Chapter 4

Expression of Genetic Information

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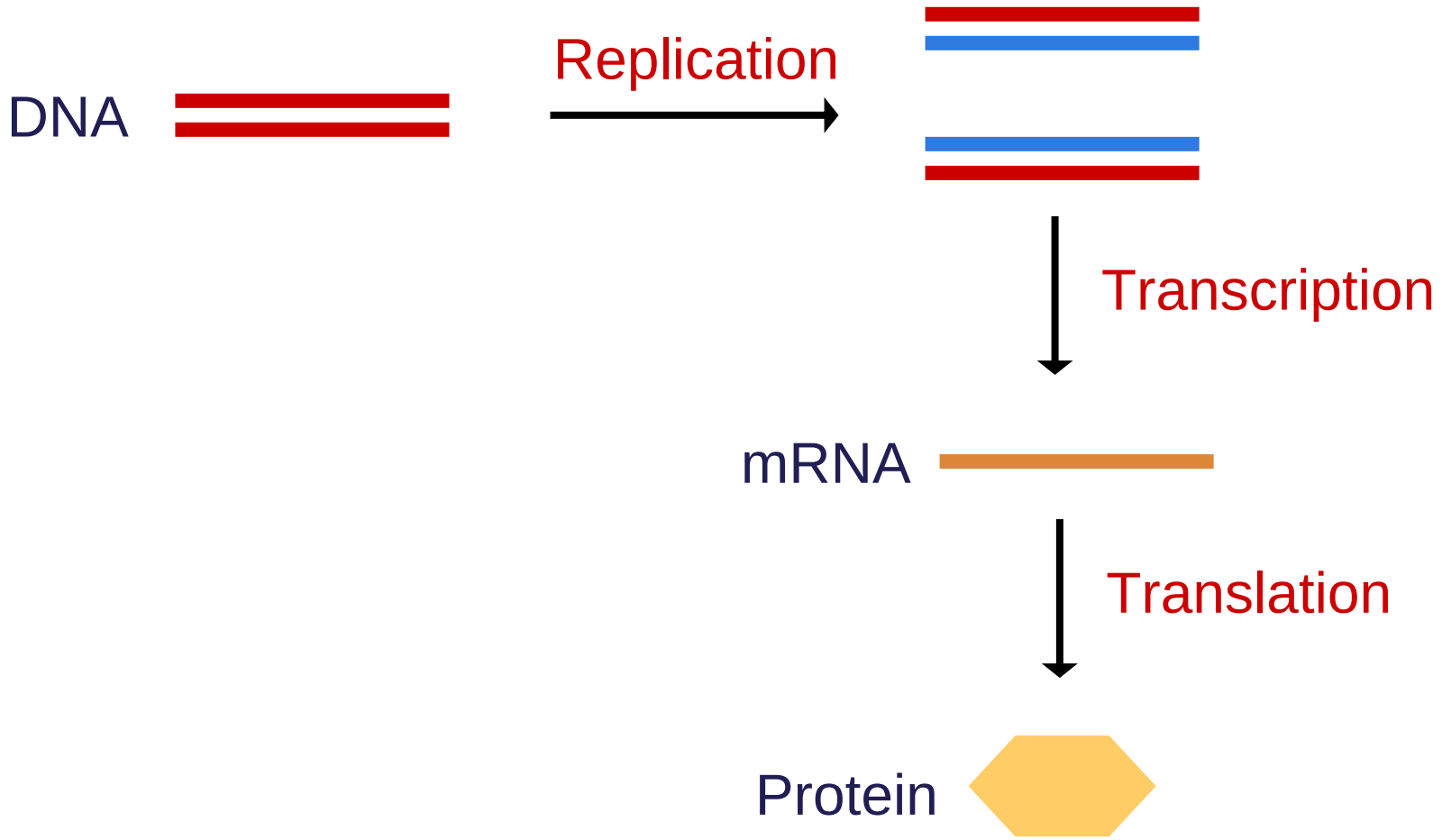
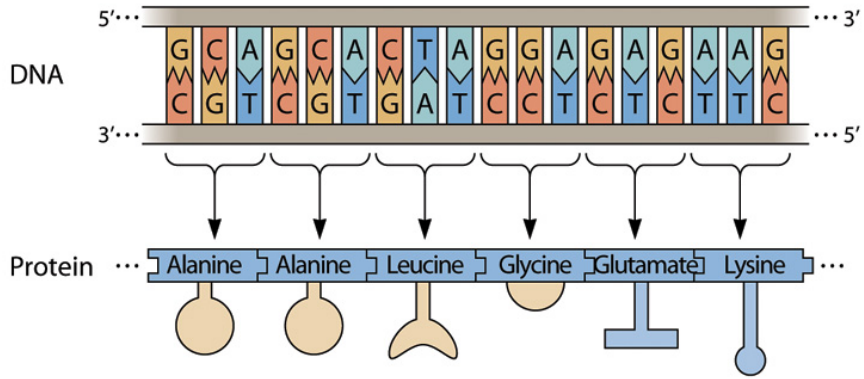


Genetic Code

- Information in DNA → amino acid sequence in protein

5’ AUG CGC AUC UAG UCG 3’

