Lecture for Wednesday

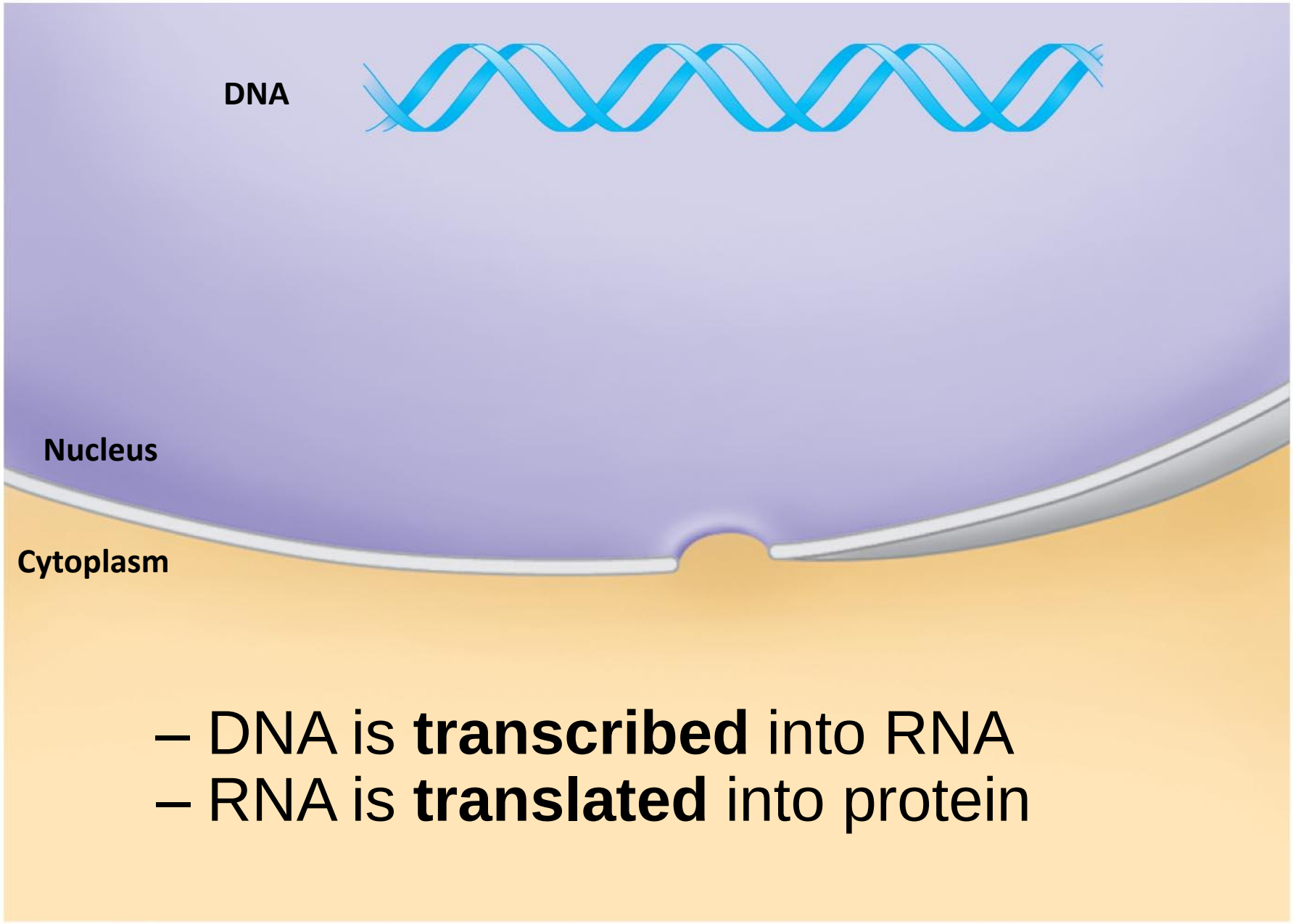
Dr. Prince

BIOL 1408

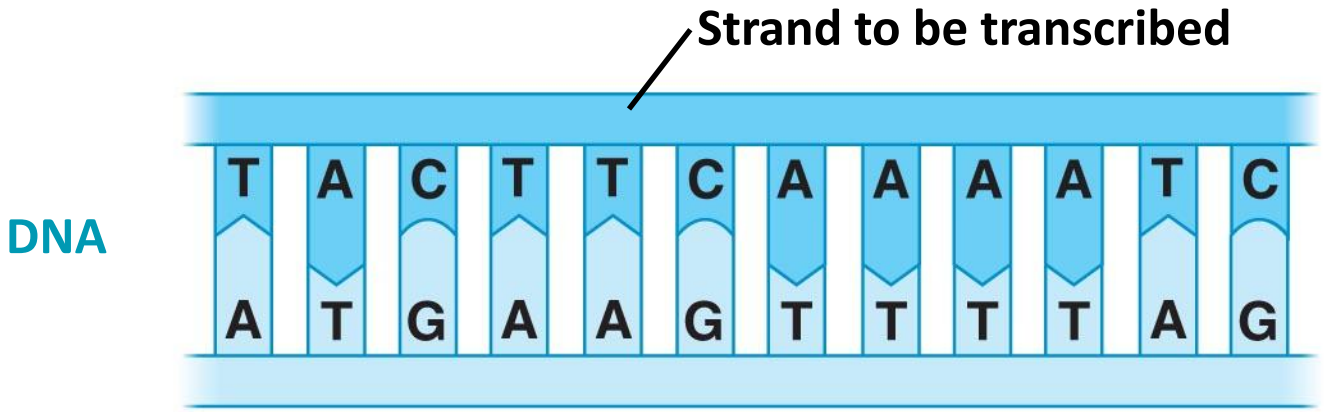
THE FLOW OF GENETIC INFORMATION FROM DNA TO RNA TO PROTEIN

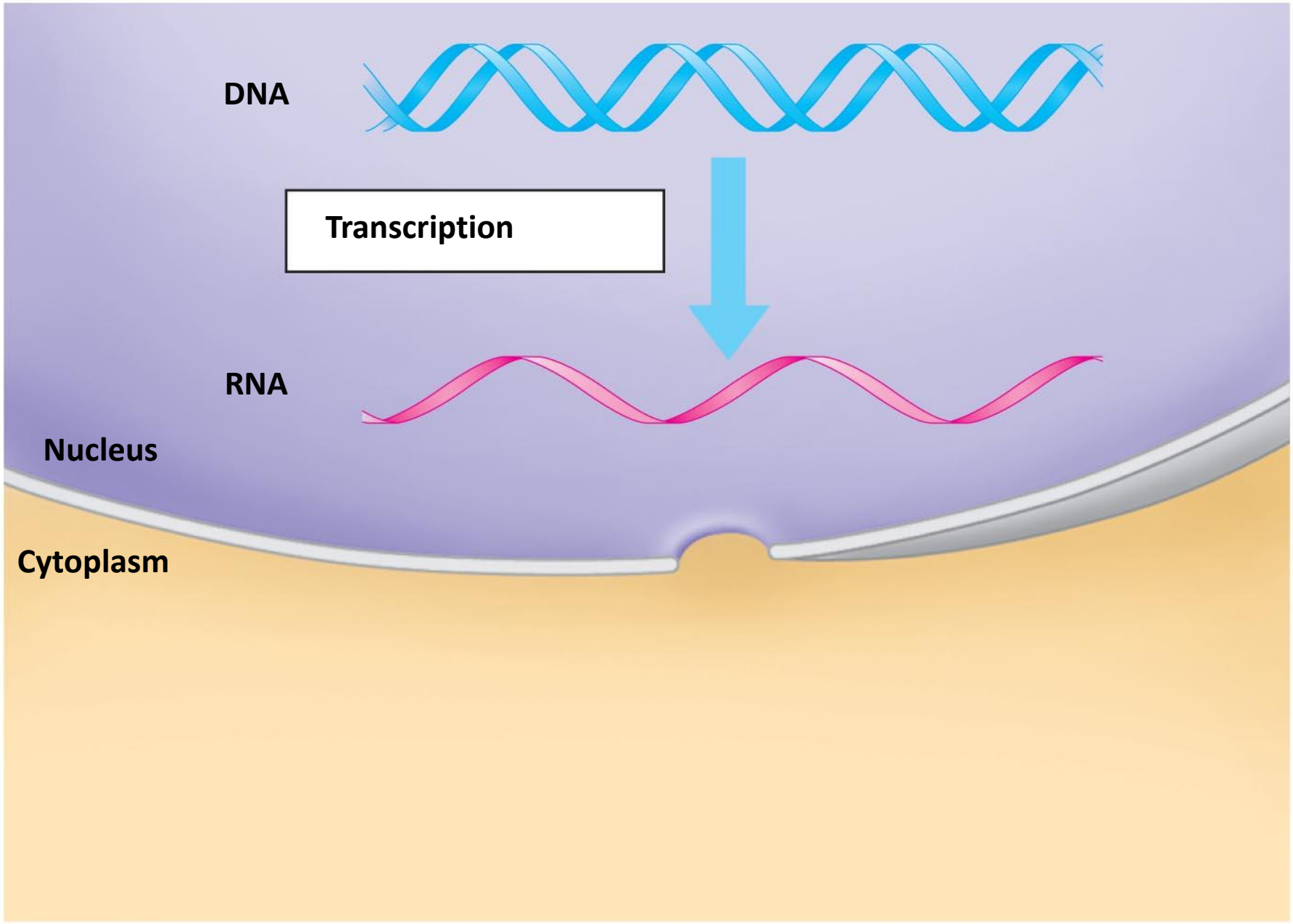
Genes are expressed as proteins

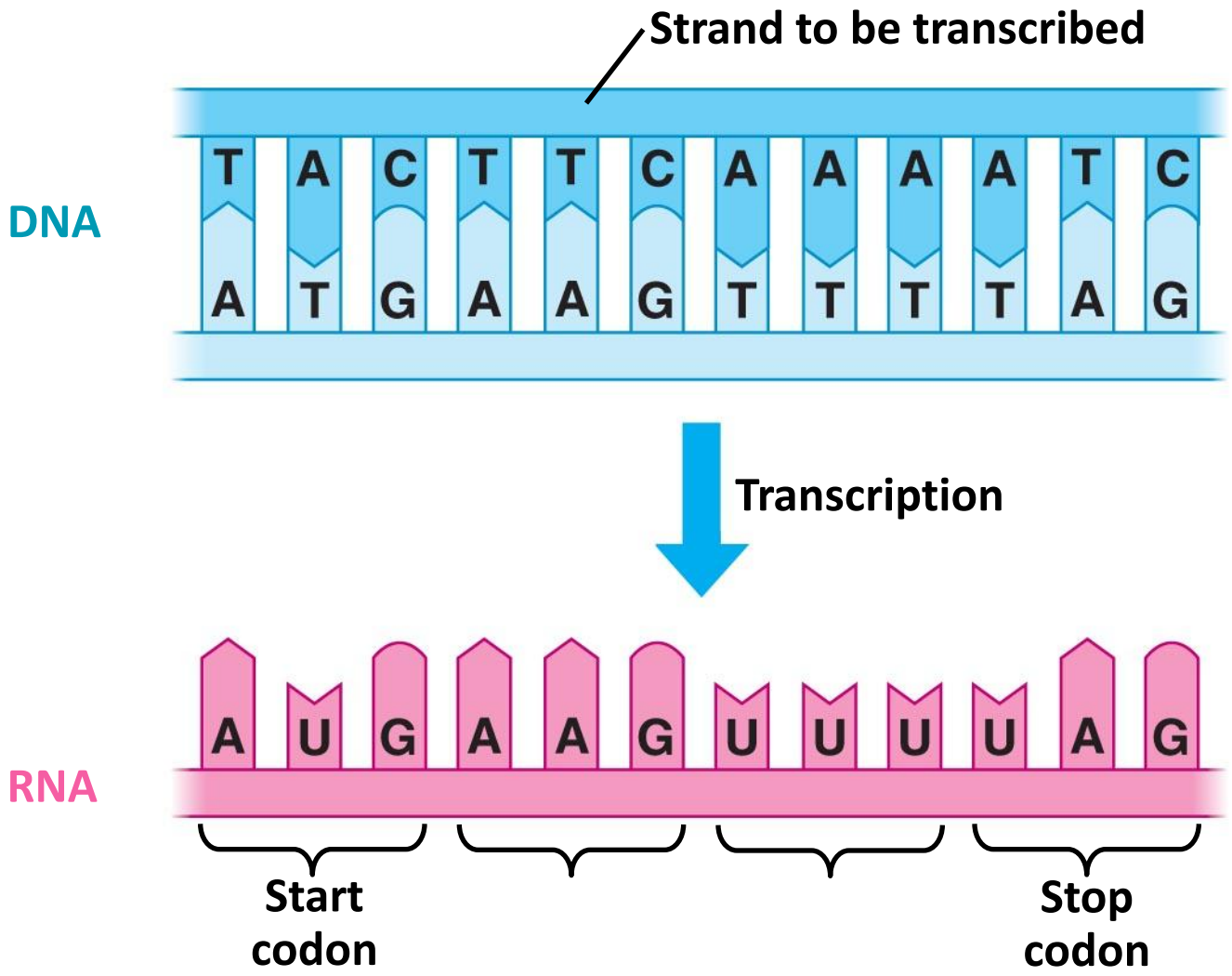
- A gene is a segment of DNA that contains the instructions for the synthesis of a specific protein
  - It is these proteins that ultimately determine the phenotype of an organism
