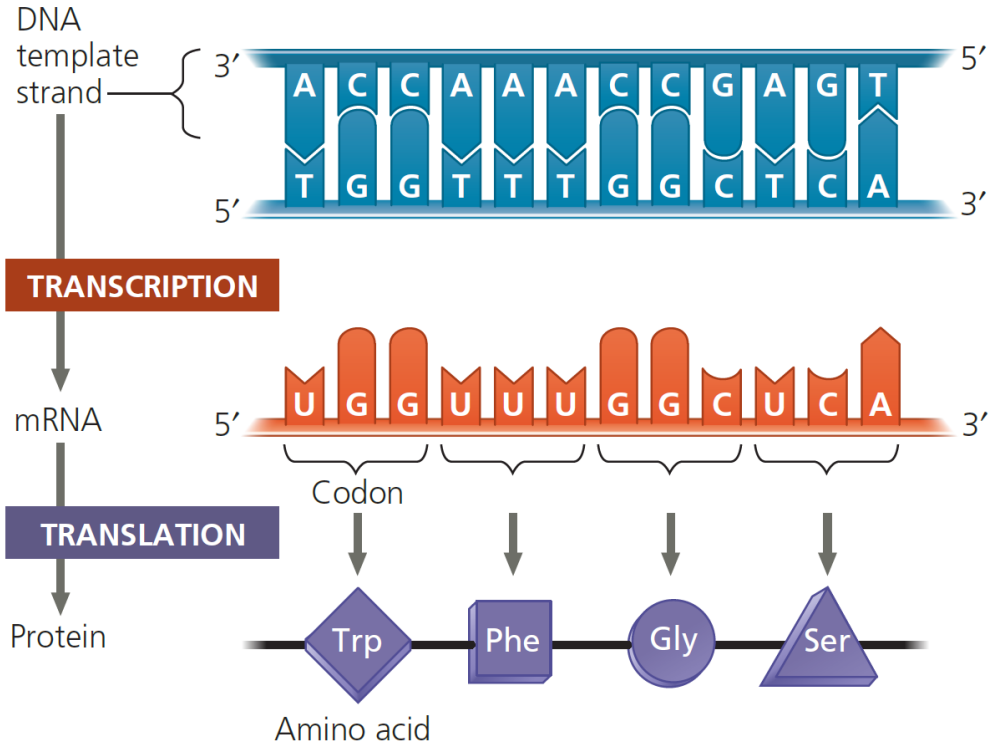
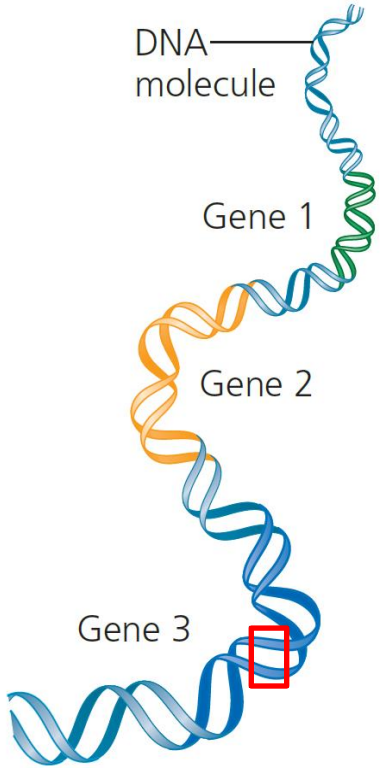
Central Dogma

