

Chapter 4

Expression of Genetic Information



Genetic Code

- Information in DNA → amino acid sequence in protein

mRNA

5' GCA GCA CUA GGA GAG AAG 3'

- Codon: triplet of RNA bases

20 amino acids in nature

Codon (nt)

1

2

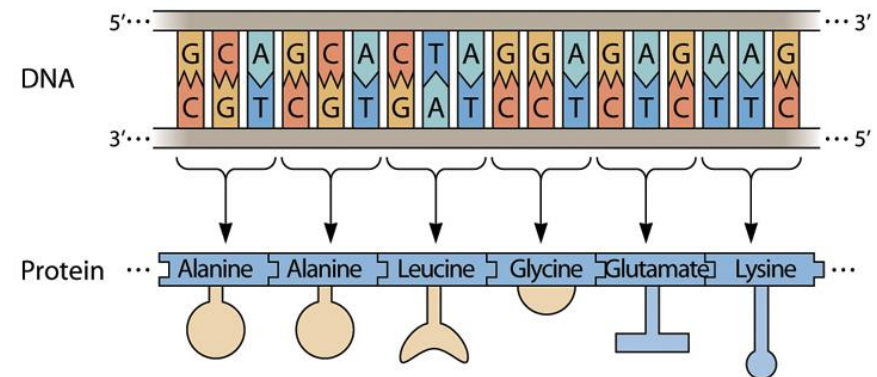
3

Amino acid

4

16

64



Genetic Code

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

Genome

- Gene

- The complete stretch of DNA needed to determine the amino acid sequence of a protein

- Genome

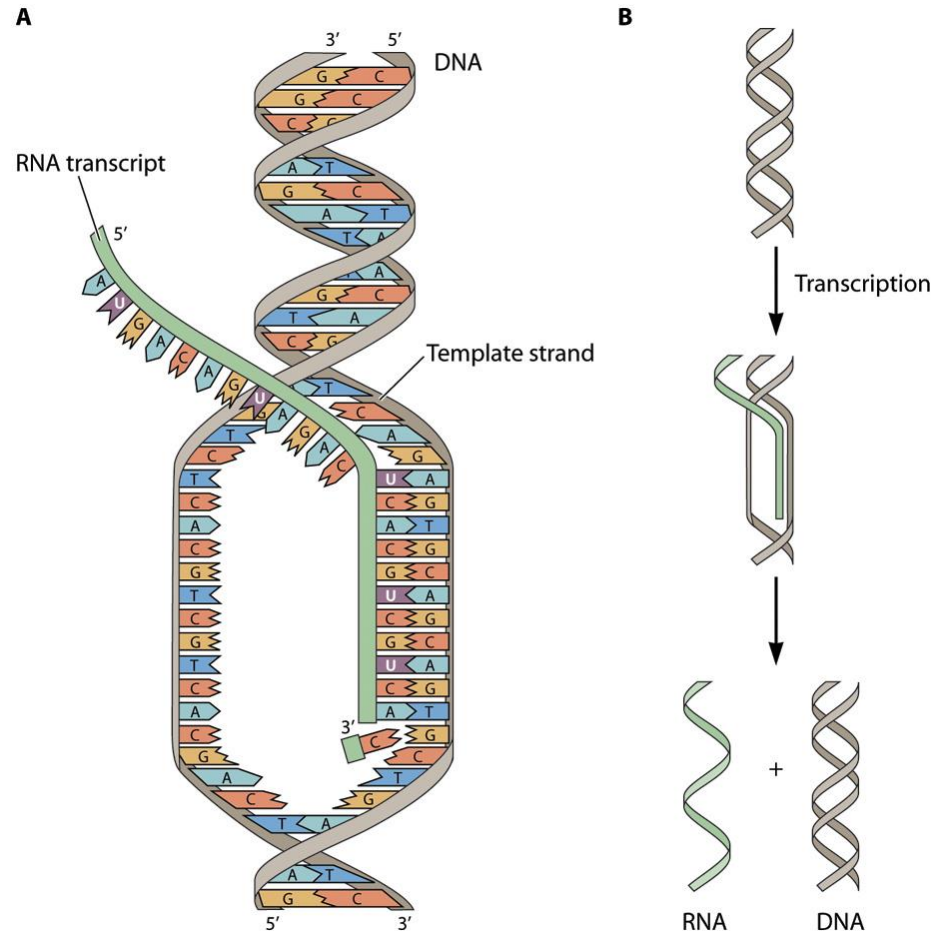
- The complete set of genetic material in an organism
- Human genome project
 - 1990-2003
 - U.S. department of energy and the National Institute of Health
 - 3.2×10^9 bp, 19,000~20,000 genes
 - 98% is noncoding DNA