  - **The one gene–one enzyme hypothesis** was based on studies of inherited metabolic diseases
  - **The one gene–one protein hypothesis** expands the relationship to proteins other than enzymes
  - **The one gene–one polypeptide hypothesis** recognizes that some proteins are composed of multiple polypeptides

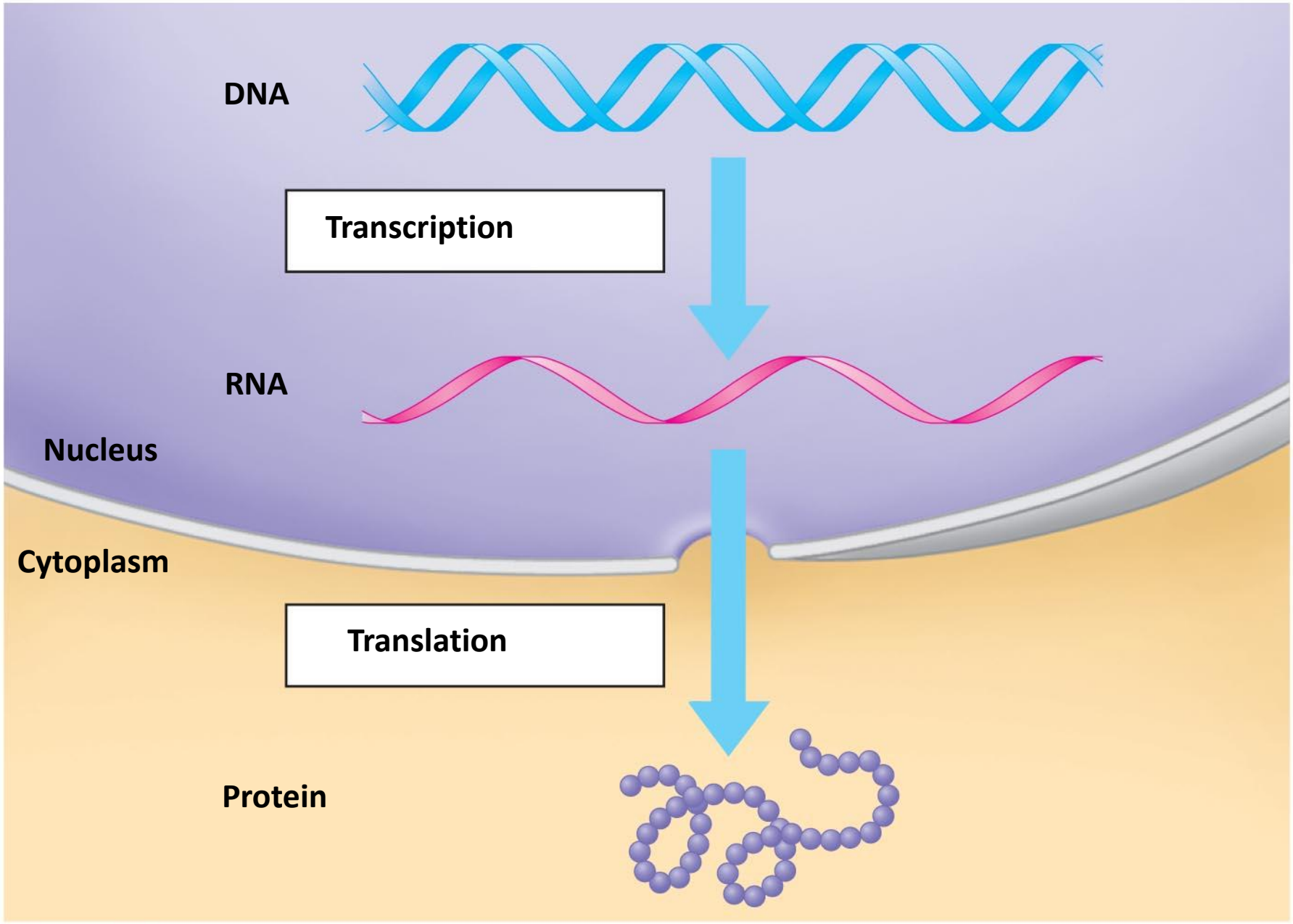


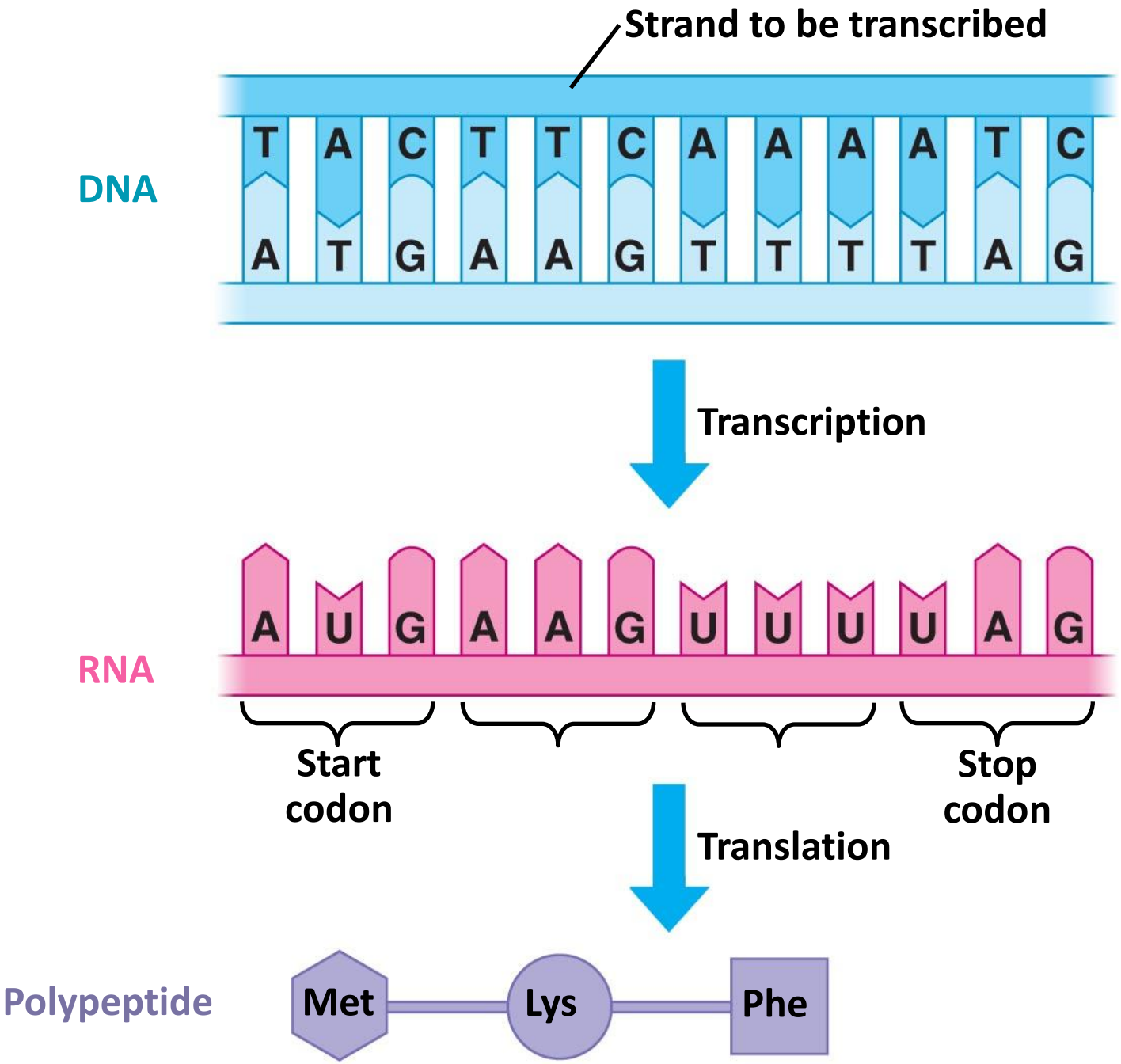
– DNA is **transcribed** into RNA
– RNA is **translated** into protein