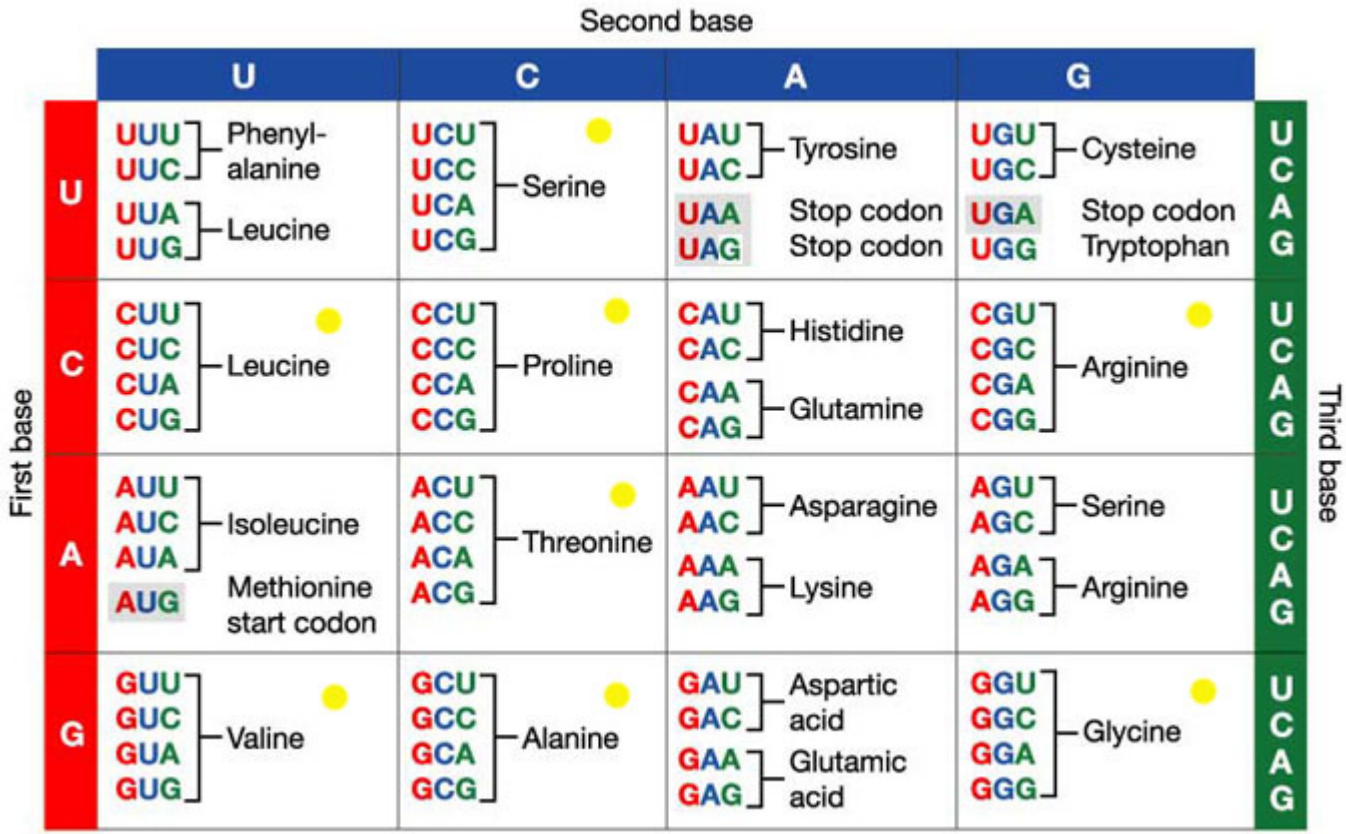
- Codon
- Reading Frame



20 amino acids in nature

Codon (nt)	Amino acid
1	4
2	16
3	64

Genetic Code



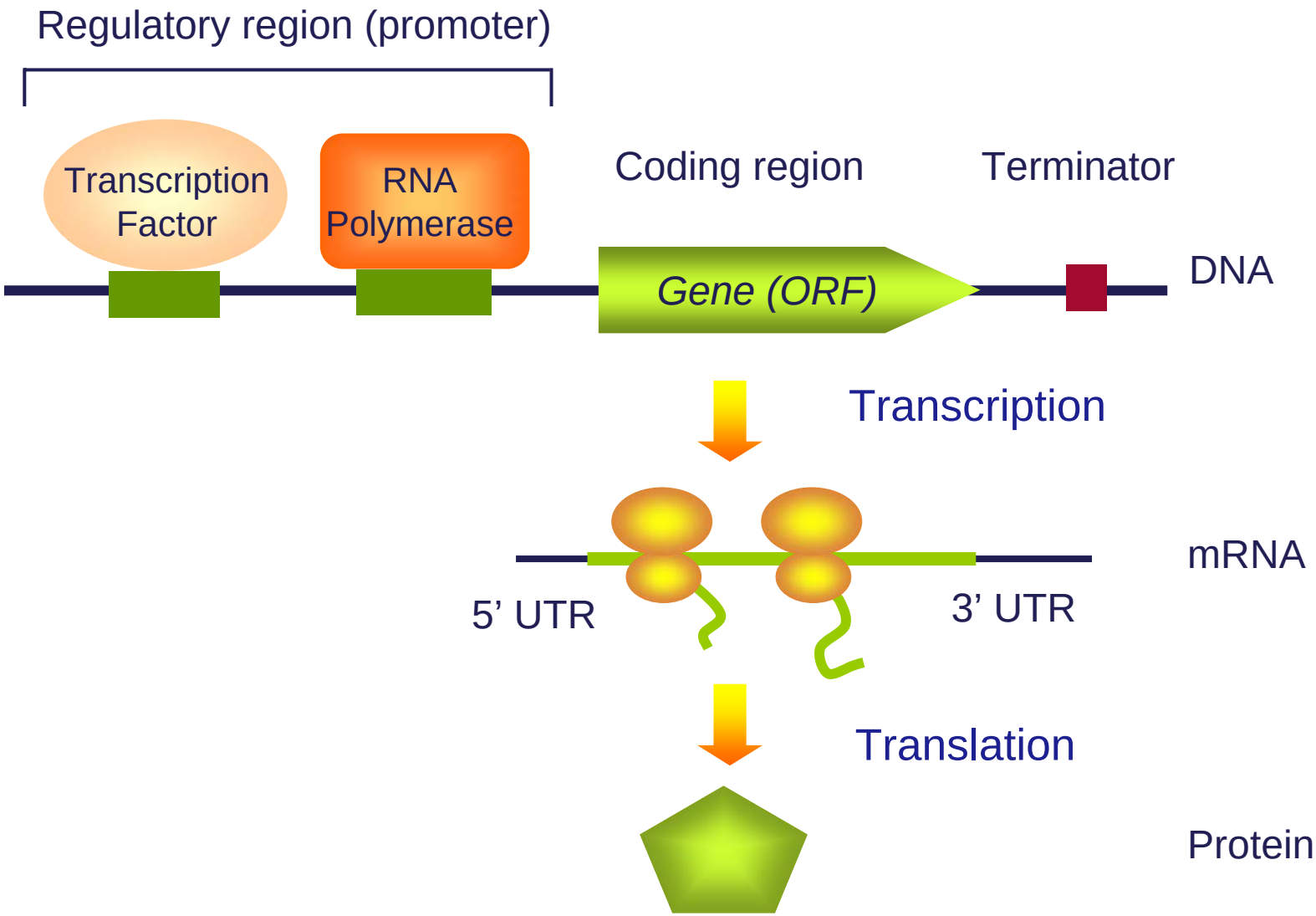
Genome

- Gene
  - The complete stretch of DNA needed to determine the amino acid sequence of a protein
- Genome
  - The complete set of genetic material in an organism
  - Human genome project
    - 1990-2003