Protein Synthesis

- Transcription
 - From DNA to mRNA (messenger RNA)
- Translation
 - From mRNA to protein
 - tRNA (transfer RNA) matches the codon to amino acid
 - Ribosome (made of Proteins and RNAs)
 - Protein synthesis

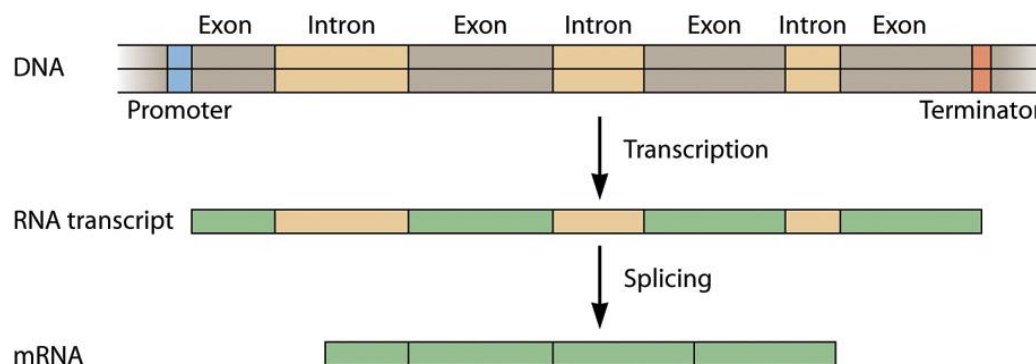
Transcription

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