Flow of genetic information





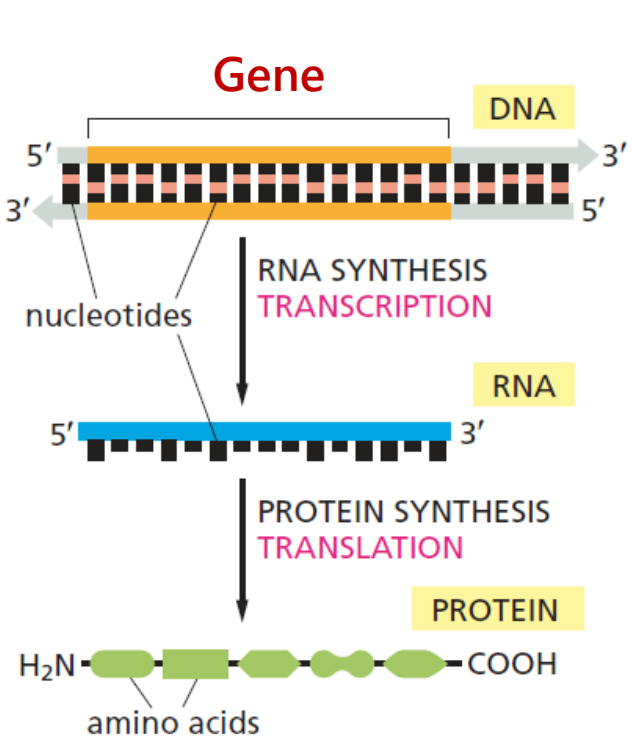
Proteins are the major players in cells

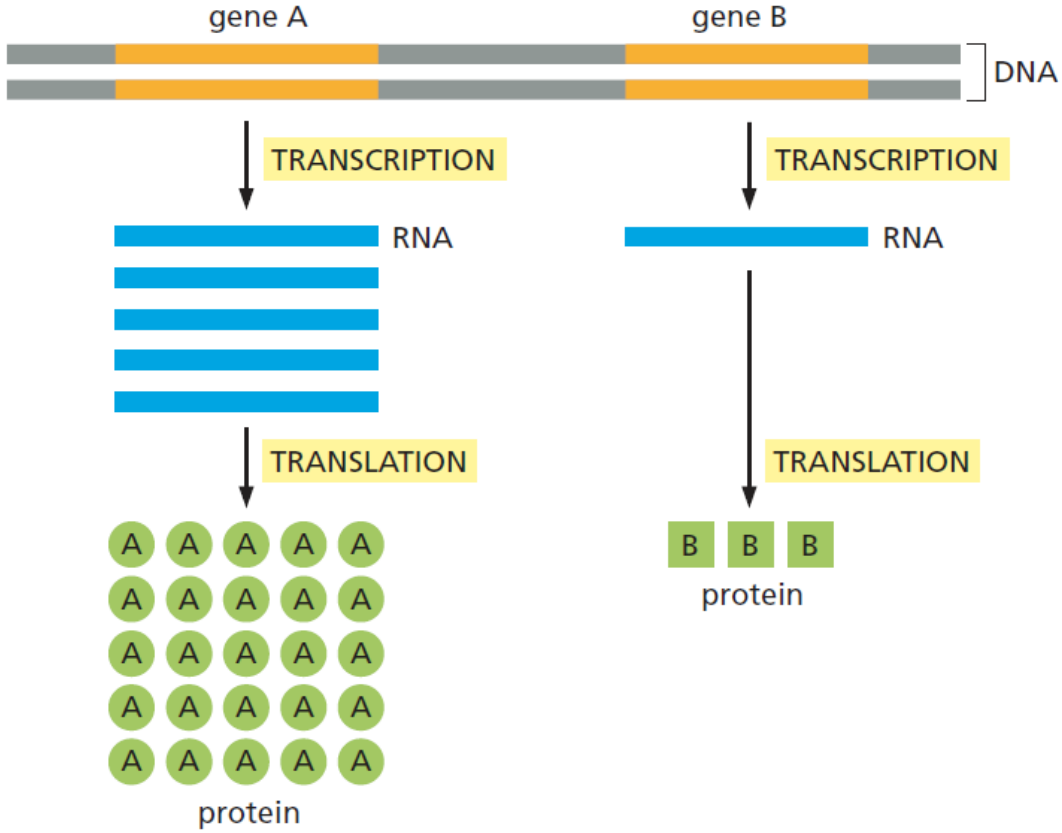
- Even before the DNA code was broken, it was known that proteins are the principal constituents of cells and determine not only cell structure but also cell function.
- There are thousands of different kinds of proteins that cells can make.
- There are only 20 different amino acids that make up all these different proteins.
- The unique amino acid sequence of each protein dictates how the chain will fold to form a molecule with a distinctive shape and chemistry.
- The genetic instructions carried by DNA must therefore specify the amino acid sequences of proteins.

Transcription: DNA → RNA

- DNA does not synthesize proteins itself, but it acts like a manager to get the task done.
- When a particular protein is needed by the cell, the nucleotide sequence of the appropriate segment of a DNA molecule is first copied into another type of nucleic acid—RNA that then helps in the synthesis of protein.
- The flow of genetic information in cells is therefore from DNA to RNA to protein.
- And this process of DNA to RNA synthesis is called Transcription.

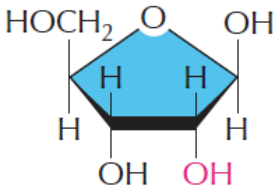
A cell can express different genes at different rates