    - U.S. department of energy and the National Institute of Health
    - 2.8 x 10^9 bp, ~30,000 genes
    - 90% is noncoding DNA

Protein Synthesis

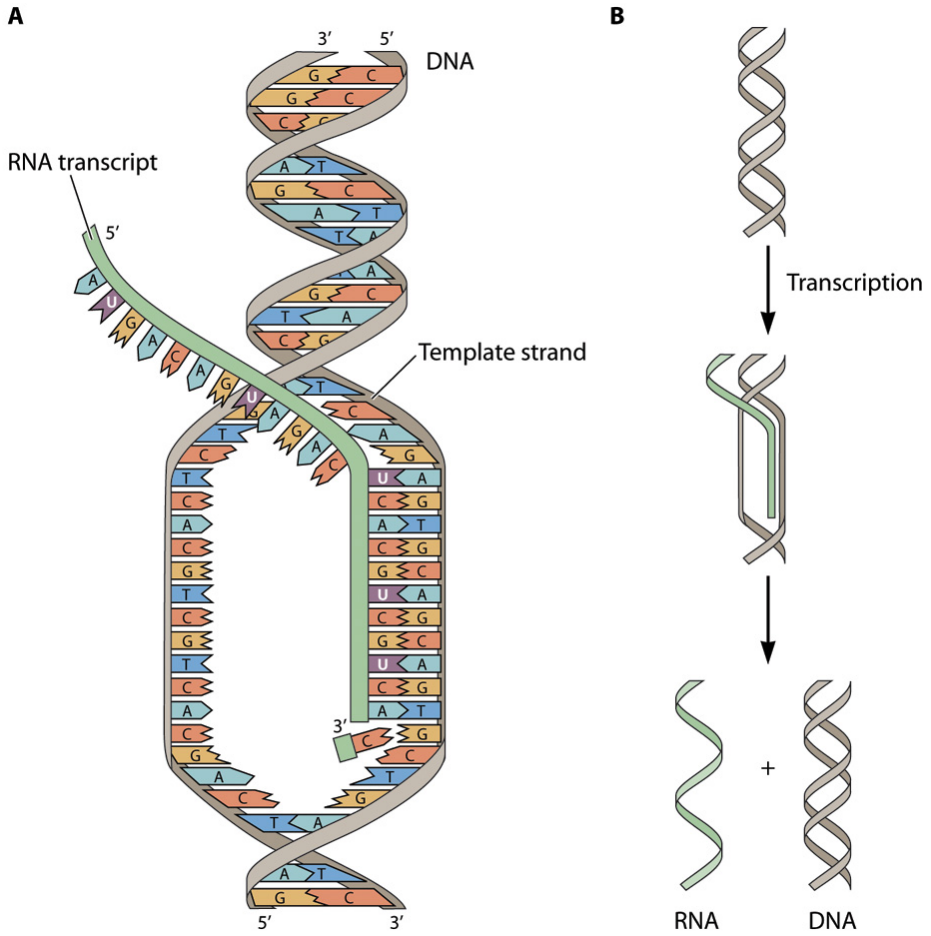
- Transcription
  - From DNA to mRNA (messenger RNA)
- Translation
  - From mRNA to protein
  - tRNA (transfer RNA) matches the condon to amino acid
  - Ribosome : Proteins + RNAs
    - Protein synthesis