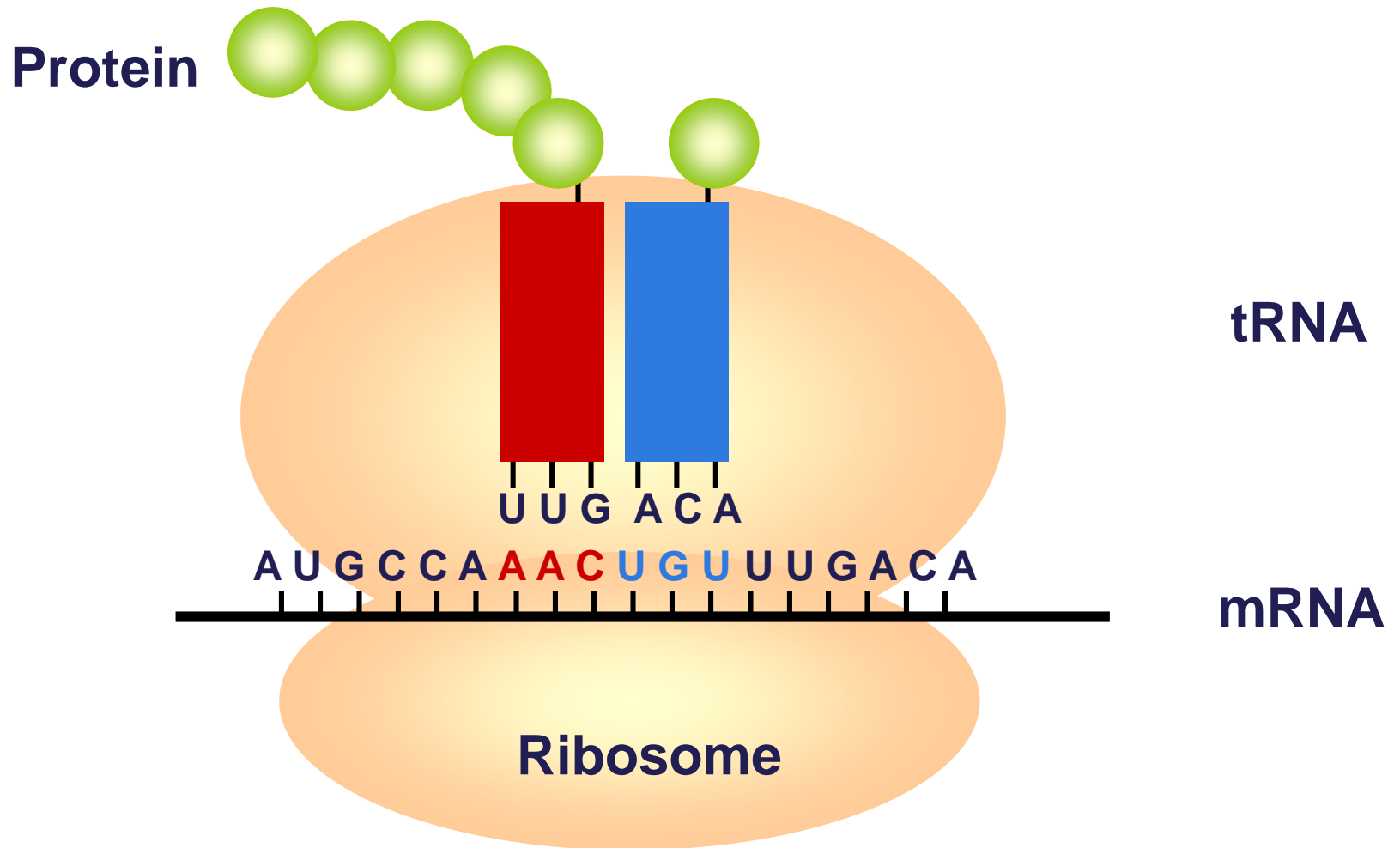


Regulation of Transcription

- 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



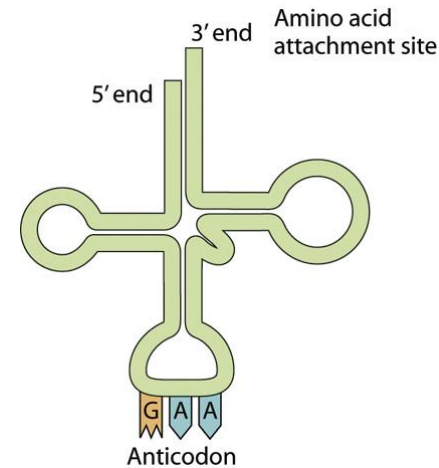
Translation



Translation

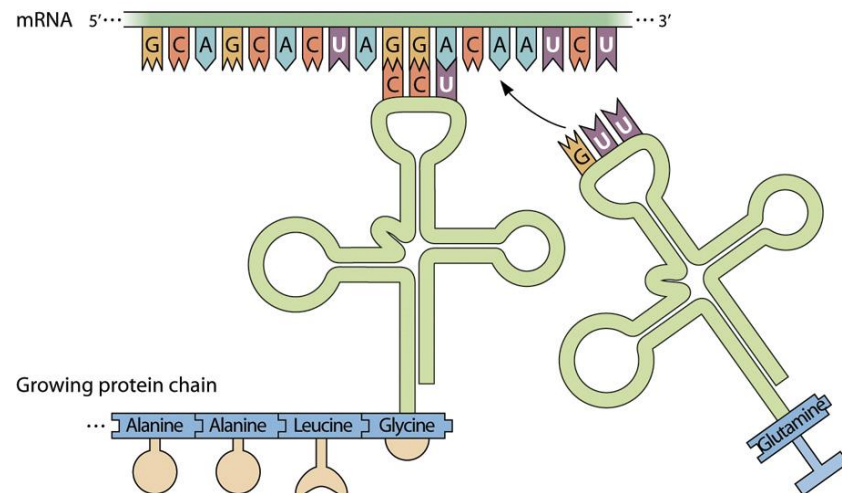
■ tRNA

- Cloverleaves shaped folding
- Anticodon: complementary to codon
- 3' end: amino acid attachment