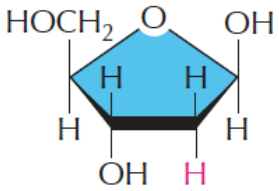
DNA *vs.* RNA

SUGAR DIFFERENCES



ribose

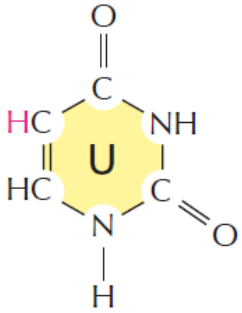
used in RNA



deoxyribose

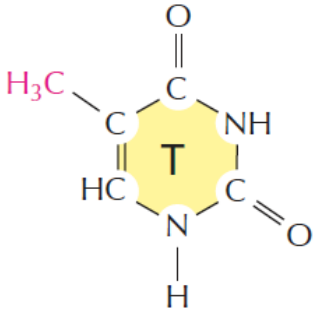
used in DNA

BASE DIFFERENCES



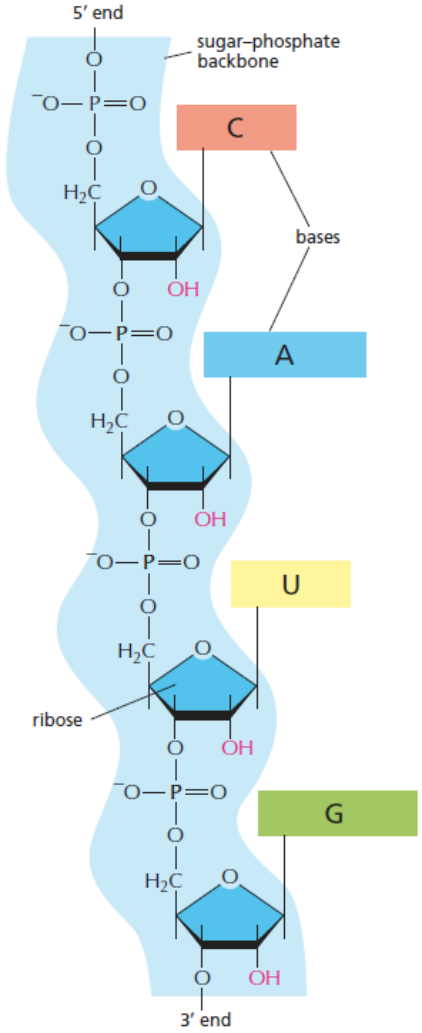
uracil

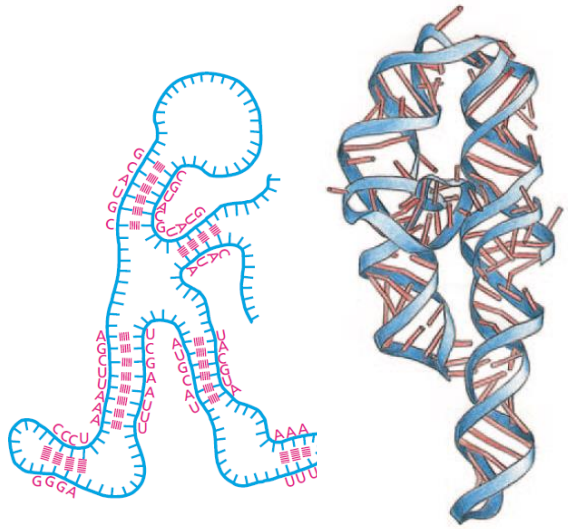
used in RNA



thymine

used in DNA

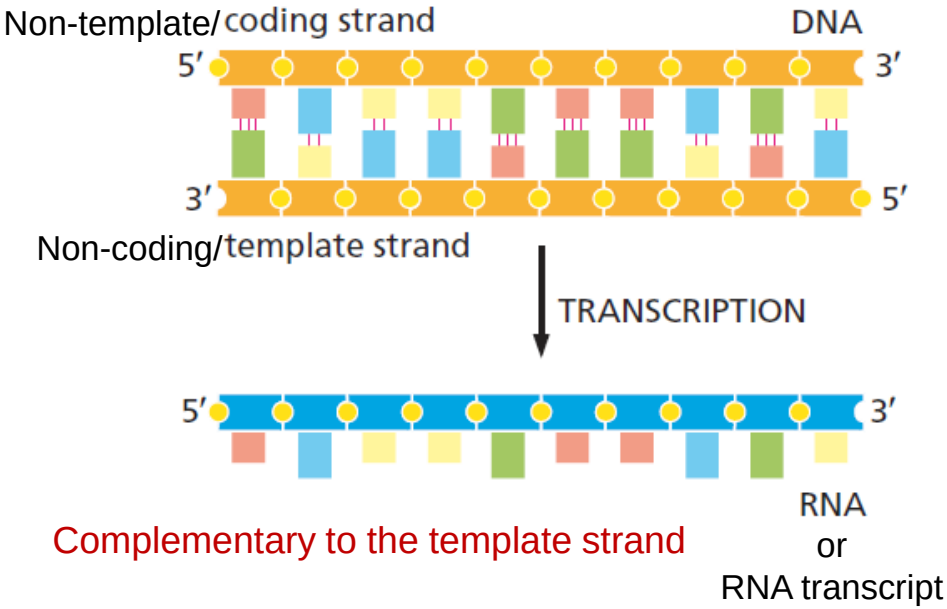




RNA molecules can form intramolecular base pairs and fold into specific structures

Roles: messenger between DNA and protein, structural, regulatory and catalytic

RNA is complementary to only one strand of DNA

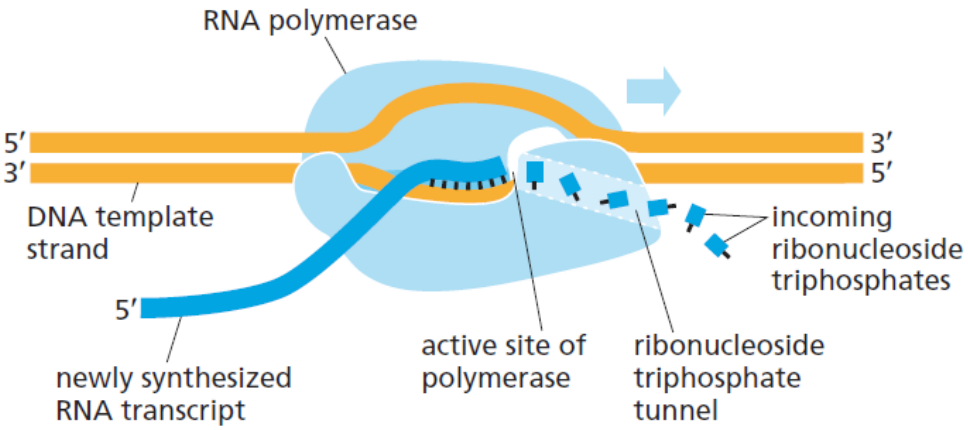


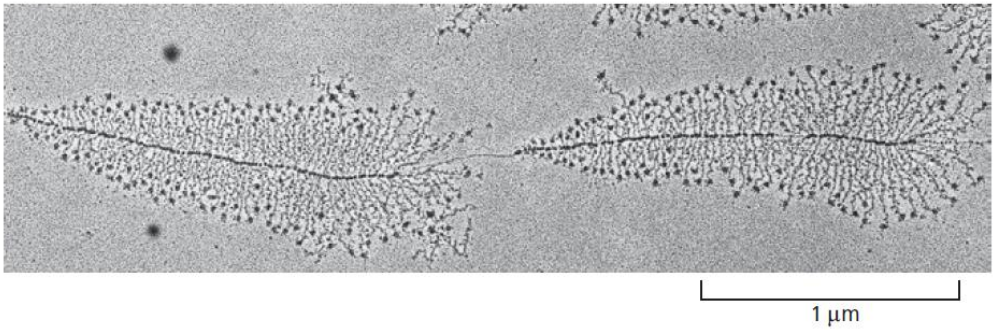
Most of the mature RNAs are no more than a few thousand nucleotides long, and many are much shorter than that.

Not all RNAs produce protein

TYPES OF RNA PRODUCED IN CELLS	
Type of RNA	**Function**
messenger RNAs (mRNAs)	code for proteins
ribosomal RNAs (rRNAs)	form the core of the ribosome's structure and catalyze protein synthesis
microRNAs (miRNAs)	regulate gene expression
transfer RNAs (tRNAs)	serve as adaptors between mRNA and amino acids during protein synthesis
other noncoding RNAs	used in RNA splicing, gene regulation, telomere maintenance, and many other processes