Gene Expression



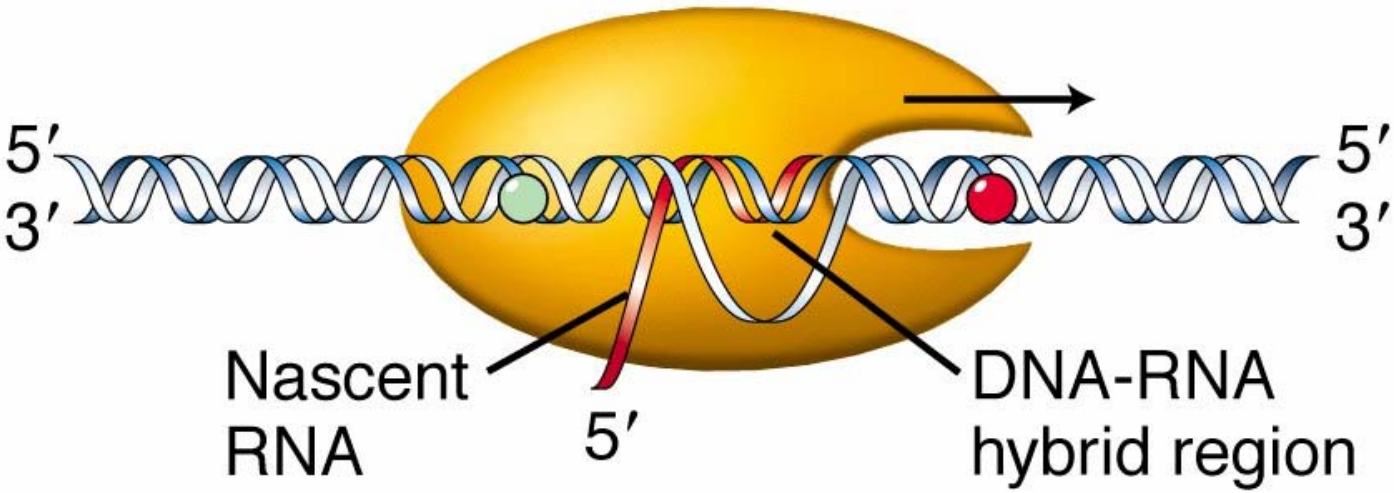
Transcription

- RNA synthesis using only one strand as a template
  - mRNA → encode protein
  - Ribosomal RNA (rRNA) and tRNA → no translation
- RNA polymerase
  - mRNA synthesis