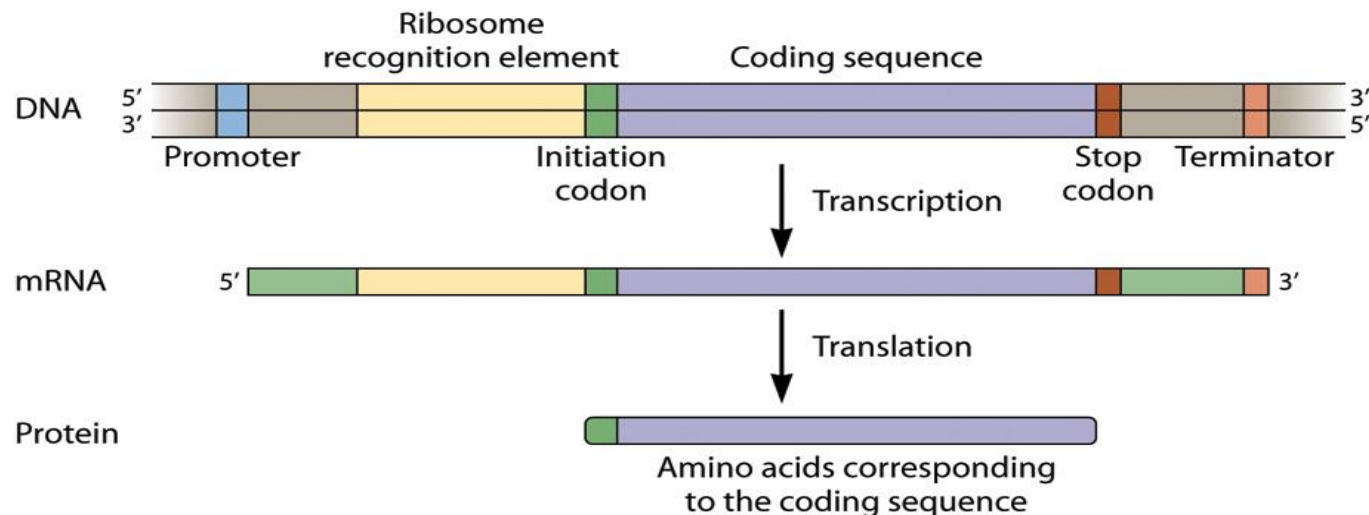
■ Translation

- Assembly of ribosome and mRNA
- Binding of tRNA
- Peptide bond formation
- Release of tRNA