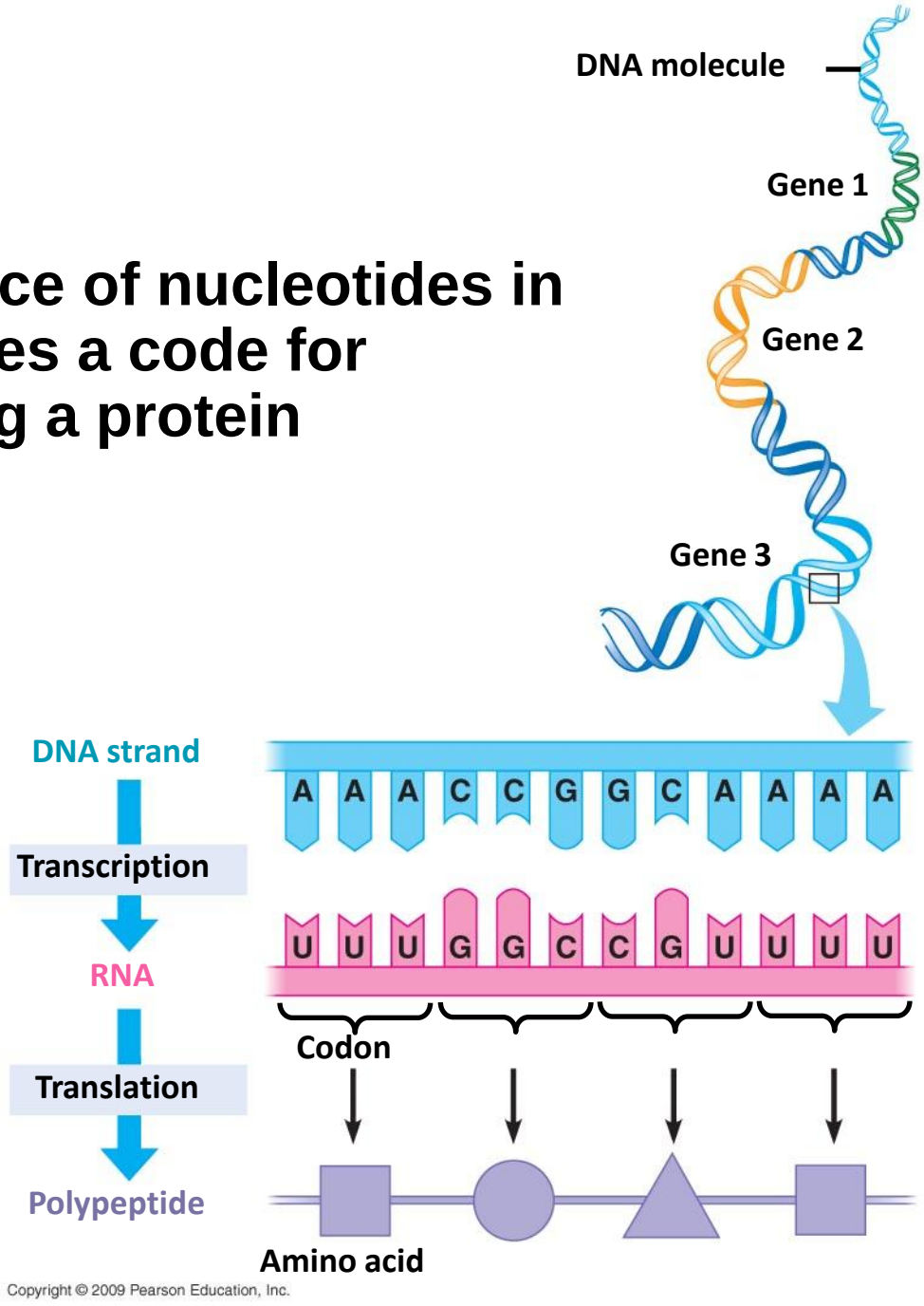






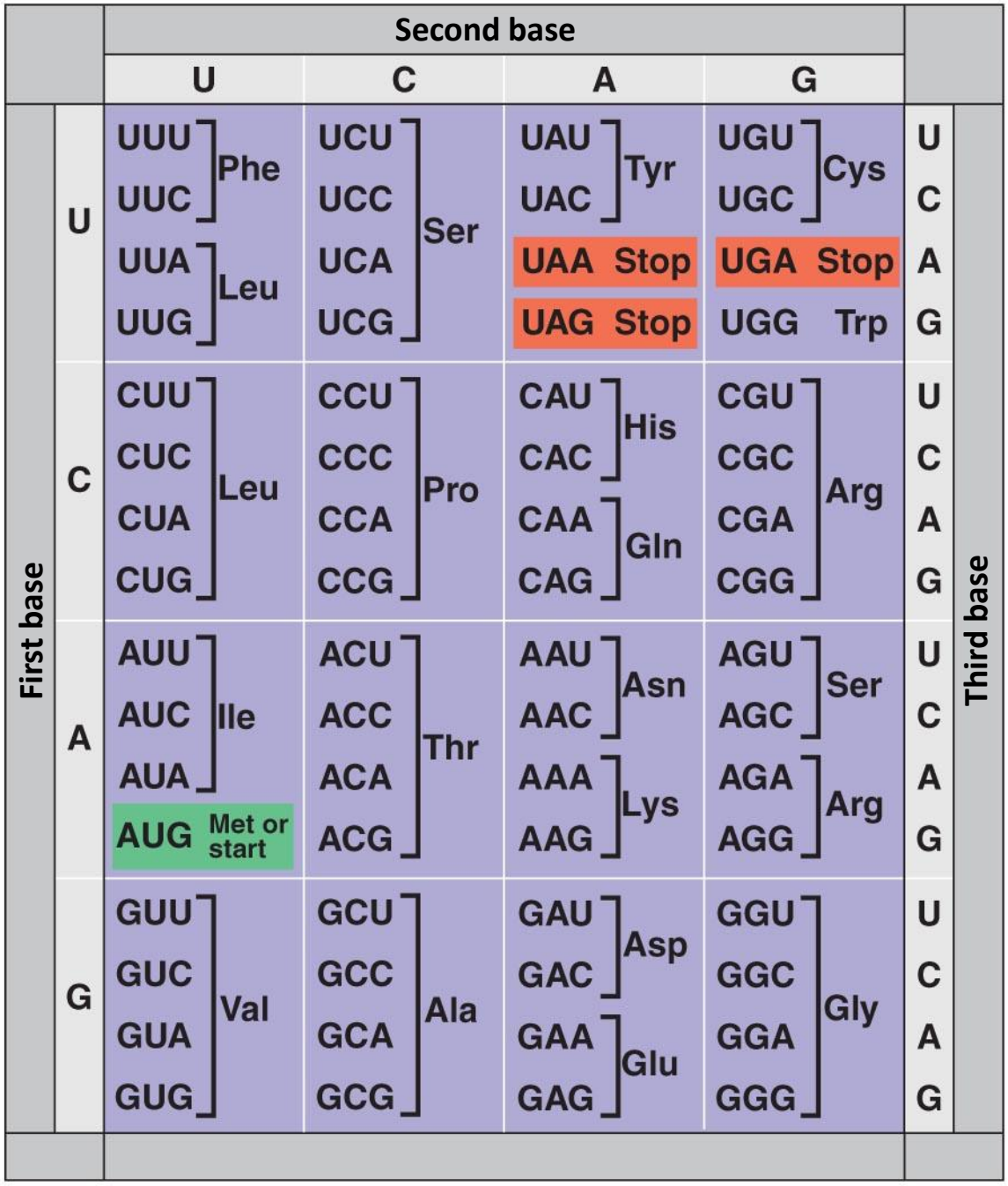


The sequence of nucleotides in DNA provides a code for constructing a protein



10.8 The genetic code is the Rosetta stone of life

- Characteristics of the **genetic code**
  - Triplet: Three nucleotides specify one amino acid
    - 61 codons correspond to amino acids
    - AUG codes for methionine and signals the start of transcription
    - 3 “stop” codons signal the end of translation
  - Redundant: More than one codon for some amino acids
  - Unambiguous: Any codon for one amino acid does not code for any other amino acid
  - Does not contain spacers or punctuation: Codons are adjacent to each other with no gaps in between
  - Nearly universal