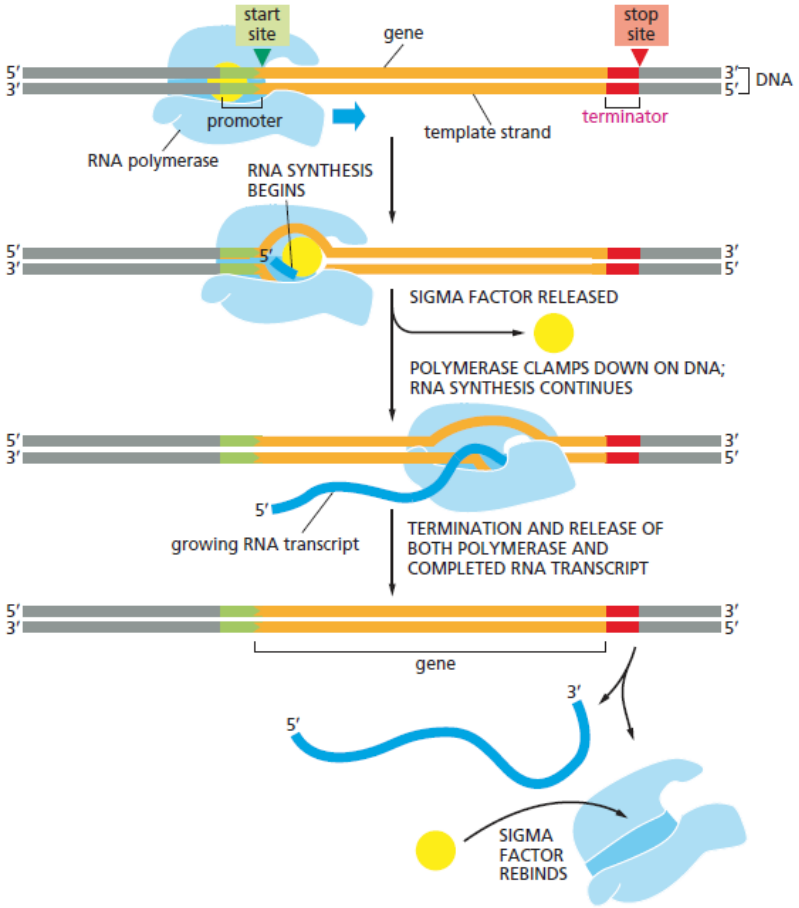
Prokaryotic transcriptional machinery



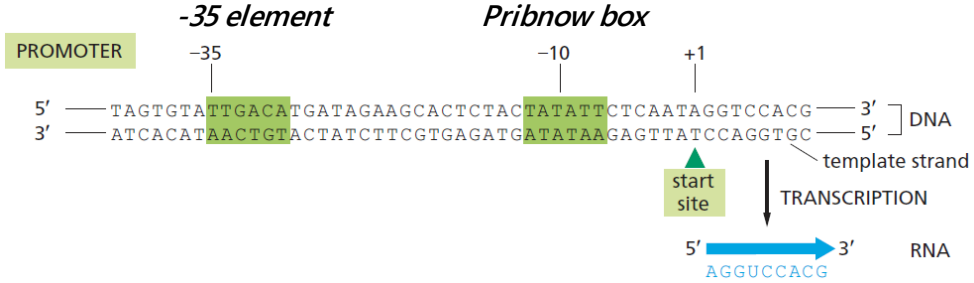


- RNA polymerases catalyze the formation of the phosphodiester bonds that link the nucleotides together and form the sugar–phosphate backbone of the RNA chain
- RNA also grows in 5′-to-3′ direction.
- RNA strand is immediately released from the DNA as it is synthesized.
- Many RNA copies can be made from the same gene in a relatively short time. The synthesis of the next RNA is usually started before the first RNA has been completed.
- Transcription of 1500 nucleotide pairs takes ~50 sec.

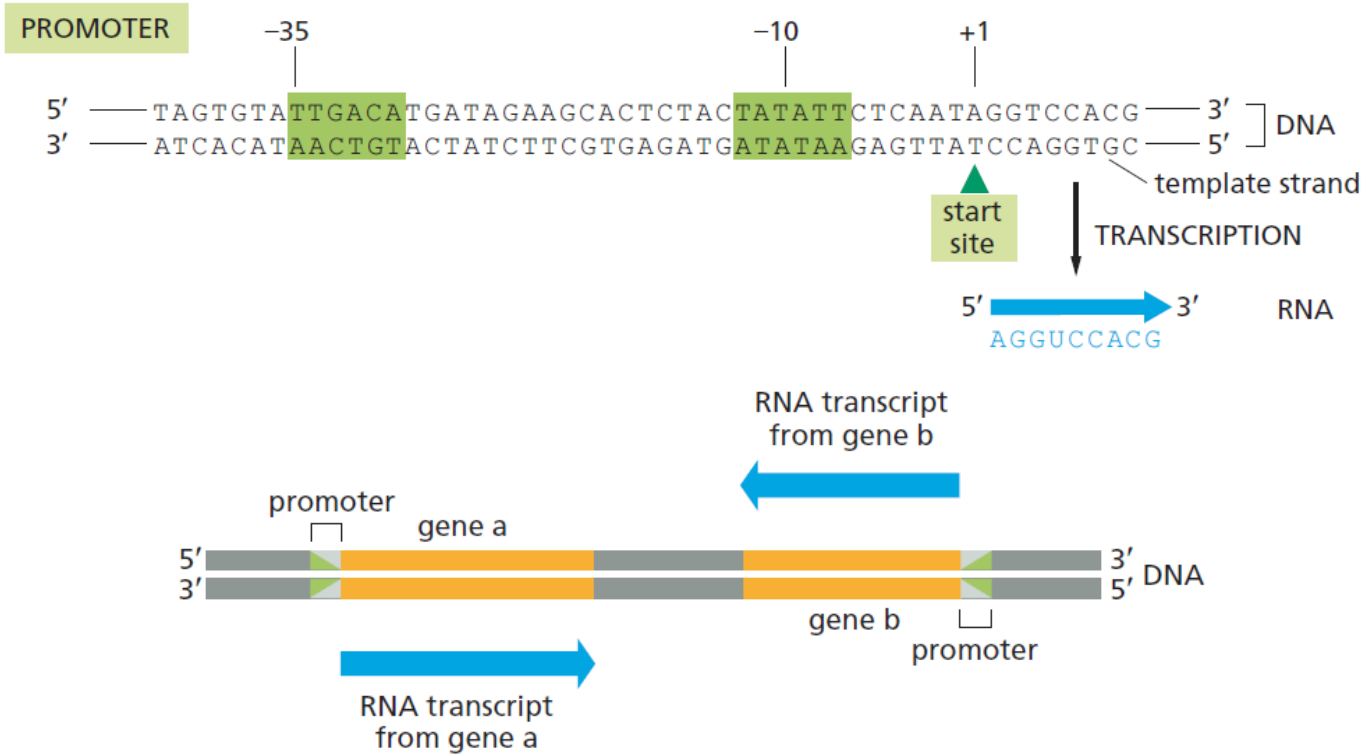
Start and stop signals – Promoter and Terminator