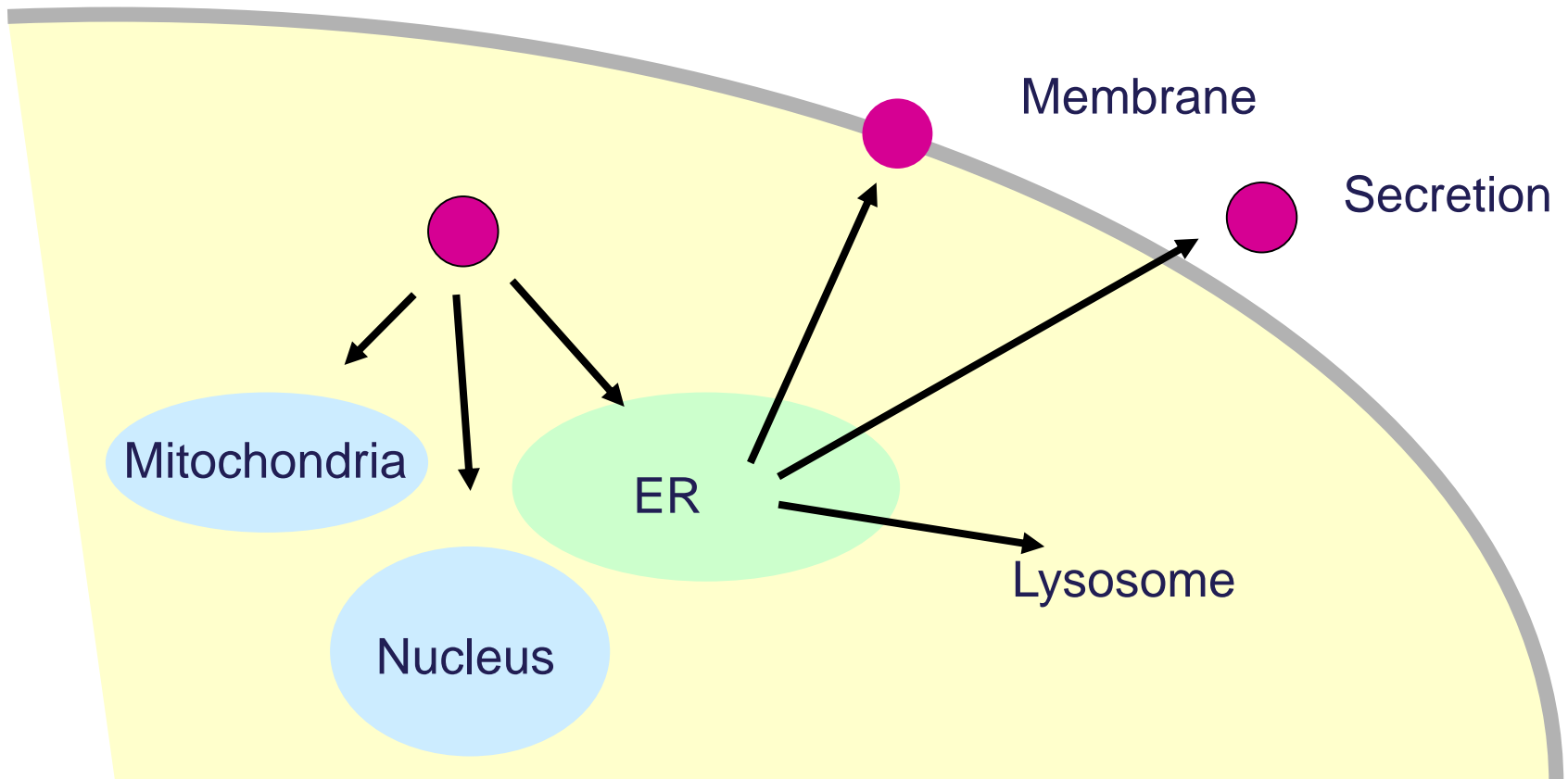
Signals for Transcription and Translation