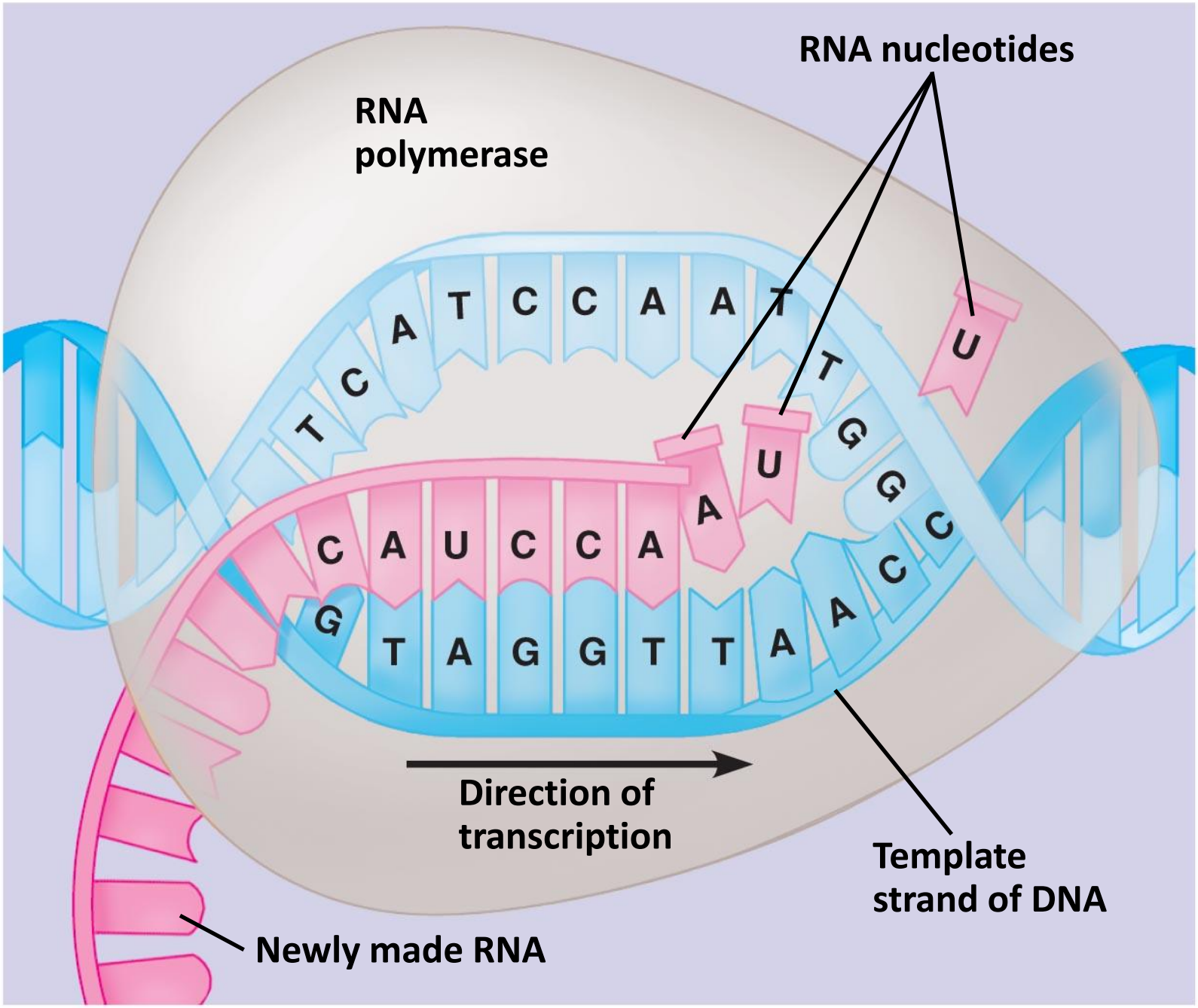


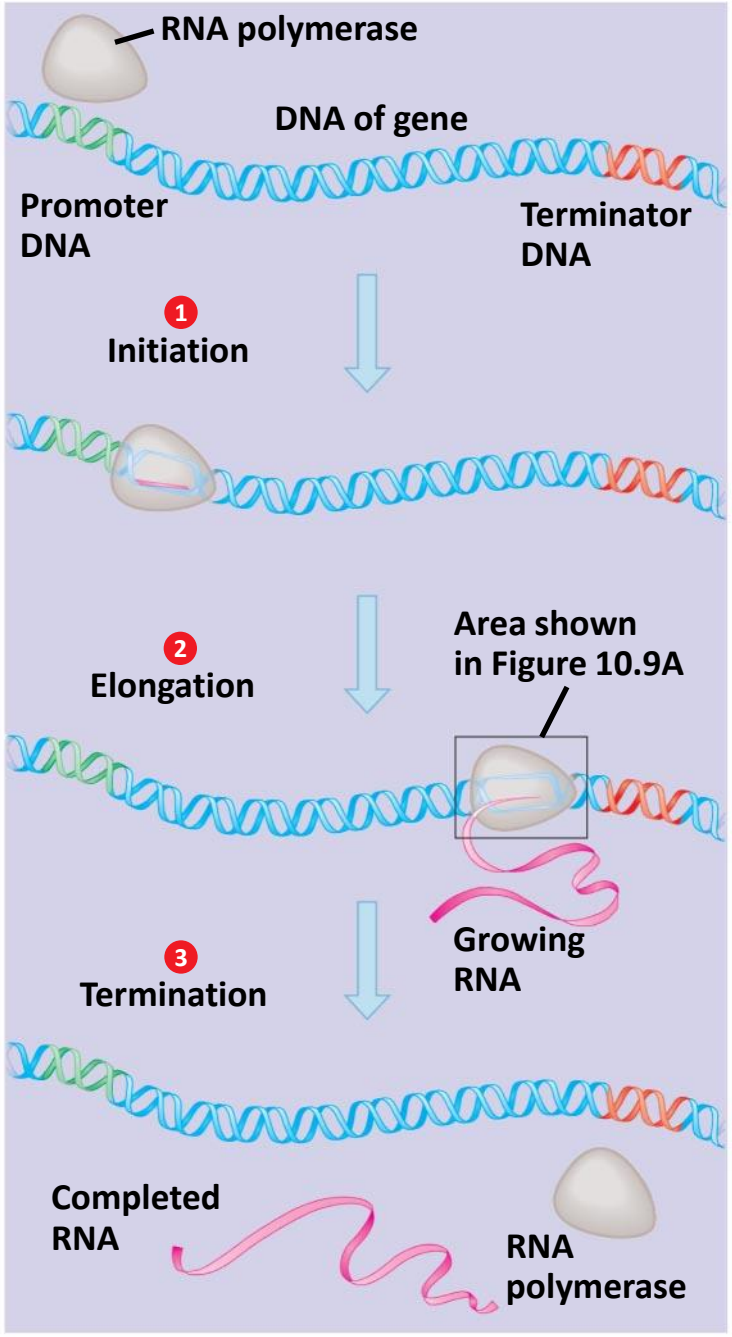
10.9 Transcription produces genetic messages in the form of RNA

- Overview of transcription
  - The two DNA strands separate
  - One strand is used as a pattern to produce an RNA chain, using specific base pairing
    - For A in DNA, U is placed in RNA
  - **RNA polymerase** catalyzes the reaction

10.9 Transcription produces genetic messages in the form of RNA

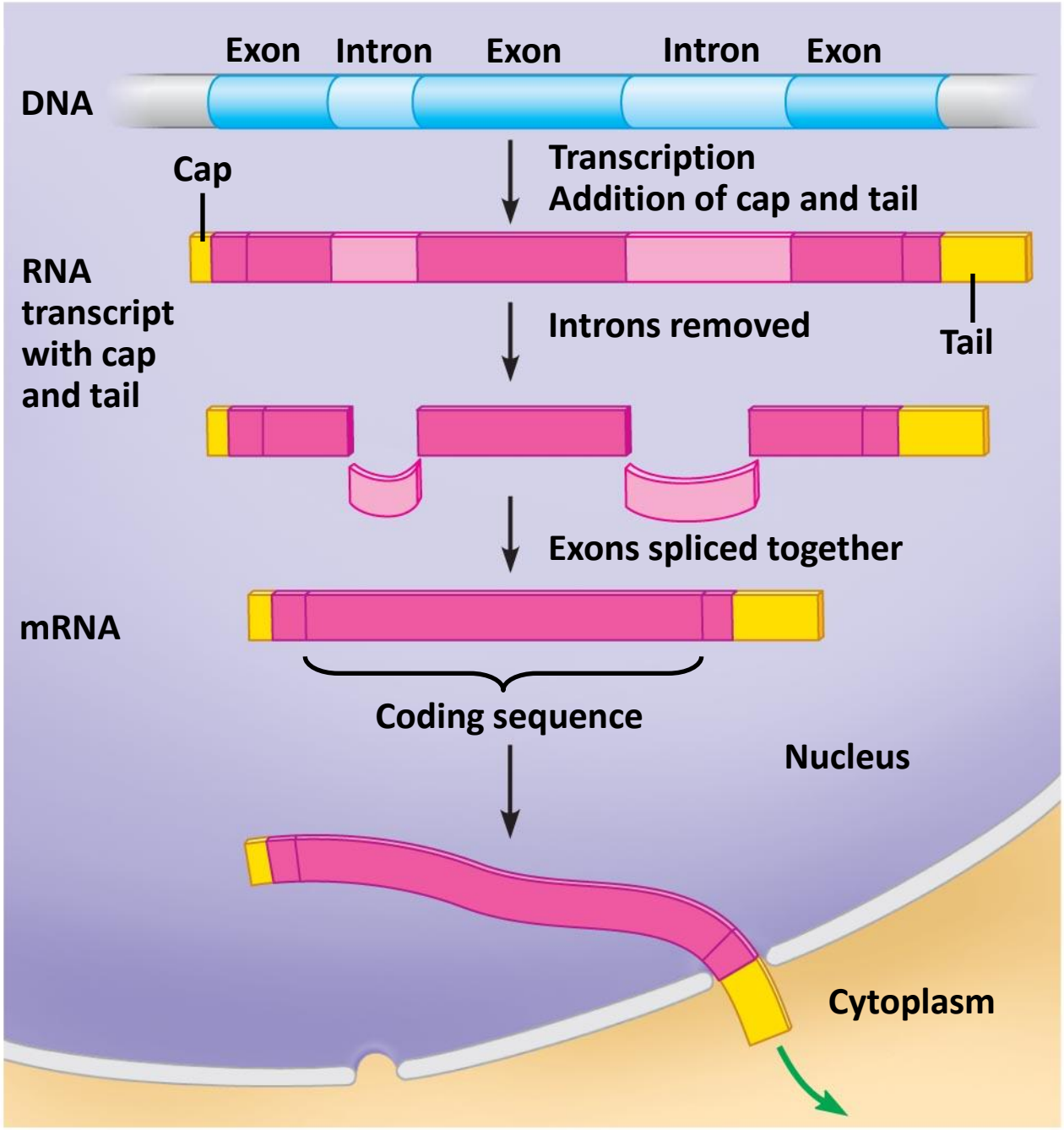
- Stages of transcription
  - Initiation: RNA polymerase binds to a **promoter**, where the helix unwinds and transcription starts
  - Elongation: RNA nucleotides are added to the chain
  - Termination: RNA polymerase reaches a **terminator** sequence and detaches from the template





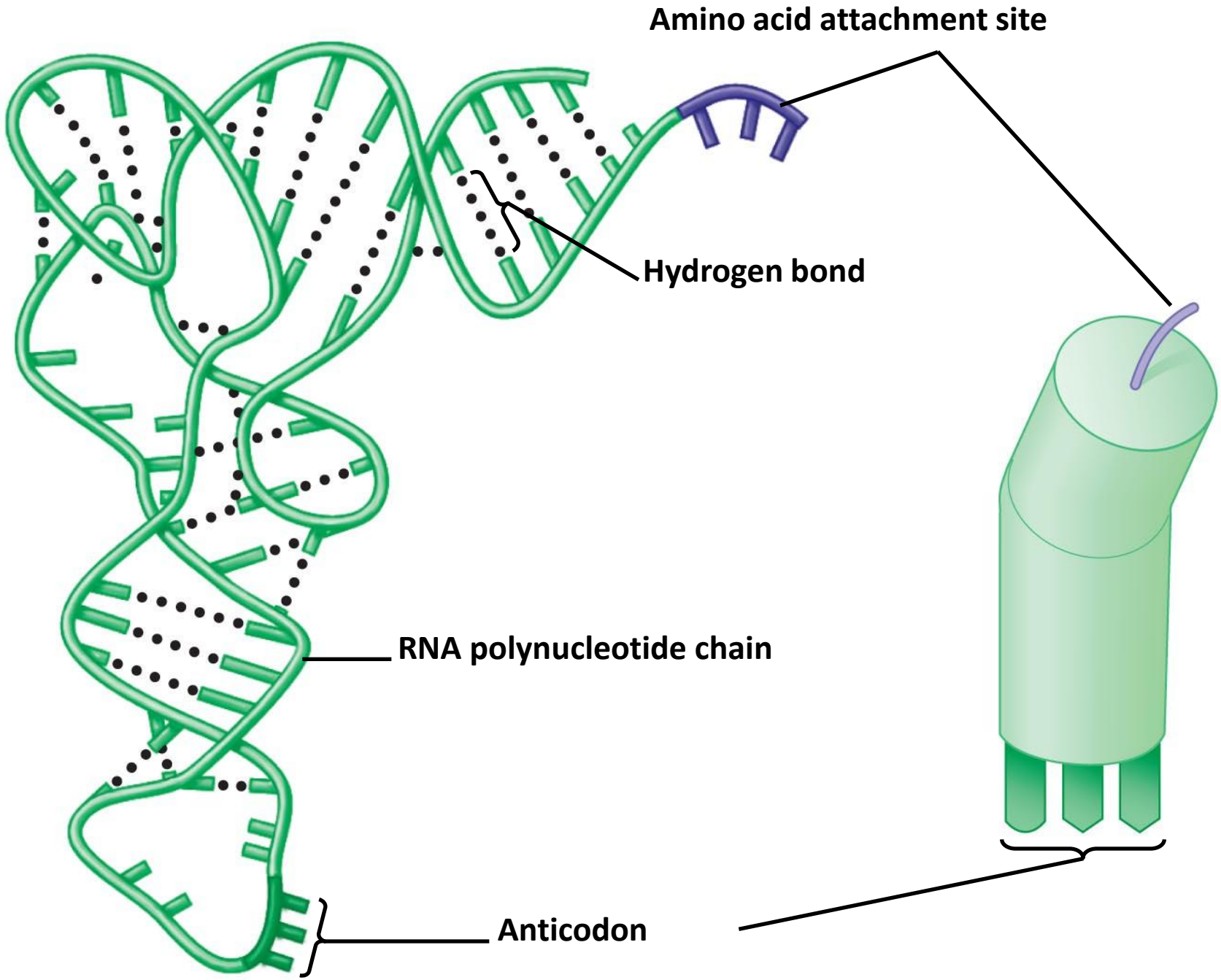
10.10 Eukaryotic RNA is processed before leaving the nucleus