Transcription Elongation in Prokaryote

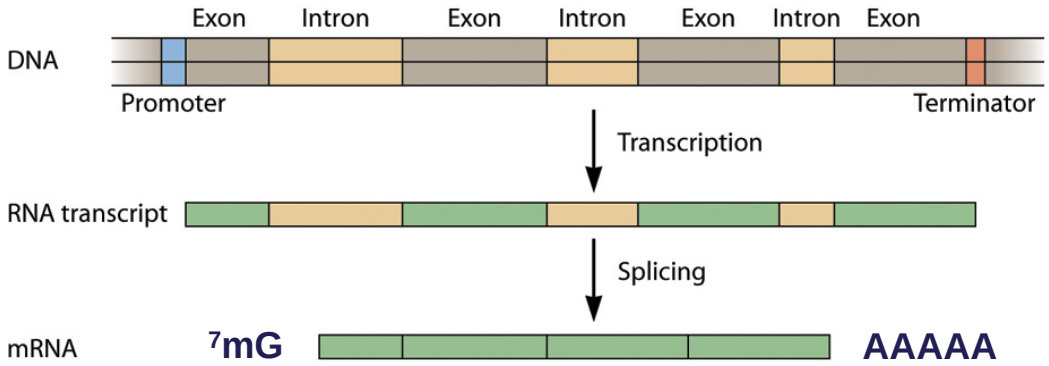
DNA unwinding: ~17 bp



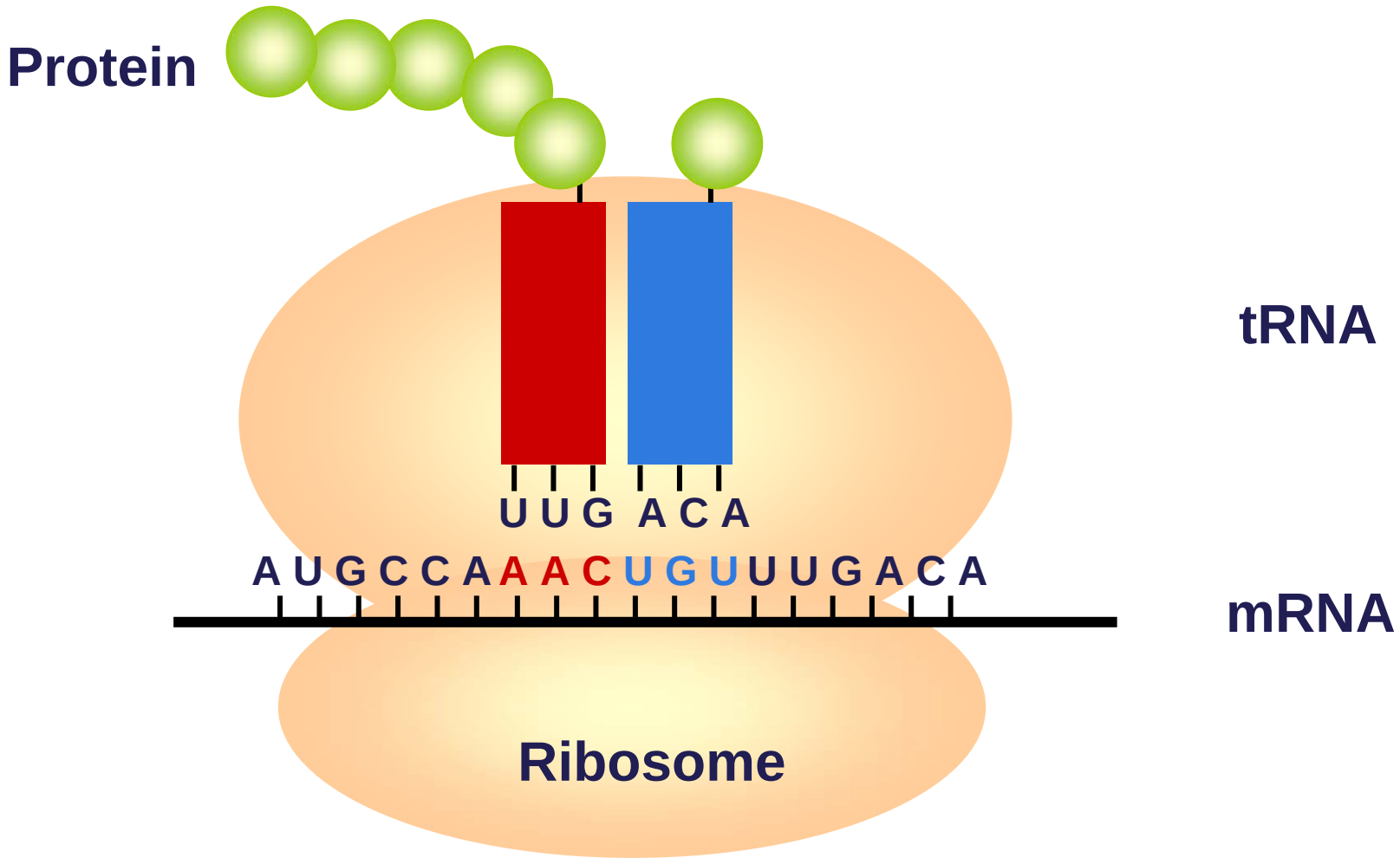
~12 bp

Regulation of Transcription

- Promoter
  - Binding site of RNA polymerase and regulatory proteins (transcriptional regulator; activator or repressor)
- Terminator
  - The site where transcription stops
- Processing of eukaryotic RNA
  - Splicing : joining of exons (coding stretch)