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

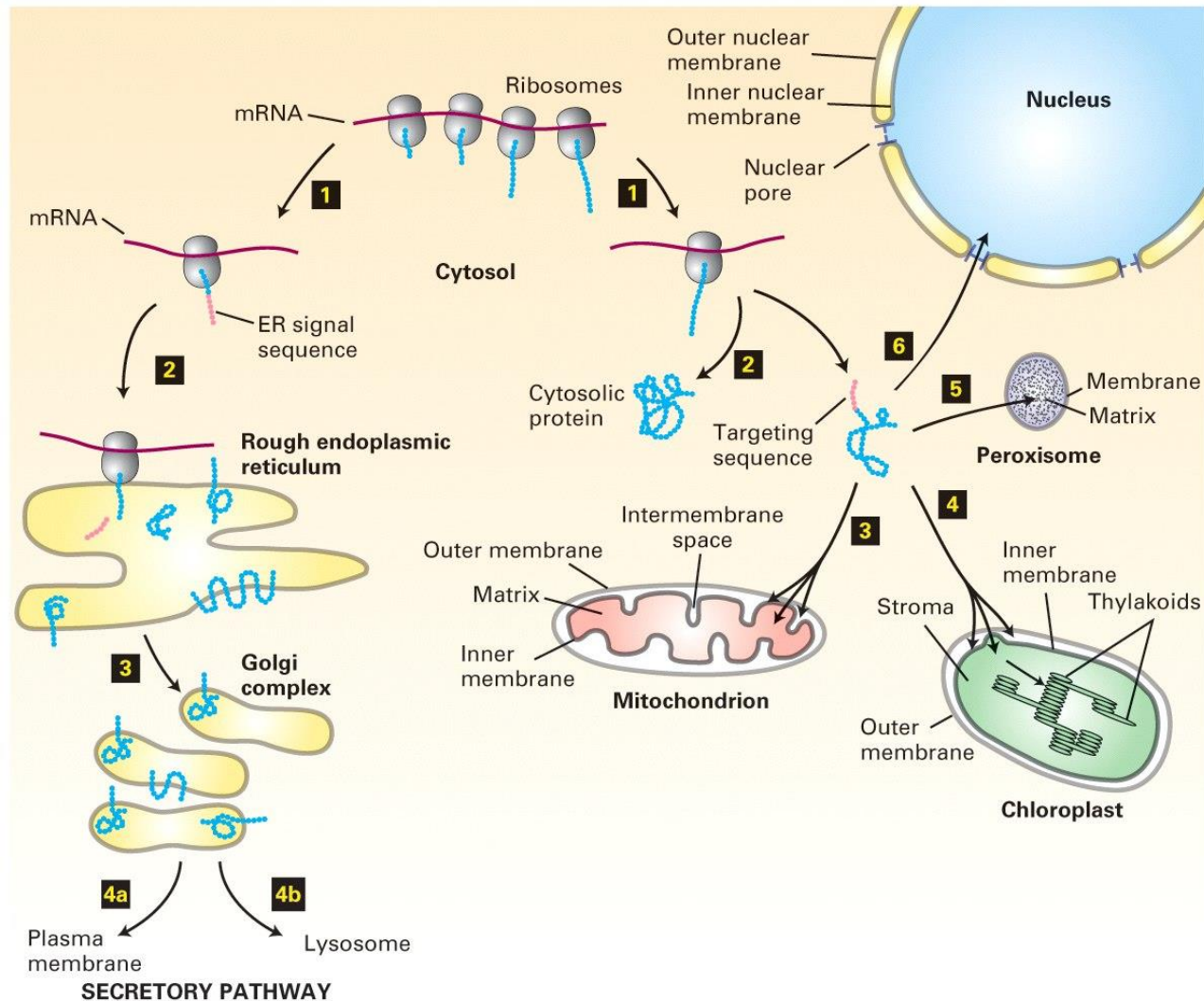


Cellular Fate of Proteins

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

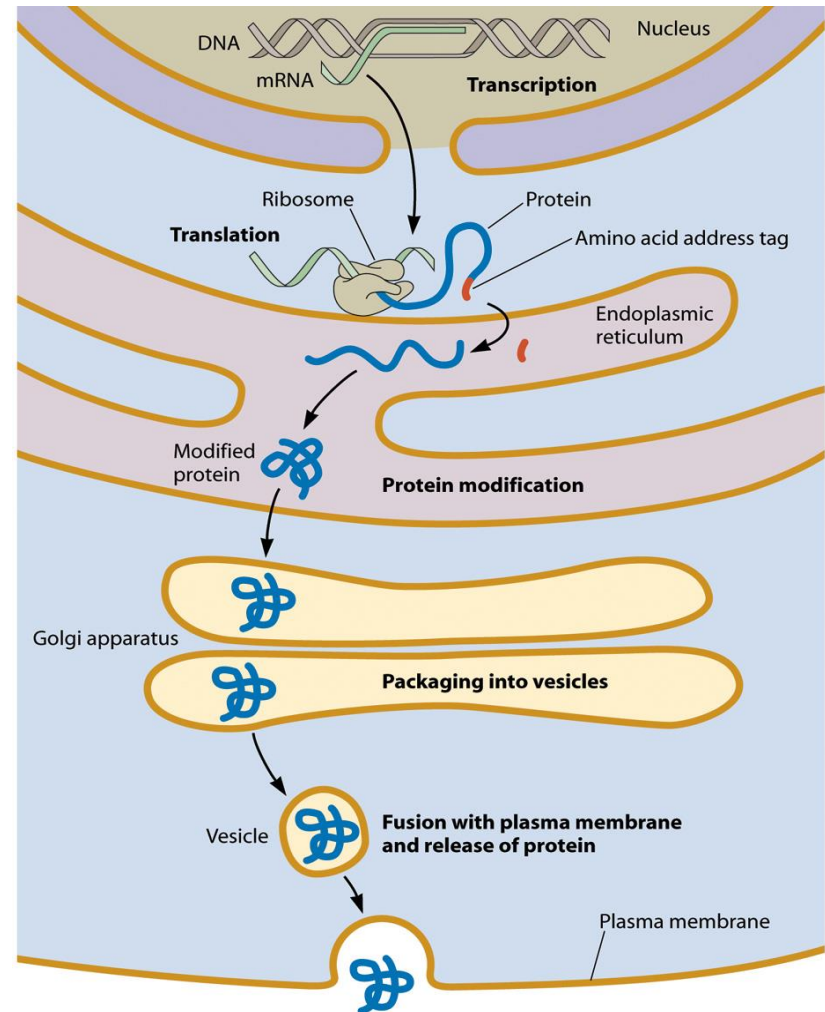


Overview of Protein Sorting Pathway



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

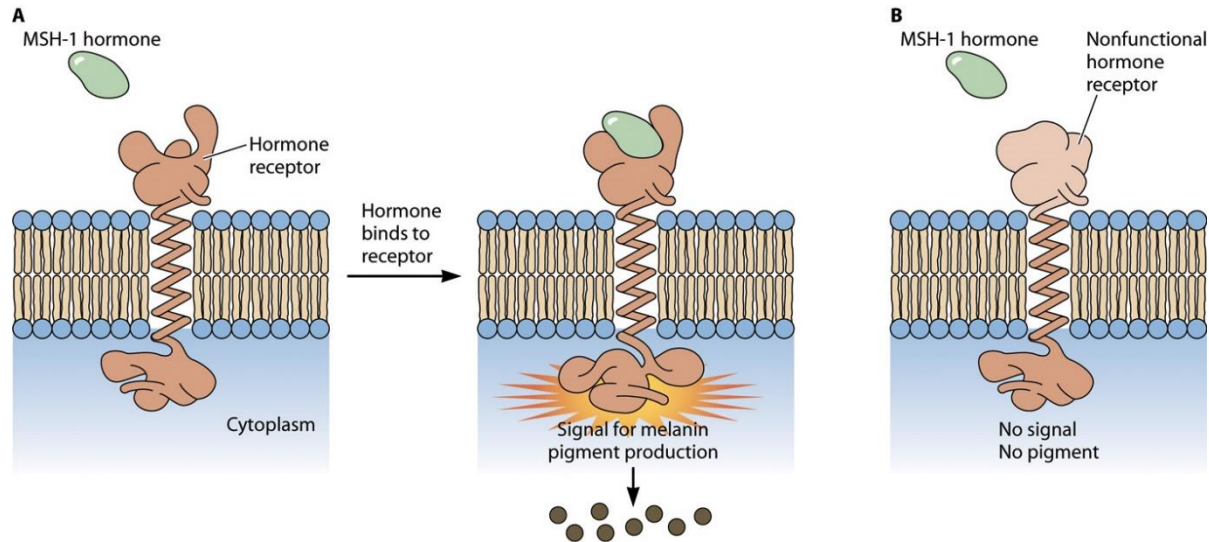
- Any change in a DNA sequence
 - During normal cellular processes
 - Error of DNA polymerase
 - Transposition (Chapter 13)
 - Environmental factors
 - DNA damage by UV or chemicals
- Source of genetic variation and evolution

■ Types of mutation

- Silent mutation: : mutation with no effect on a protein (the codon encoding the same amino acid)
- Mutations having slight effect : mutation in non-functional domain of a protein
- Mutations affecting protein function
 - Promoter or ribosome binding sequence : no protein synthesis
 - Essential protein sequence