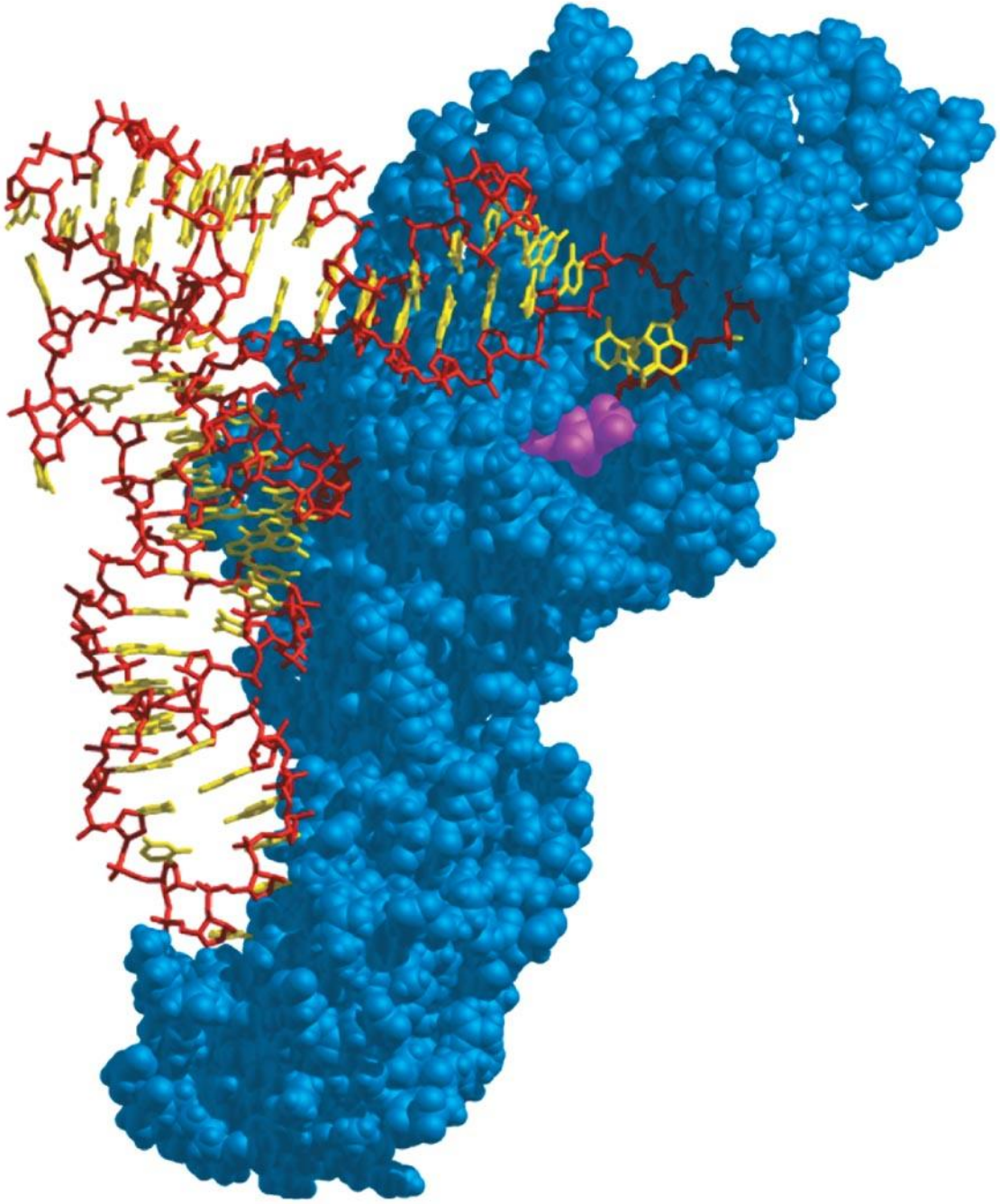
- **Messenger RNA** (**mRNA**) contains codons for protein sequences
- Eukaryotic mRNA has interrupting sequences called **introns**, separating the coding regions called **exons**
- Eukaryotic mRNA undergoes processing before leaving the nucleus
  - Cap added to 5’ end: single guanine nucleotide
  - Tail added to 3’ end: Poly-A tail of 50–250 adenines
  - **RNA splicing**: removal of introns and joining of exons to produce a continuous coding sequence



10.11 Transfer RNA molecules serve as interpreters during translation

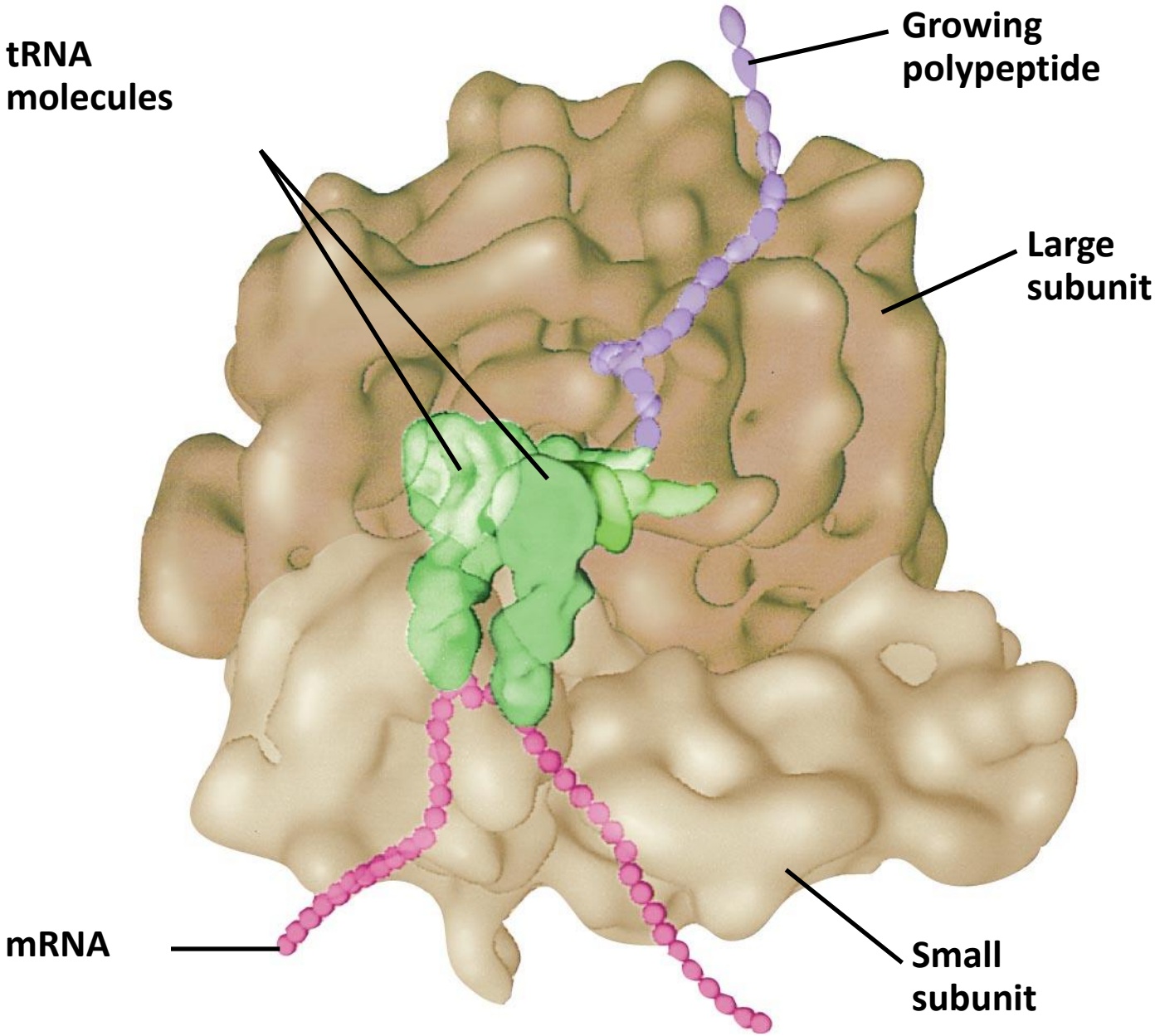
- **Transfer RNA** (**tRNA**) molecules match an amino acid to its corresponding mRNA codon
  - tRNA structure allows it to convert one language to the other
    - An amino acid attachment site allows each tRNA to carry a specific amino acid
    - An **anticodon** allows the tRNA to bind to a specific mRNA codon, complementary in sequence
      - A pairs with U, G pairs with C