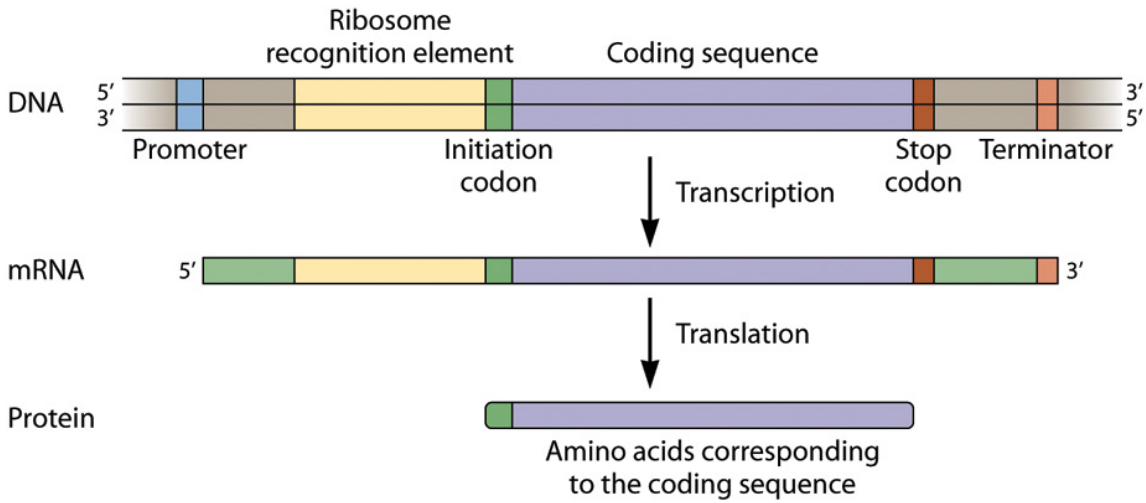


Translation



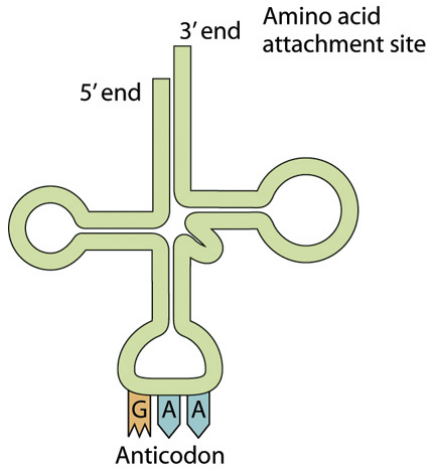
Signals for Transcription and Translation

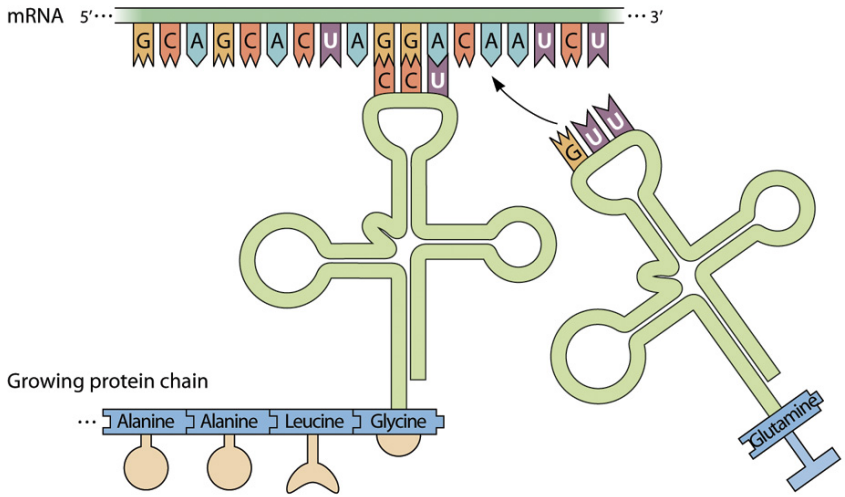
- Ribosome binding site in mRNA
  - Shine-Dalgarno Sequence
- Initiation codon
  - AUG for methionine
- Stop codon
  - UGA, UAA, UAG : no corresponding amino acid



Translation

- tRNA
  - Cloverleaves shaped folding
  - Anticodon: complementary to codon
  - 3’ end: amino acid attachment
- Translation
  - Assembly of ribosome and mRNA
  - Binding of tRNA
  - Peptide bond formation
  - Release of tRNA