Prokaryotes



Gene transcription also happens in 5′- 3′ direction

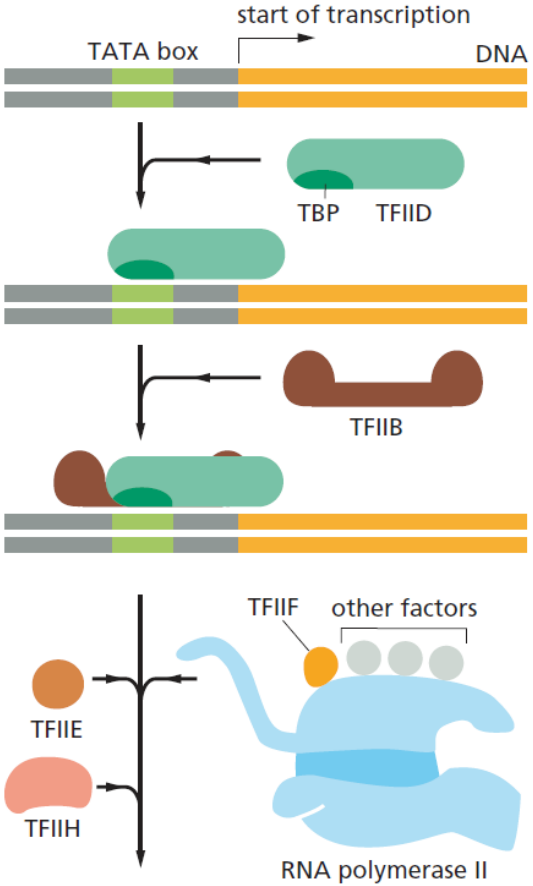


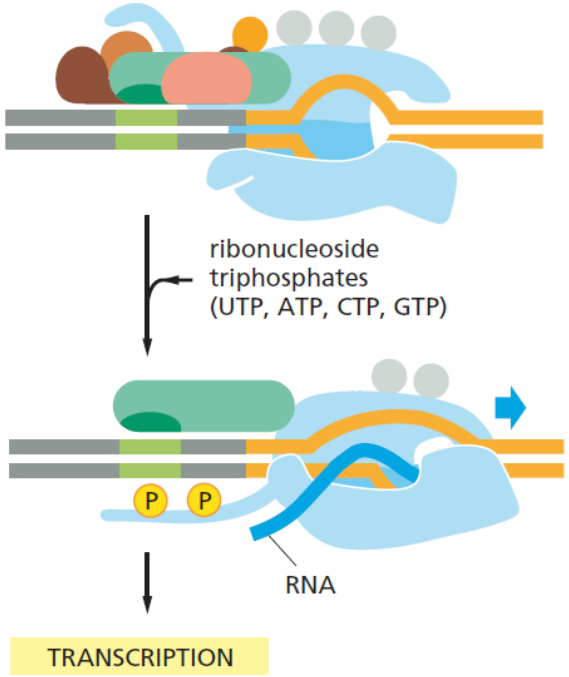
Orientation of promoter dictates the direction of gene transcription

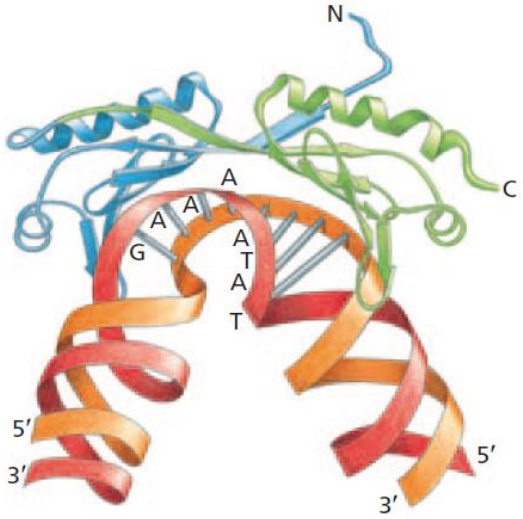
Different types of RNA polymerases in Eukaryotes

THE THREE RNA POLYMERASES IN EUKARYOTIC CELLS	
Type of Polymerase	**Genes Transcribed**
RNA polymerase I	most rRNA genes
RNA polymerase II	all protein-coding genes, miRNA genes, plus genes for other noncoding RNAs (e.g., those in spliceosomes)
RNA polymerase III	tRNA genes 5S rRNA gene genes for many other small RNAs

Eukaryotic transcriptional machinery





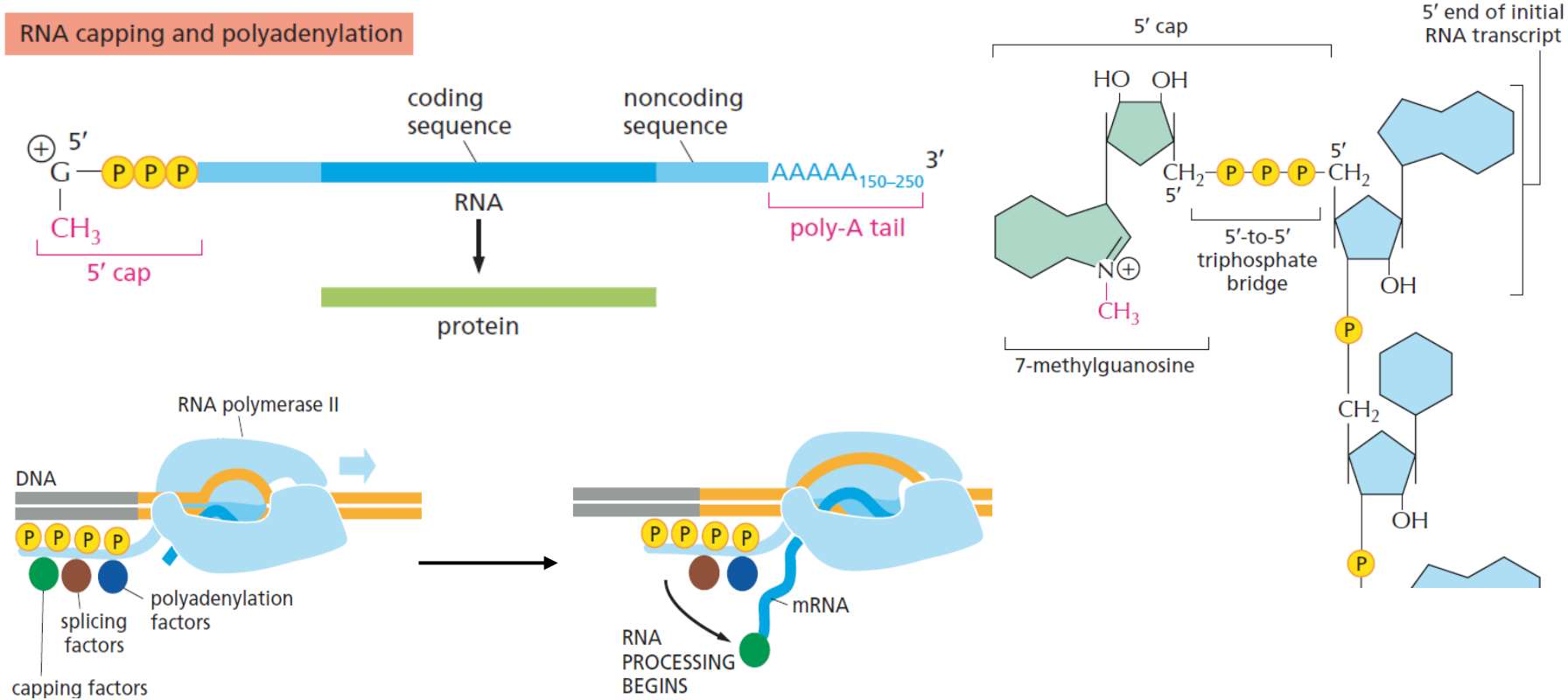


Binding to TATA box causes structural distortion in DNA

It is typically located 25 nucleotides upstream from the transcription start site.