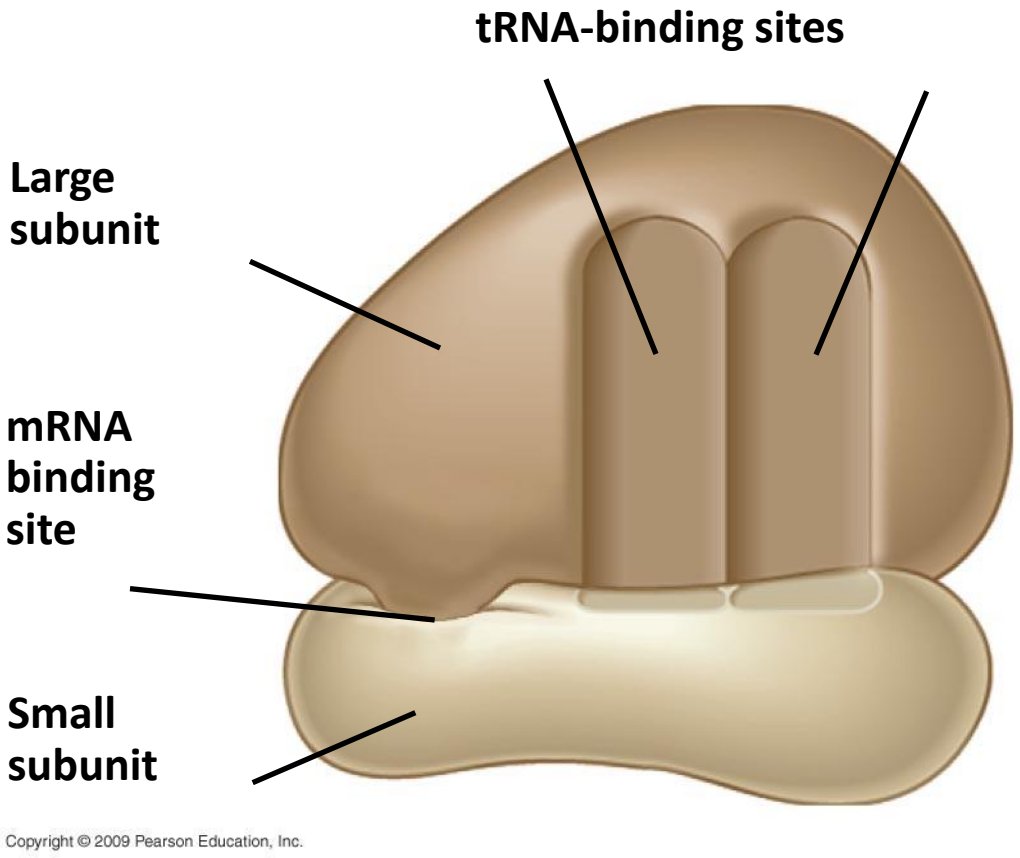


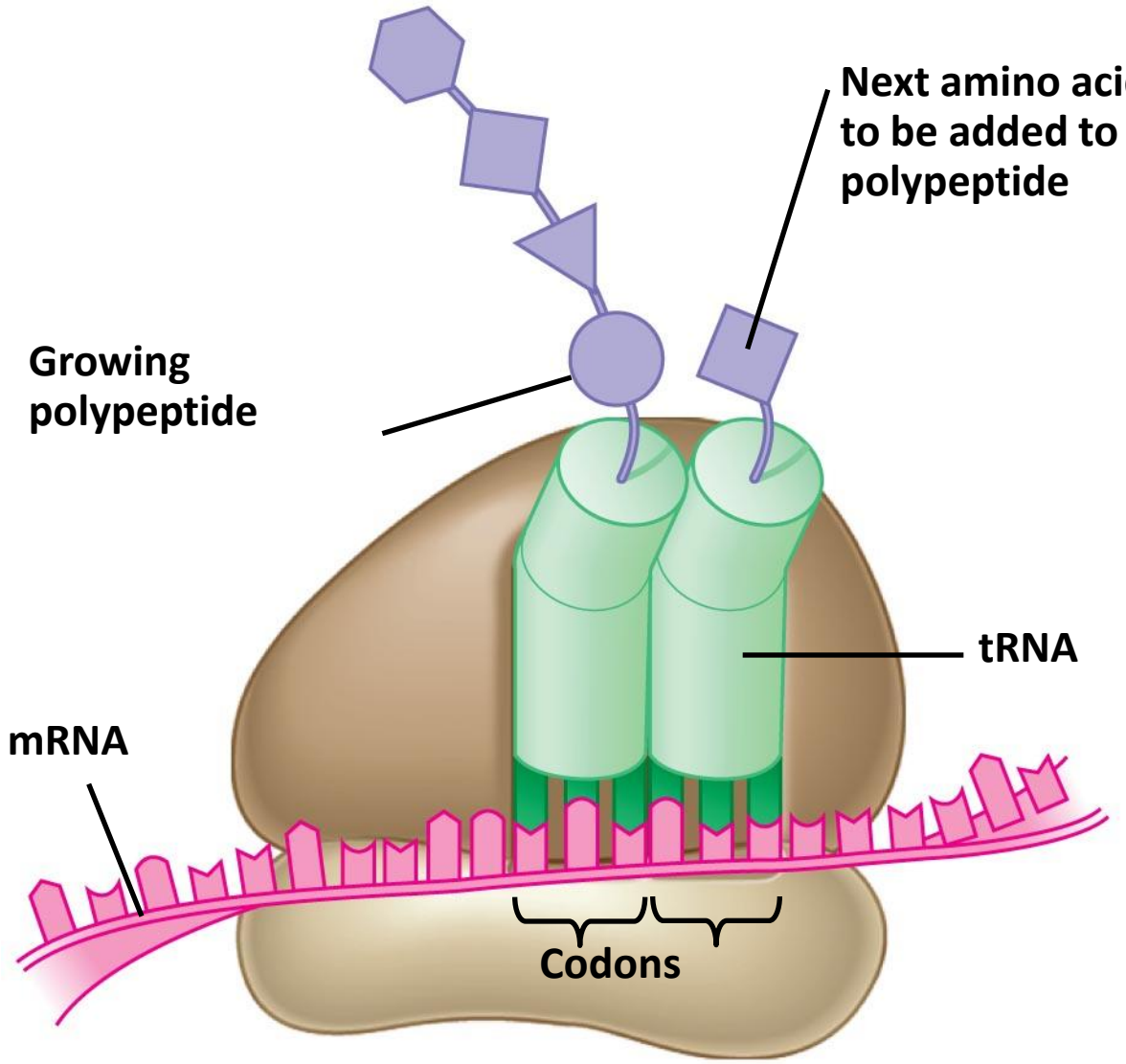


10.12 Ribosomes build polypeptides

- Translation occurs on the surface of the ribosome
  - Ribosomes have two subunits: small and large
  - Each subunit is composed of ribosomal RNAs and proteins
  - Ribosomal subunits come together during translation
  - Ribosomes have binding sites for mRNA and tRNAs

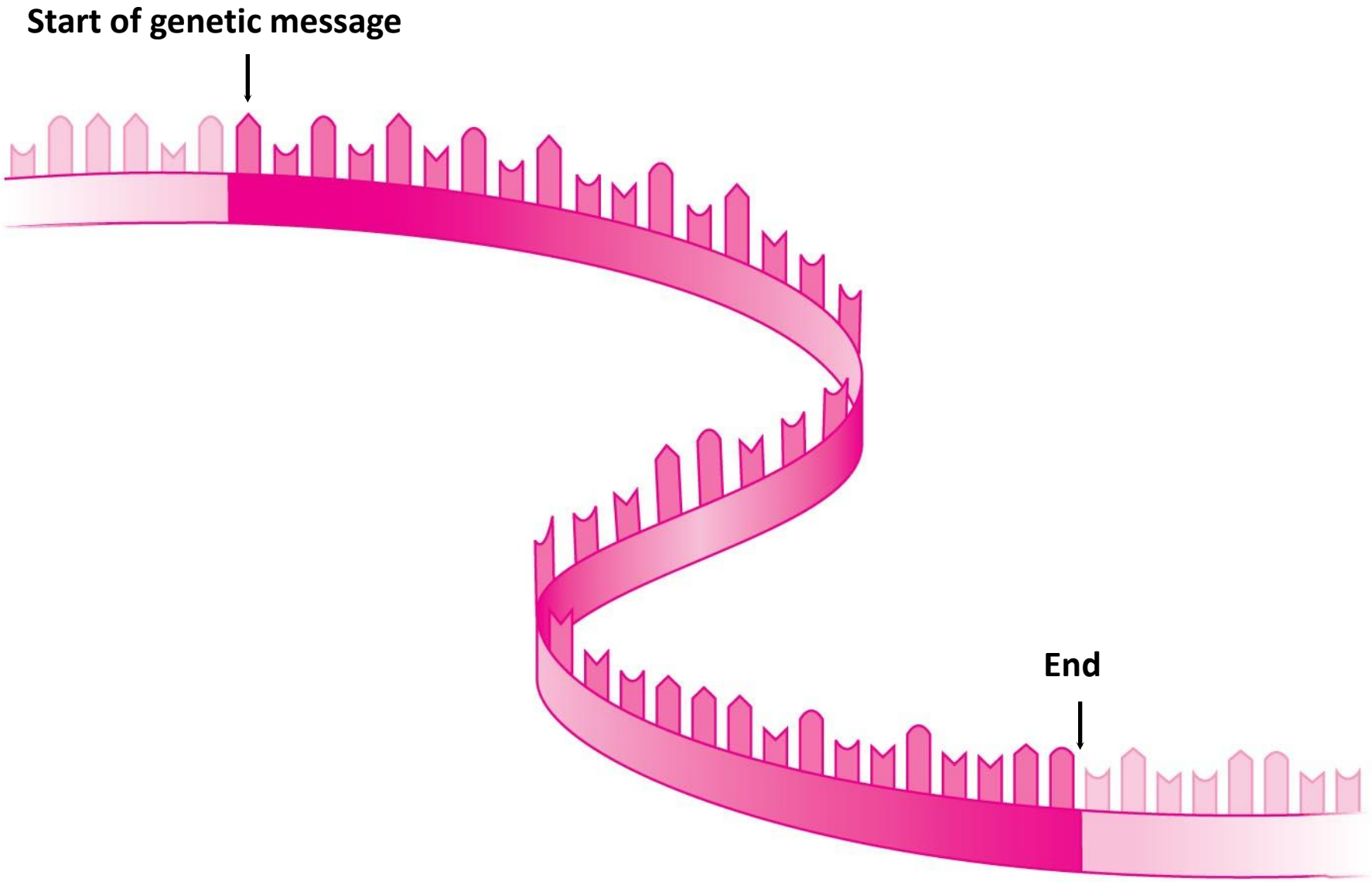


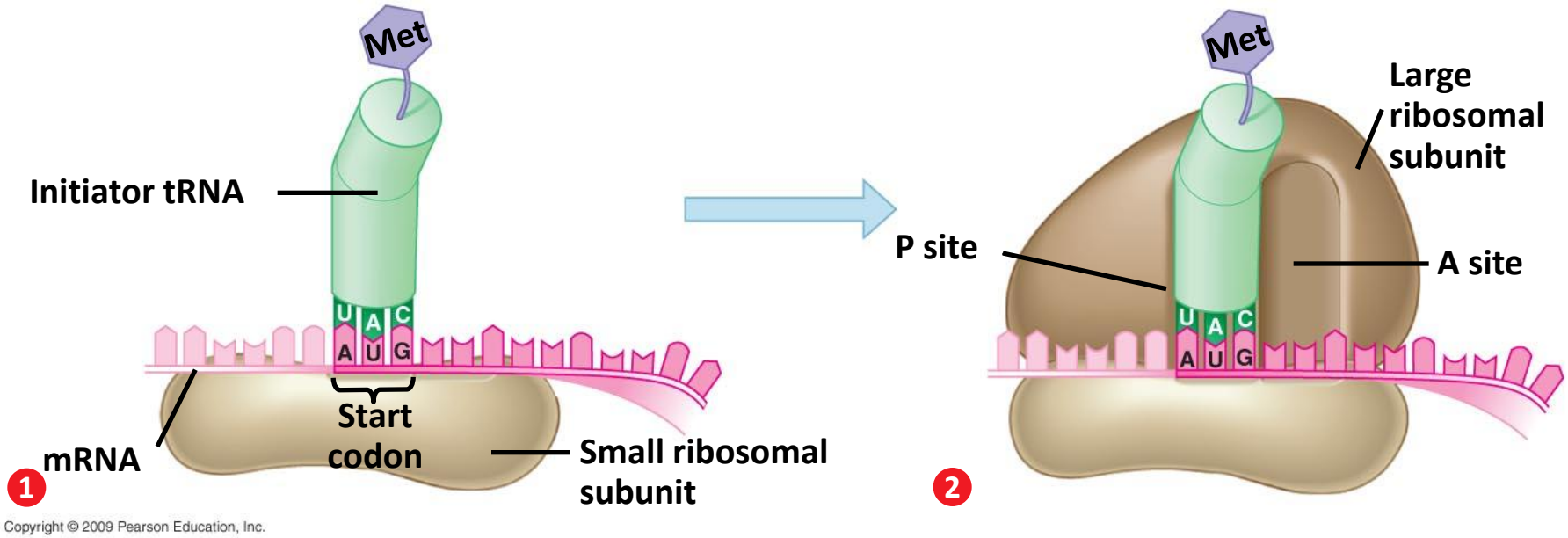




10.13 An initiation codon marks the start of an mRNA message

- Initiation brings together the components needed to begin RNA synthesis
- Initiation occurs in two steps
  1. mRNA binds to a small ribosomal subunit, and the first tRNA binds to mRNA at the start codon
     - The start codon reads AUG and codes for methionine
     - The first tRNA has the anticodon UAC
  2. A large ribosomal subunit joins the small subunit, allowing the ribosome to function
     - The first tRNA occupies the P site, which will hold the growing peptide chain
     - The A site is available to receive the next tRNA