Mutations

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



Mutations

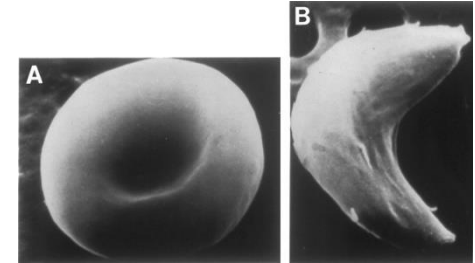
- Harmful

- e.g. sickle-cell anemia

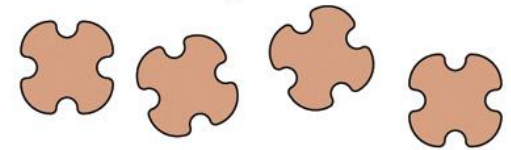
- A to T mutation of hemoglobin

- 6th amino acid change from glu to val

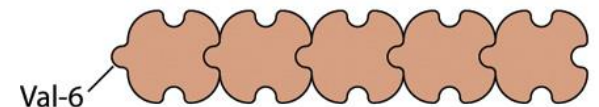
- hydrophobic aggregation of hemoglobin



A. Normal hemoglobin



B. Sickle-cell hemoglobin

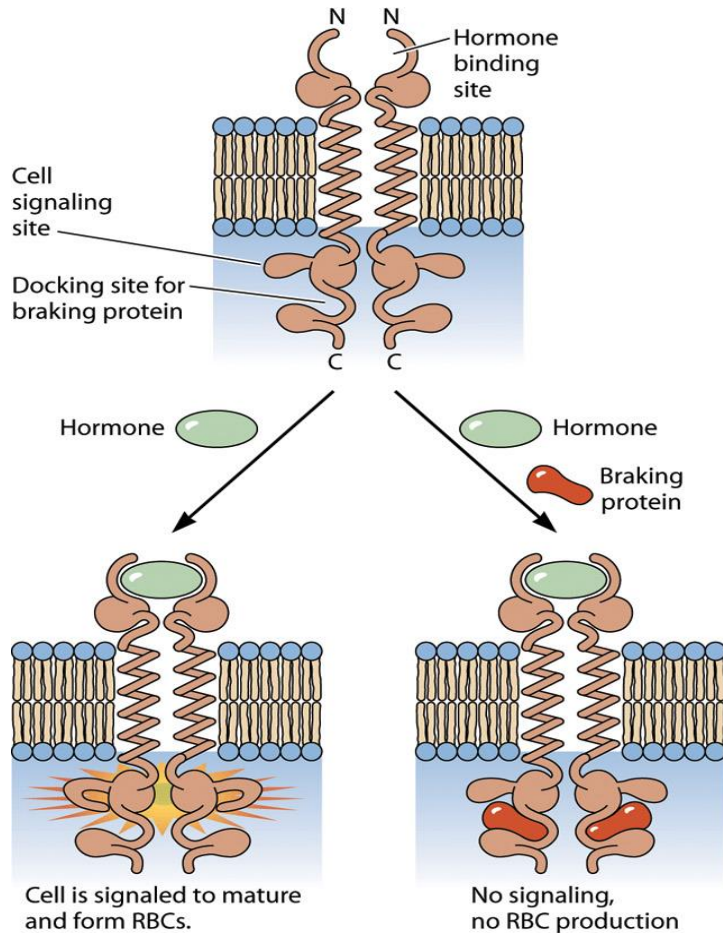


Mutations

- Benign erythrocytosis
 - Elevated levels of RBC
 - Mutation in erythropoietin receptor
 - 481 TGG to TAG (stop codon)
 - Deletion of 70 amino acids for repression of signal transduction
 - More RBC production from bone marrow stem cells
 - Greatly enhanced stamina
- (Finnish athlete Eero Mäntyranta won three gold medals for cross-country skiing in the 1964 Winter Olympics)

Mutations

A. Normal receptor protein



B. Mutant receptor protein