mRNAs processing for nuclear export

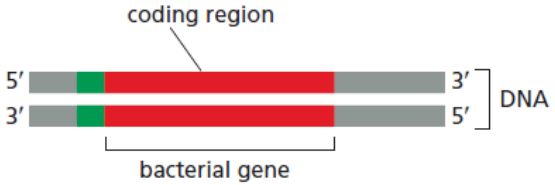
RNA processing steps include capping, splicing, and polyadenylation

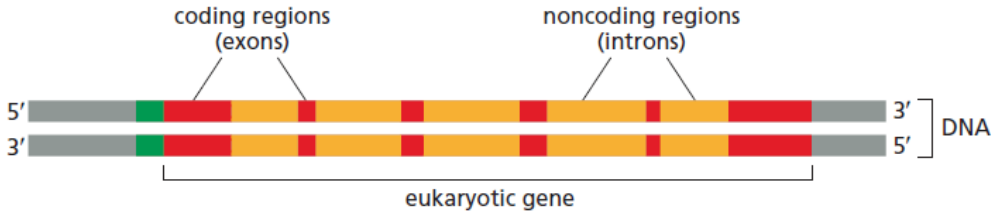


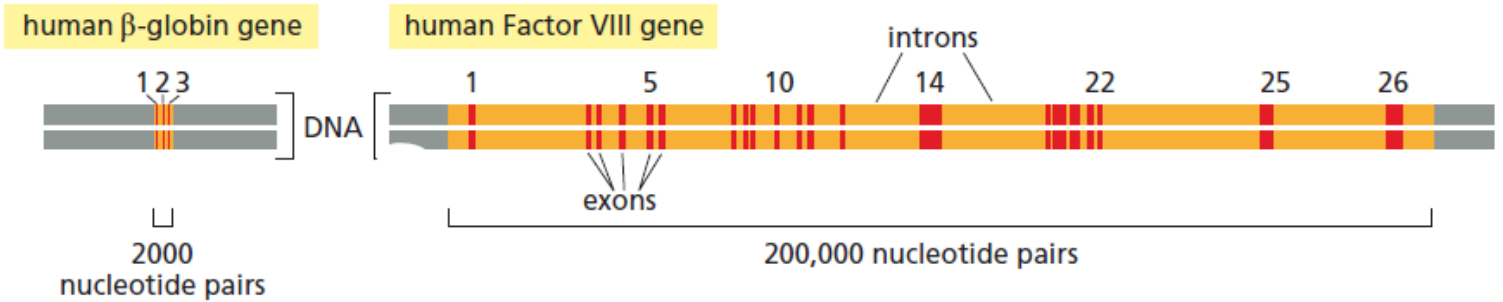
Introns and exons

Introns: long, non-coding, intervening sequences in a gene

Exons: scattered coding regions of a gene

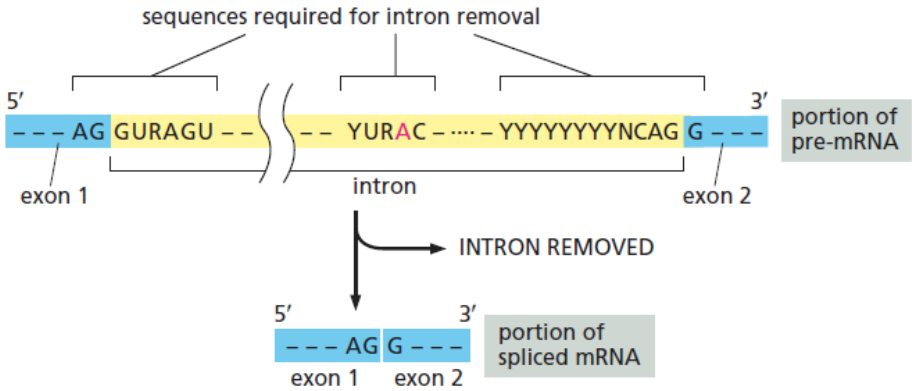