10.14 Elongation adds amino acids to the polypeptide chain until a stop codon terminates translation

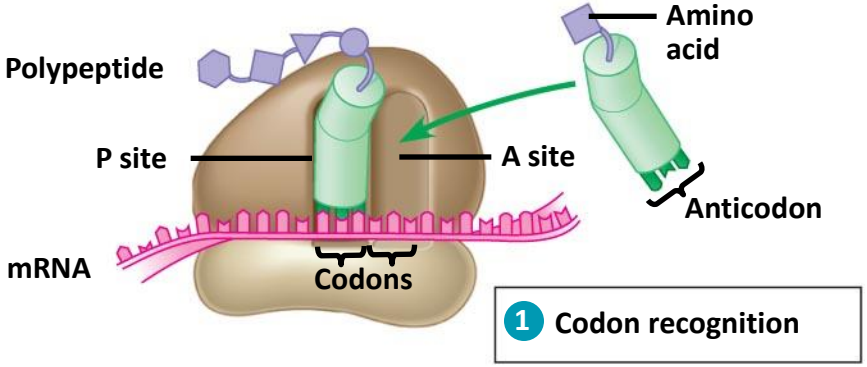
- Elongation is the addition of amino acids to the polypeptide chain
- Each cycle of elongation has three steps
  1. Codon recognition: next tRNA binds to the mRNA at the A site
  2. Peptide bond formation: joining of the new amino acid to the chain
     - Amino acids on the tRNA at the P site are attached by a covalent bond to the amino acid on the tRNA at the A site

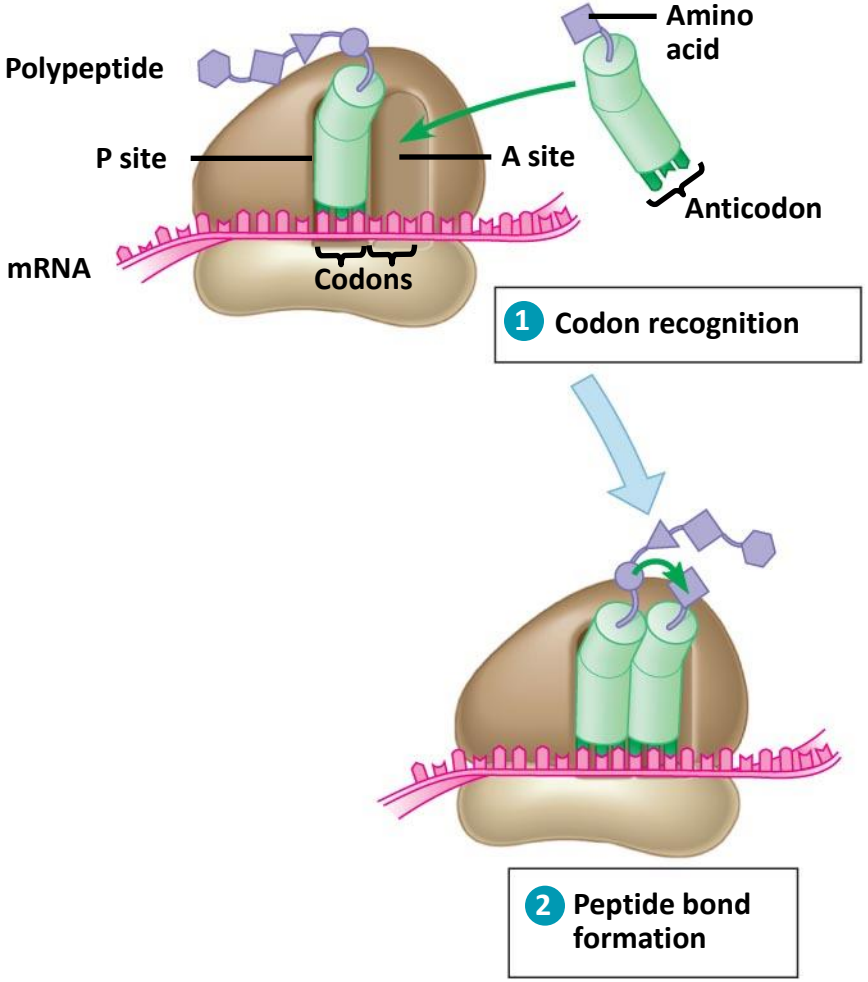
10.14 Elongation adds amino acids to the polypeptide chain until a stop codon terminates translation

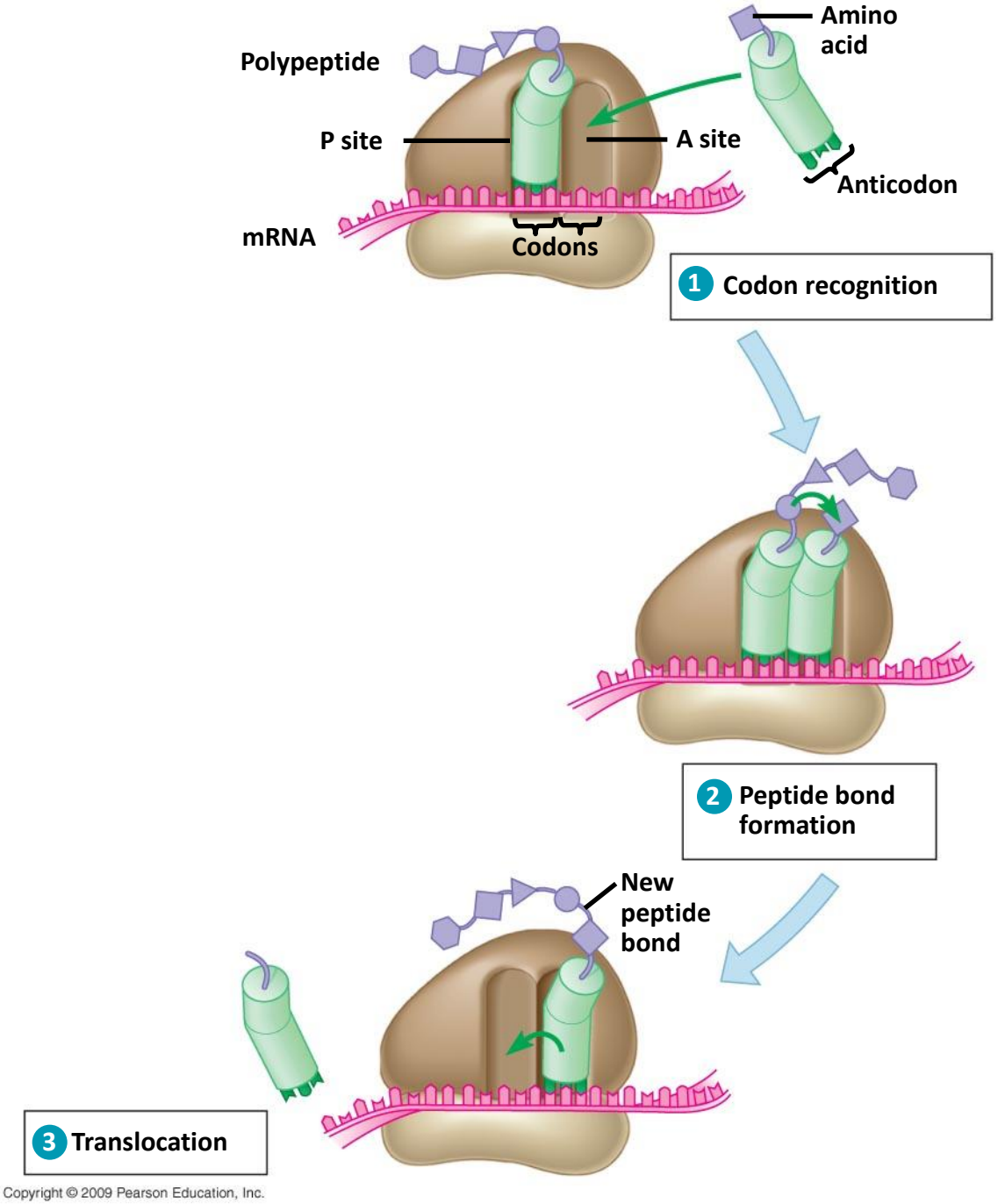
3. Translocation: tRNA is released from the P site and the ribosome moves tRNA from the A site into the P site

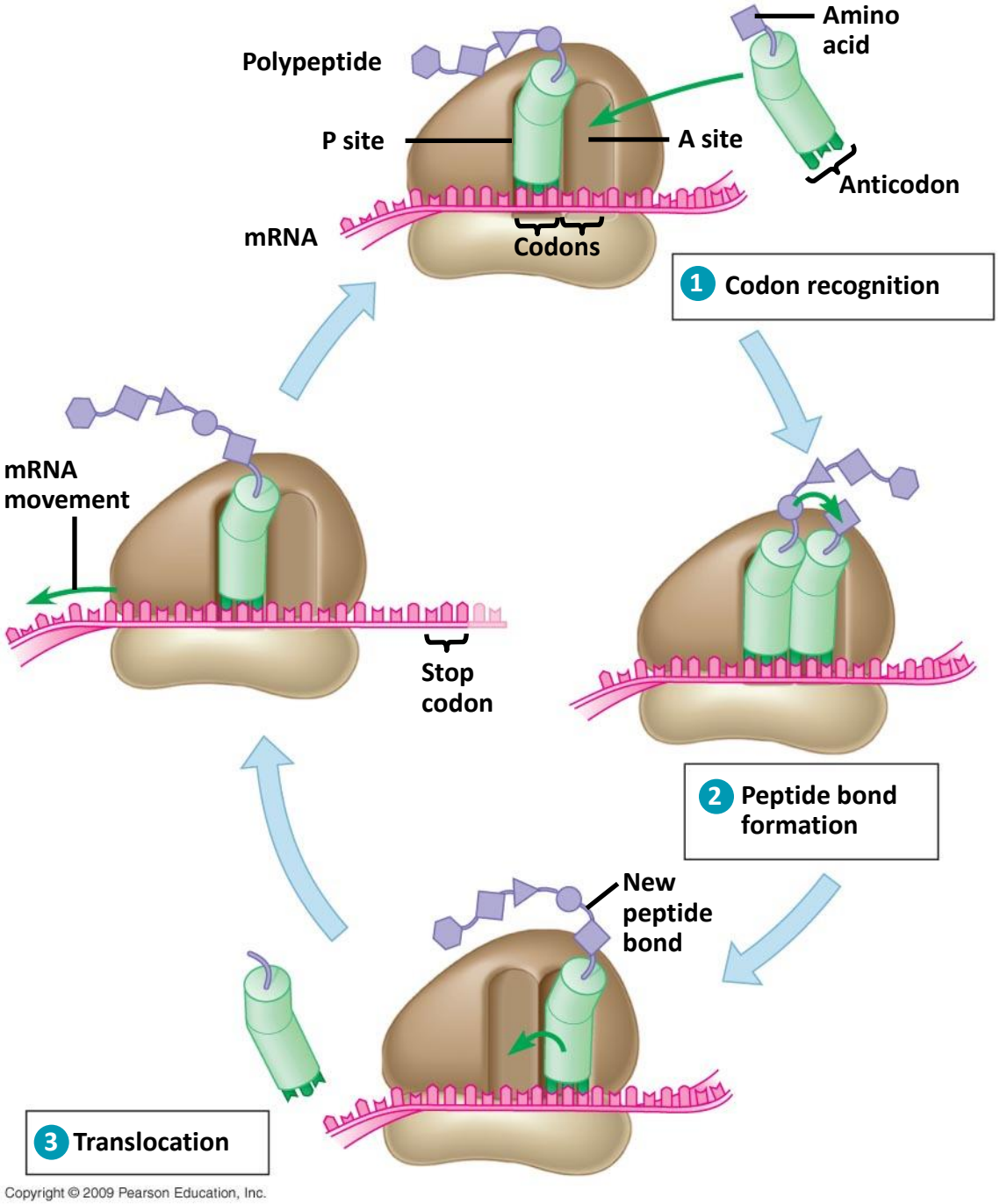
10.14 Elongation adds amino acids to the polypeptide chain until the stop codon