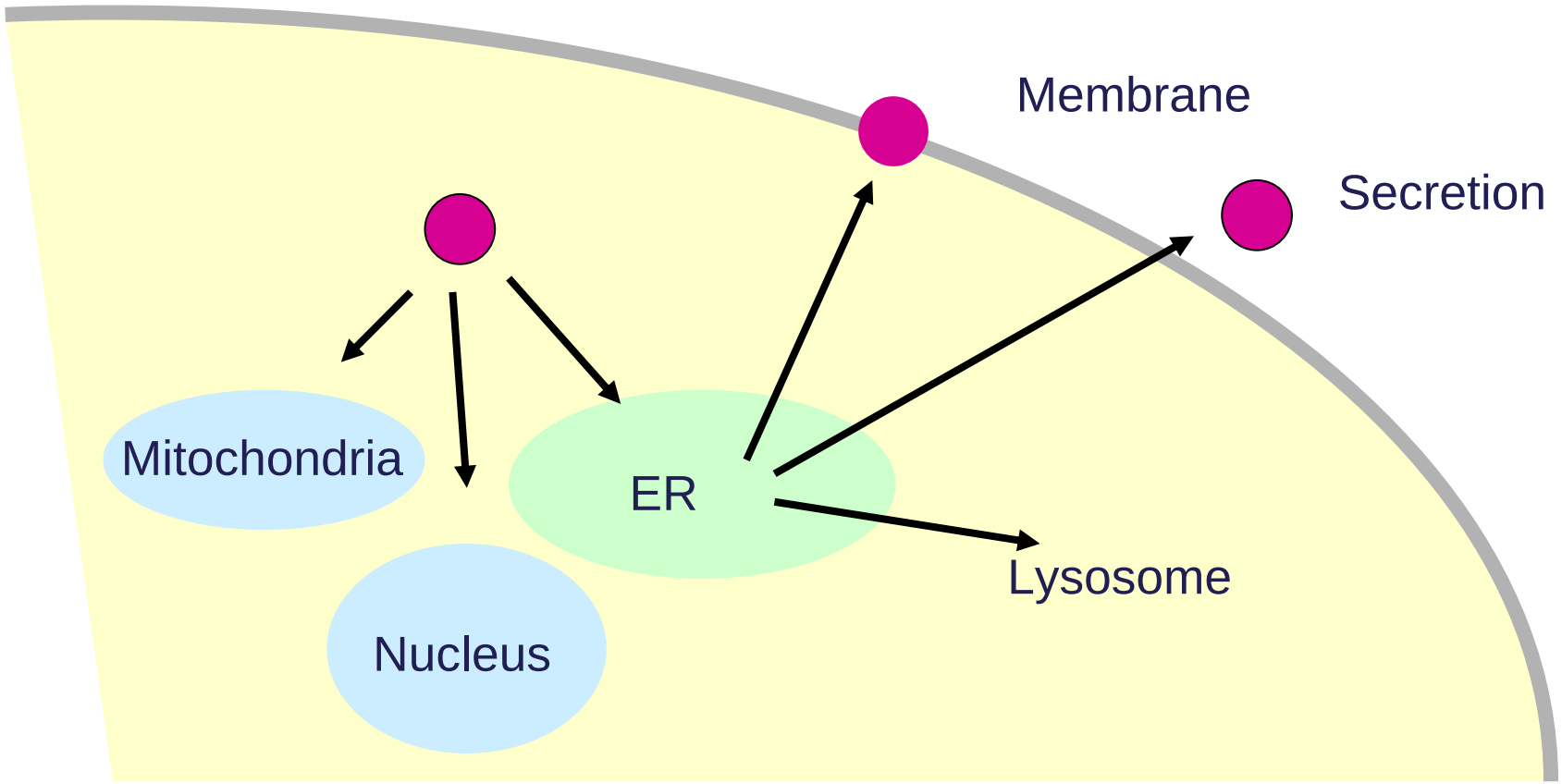


Toxins and Antibiotics

- Toxin
  - Inhibition of eukaryotic ribosome
  - Ricin: toxin produced in castor bean plant
    - Inhibition of eukaryotic ribosome by cleaving rRNA
- Antibiotics
  - Inhibition of bacterial ribosome
  - Erythromycin, azithromycin, clarithromycin
    - Preventing peptide chain elongation
  - Tetracyclin, doxycycline, minocycline tetracycline
    - Preventing proper binding of tRNA to mRNA

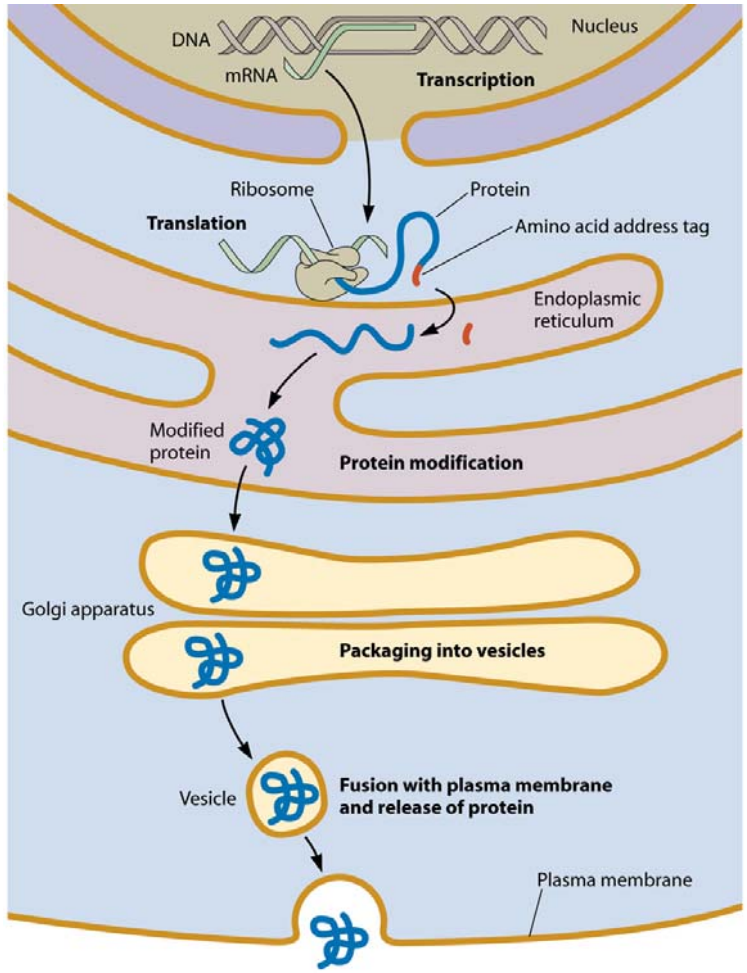
Cellular Fate of Proteins

- Protein Targeting to specific compartment (ER, Nucleus, Mitochondria) is guided by **signal peptide (tags)**



Protein Targeting to ER

- Proteins with signal peptide
  - Secretory proteins
  - Membrane proteins
  - Proteins in ER, Golgi, and lysosome
- Modification during transport from ER to Golgi apparatus
  - Glycosylation