mRNAs processing for nuclear export

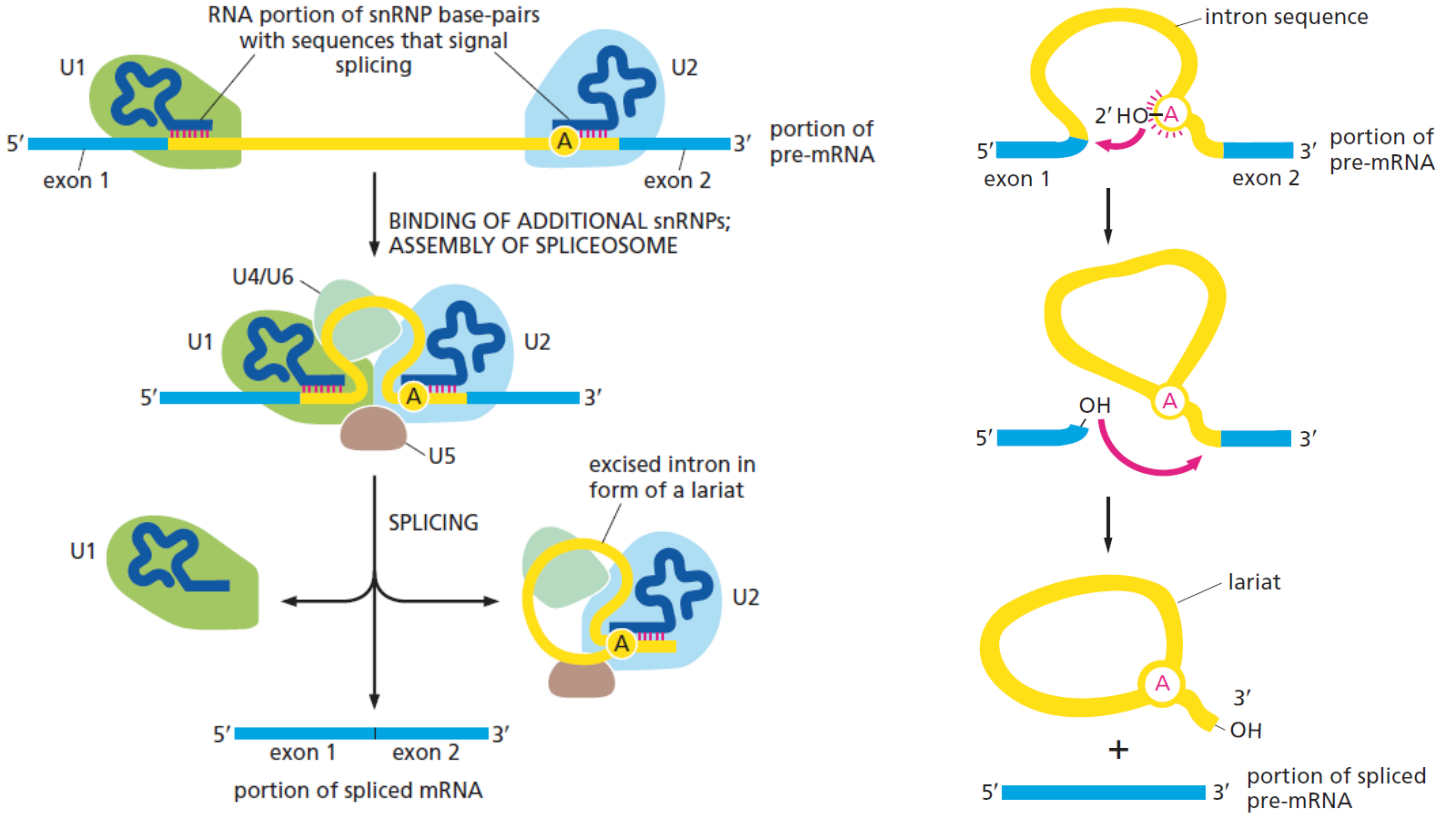
Splicing of introns



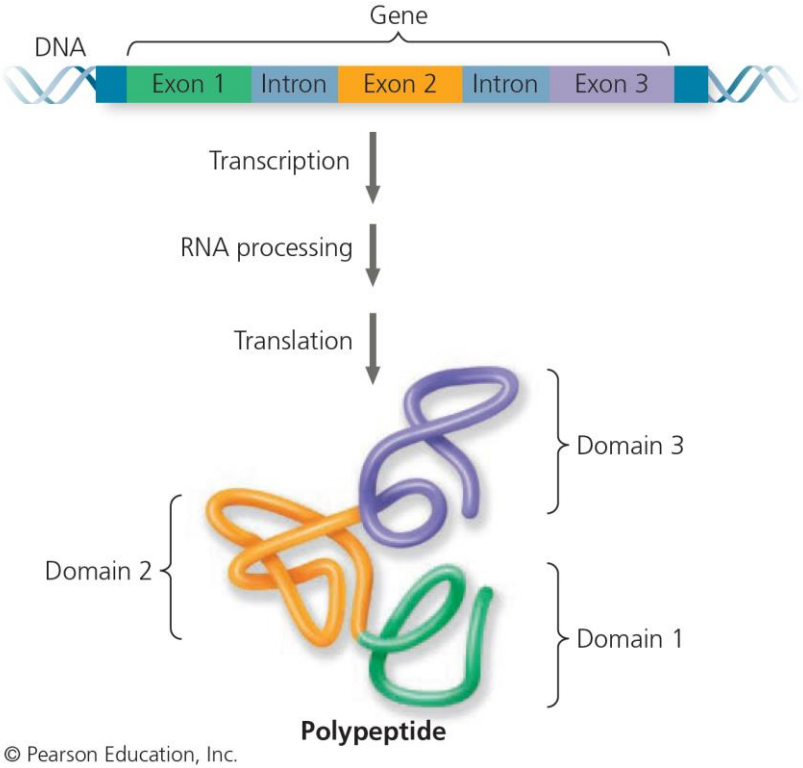
Special nucleotide sequences in a pre-mRNA transcript signal the beginning and the end of an intron.

Alternative splicing

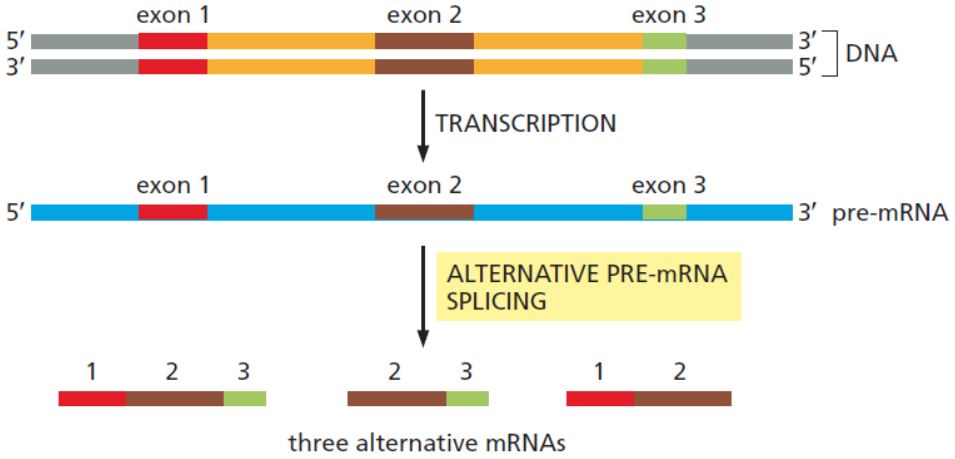
Splicing is carried out by a collection of RNA–protein complexes called small nuclear ribonucleoproteins (snRNPs, “snurps”)