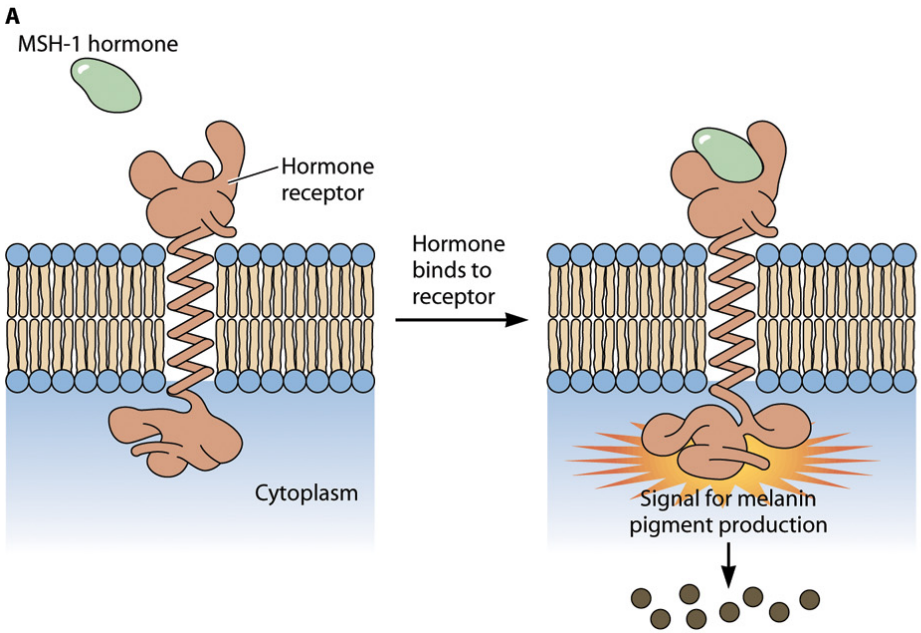


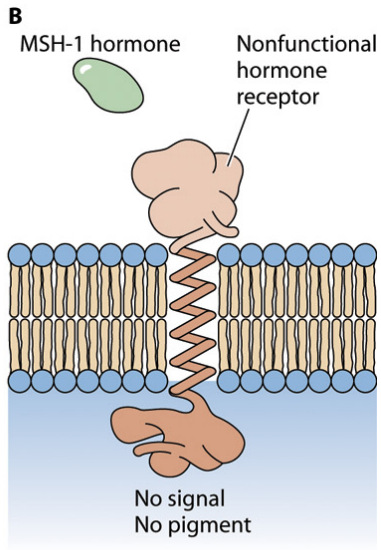
Mutations

- Mutation
  - Any change in a DNA sequence
    - During normal cellular processes
      - Error of DNA polymerase
      - Transposon
    - Environmental factors
      - DNA damage by UV, chemicals
  - Source of genetic variation and evolution
- Types of mutation
  - Silent mutation: nt change with the codon encoding the same amino acid
  - Mutations having slight effect : mutation in non-functional domain of a protein
  - Mutations affecting protein function
    - Promoter of ribosome binding sequence : no protein synthesis
    - Essential protein sequence

Mutations

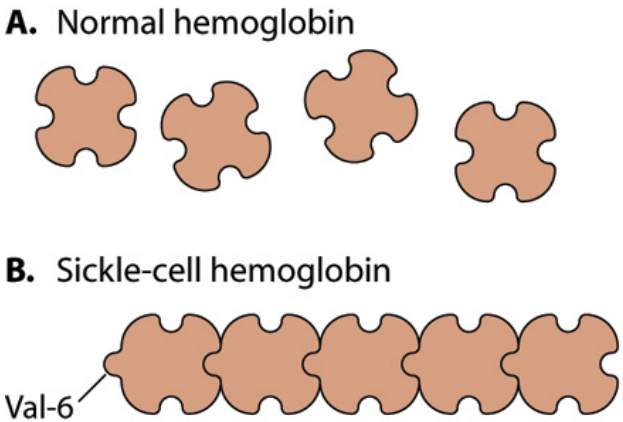
- No effect on survival
  - e.g. hair color

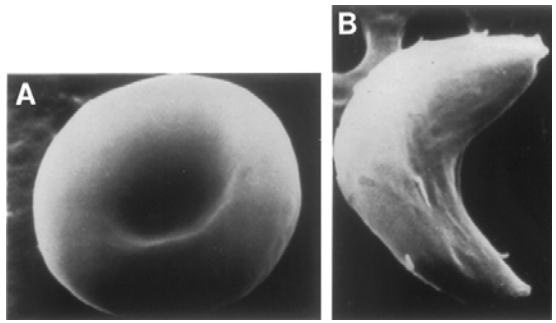




Mutations

- Harmful
  - e.g. sickle-cell anemia
    - A to T mutation of hemoglobin → 6th amino acid change from glu to val → hydrophobic aggregation of hemoglobin





Mutations

- Beneficial
  - e.g. heat-resistant enzymes
  - Depending on the environment
- Benign erythrocytosis
  - Elevated levels of RBC
  - Mutation in erythropoetin receptor (481 TGG to TAG)
  - Deletion of 70 amino acid for repression of signal transduction

  → More RBC production from bone marrow stem cells