Alternative splicing

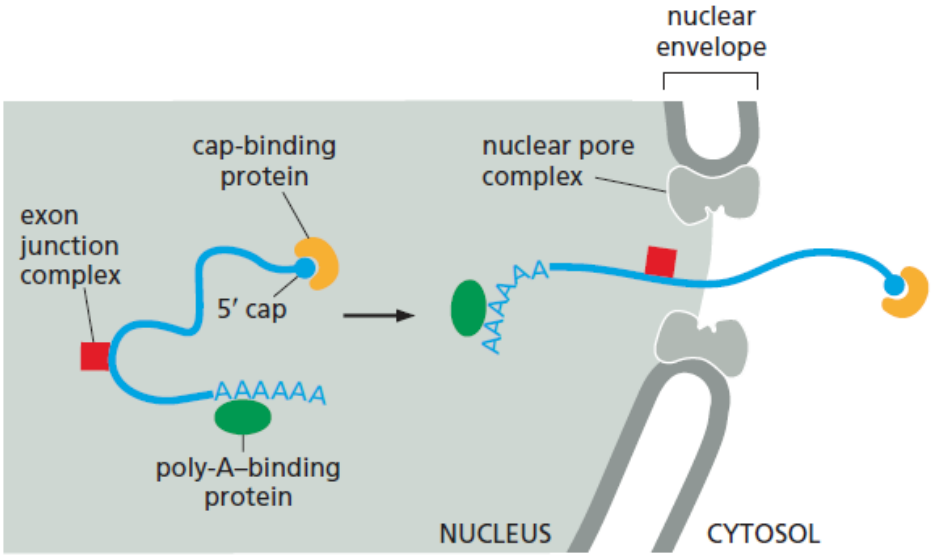


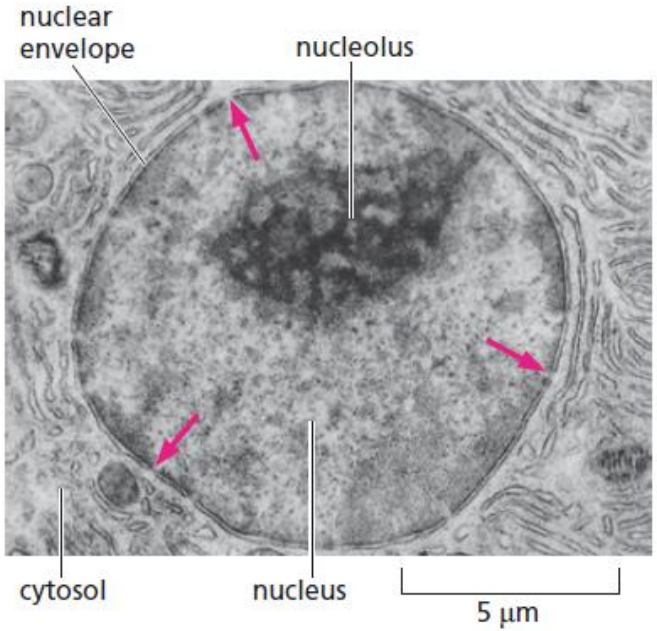
pre-mRNAs can undergo alternative RNA splicing to produce various mRNAs and proteins from the same gene.

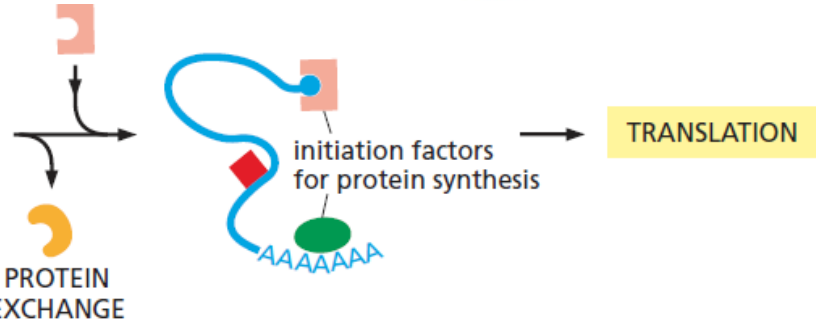


Nuclear export of mRNA

A specialized set of RNA-binding proteins signals that a mature mRNA is ready for export to the cytosol, and this export is carried out through the nuclear pores

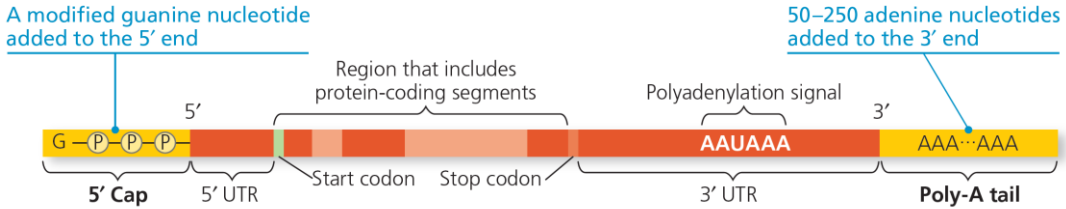






Degradation of mRNA in the cytosol

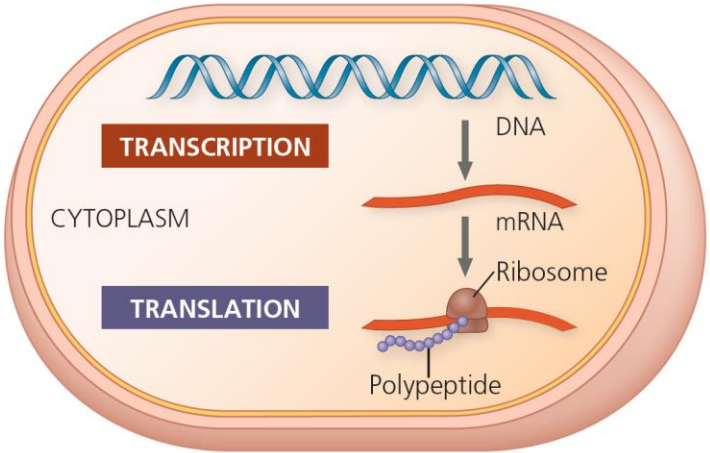
- Each mRNA molecule can be translated into protein many times, the length of time that a mature mRNA molecule persists in the cell affects the amount of protein it produces.
- mRNA is degraded into nucleotides by ribonucleases (RNAses) present in the cytosol.
- The lifetimes of mRNA molecules differ considerably—depending on the nucleotide sequence of the mRNA and the type of cell. In bacteria, most mRNAs are degraded rapidly, having a typical lifetime of about 3 minutes. The mRNAs in eukaryotic cells usually persist longer: some, such as those encoding β-globin, have lifetimes of more than 10 hours, whereas others have lifetimes of less than 30 minutes.



- The lifetimes of mRNAs are in part controlled by nucleotide sequences in the mRNA itself, most often in the portion of RNA called the 3′ untranslated region, which lies between the 3′ end of the coding sequence and the poly-A tail.

Transcription: Prokaryotes *vs.* Eukaryotes

Prokaryotes



Eukaryotes