- Elongation continues until the ribosome reaches a **stop codon**
- Applying Your Knowledge
  How many cycles of elongation are required to produce a protein with 100 amino acids?
- Termination
  - The completed polypeptide is released
  - The ribosomal subunits separate
  - mRNA is released and can be translated again



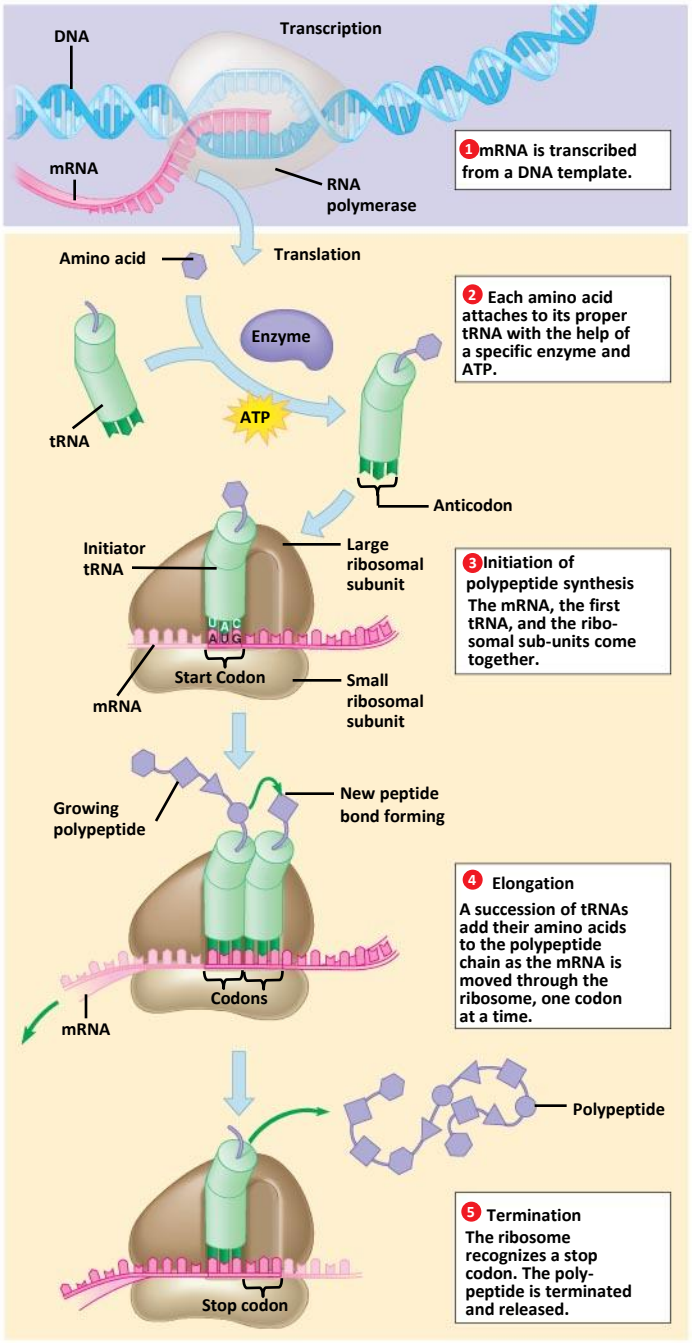


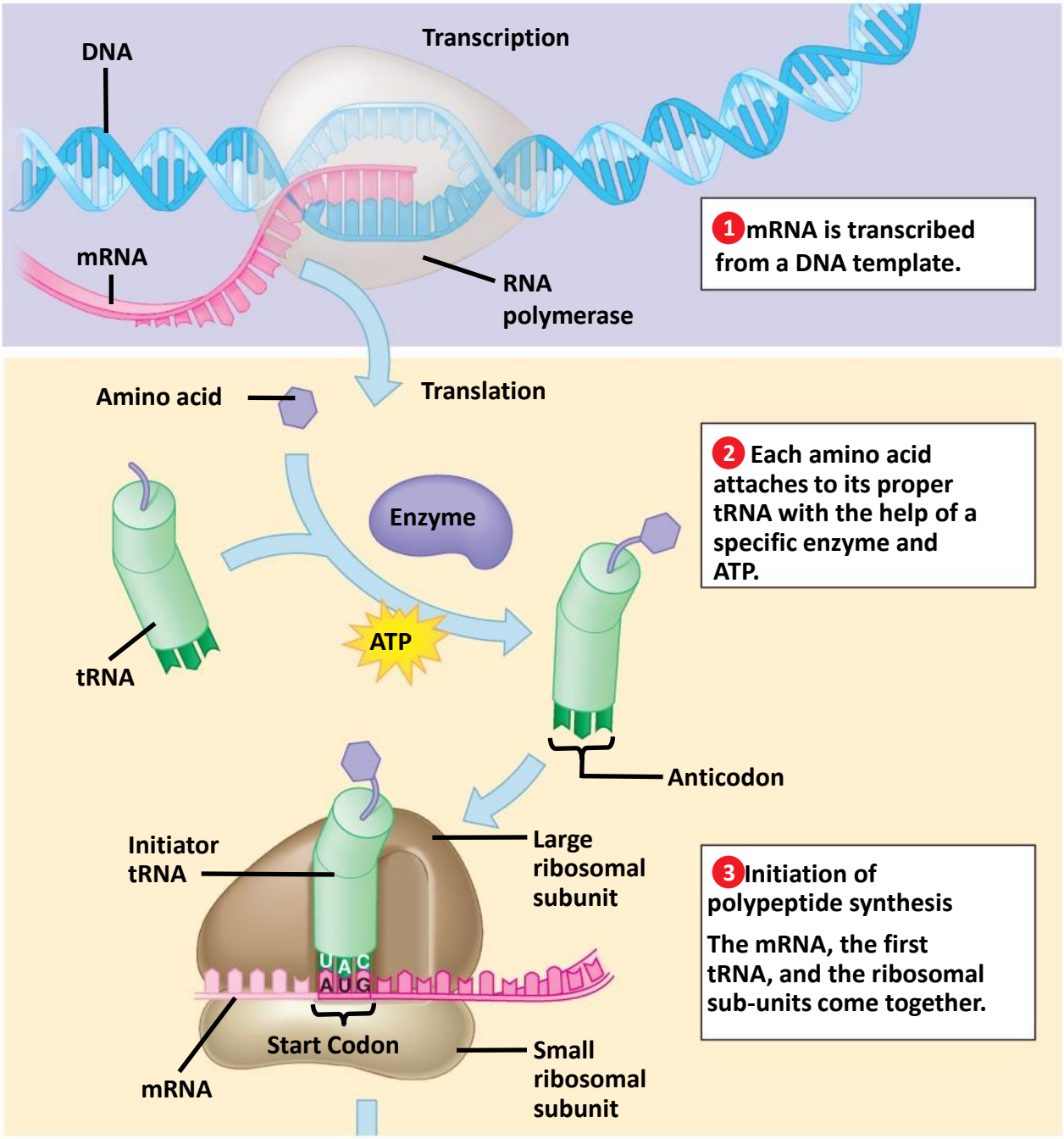


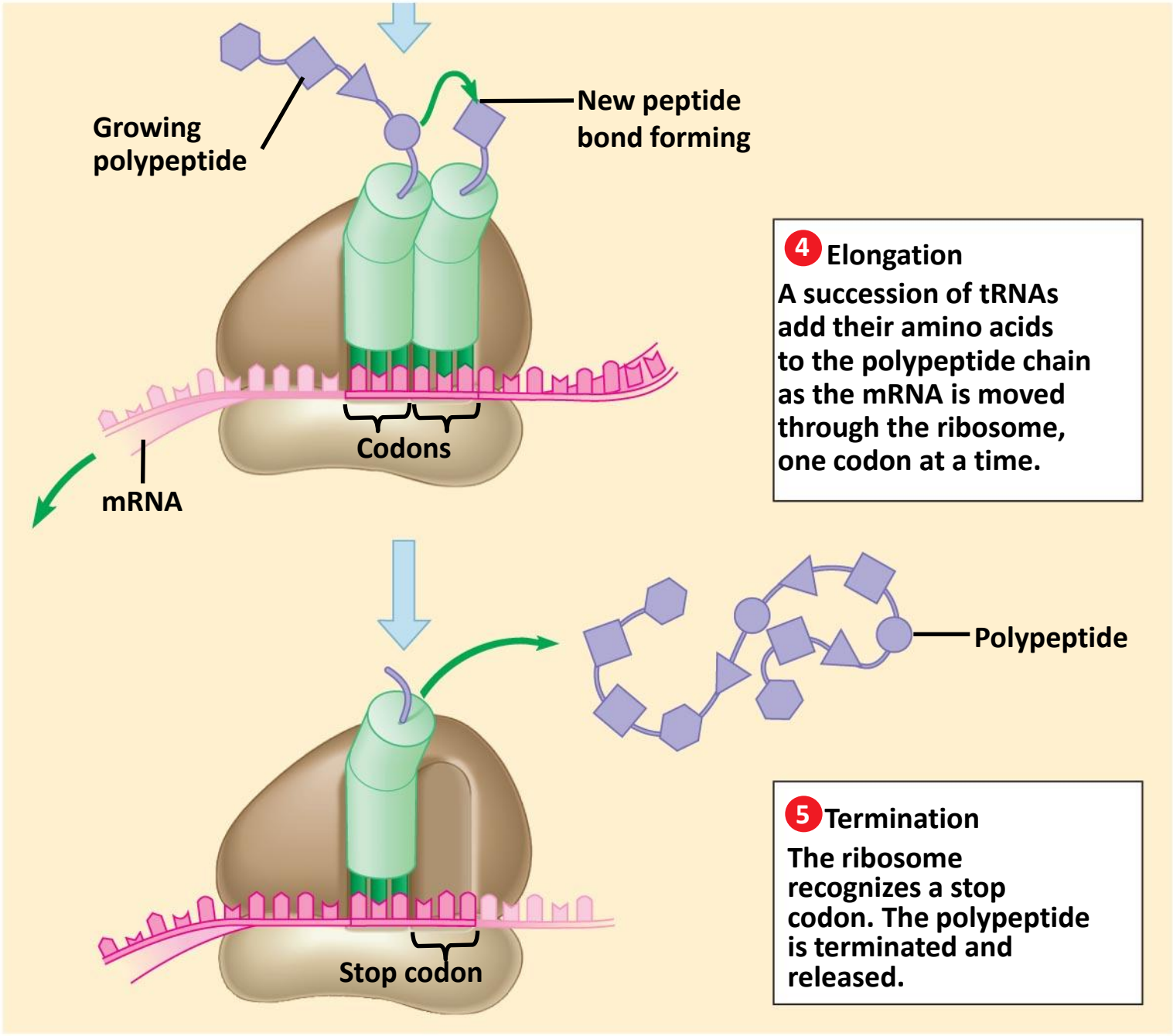


10.15 Review: The flow of genetic information in the cell is DNA → RNA → protein

- Does translation represent:
  - DNA → RNA or RNA → protein?
- Where does the information for producing a protein originate:
  - DNA or RNA?
- Which one has a linear sequence of codons:
  - rRNA, mRNA, or tRNA?
- Which one directly influences the phenotype:
  - DNA, RNA, or protein?







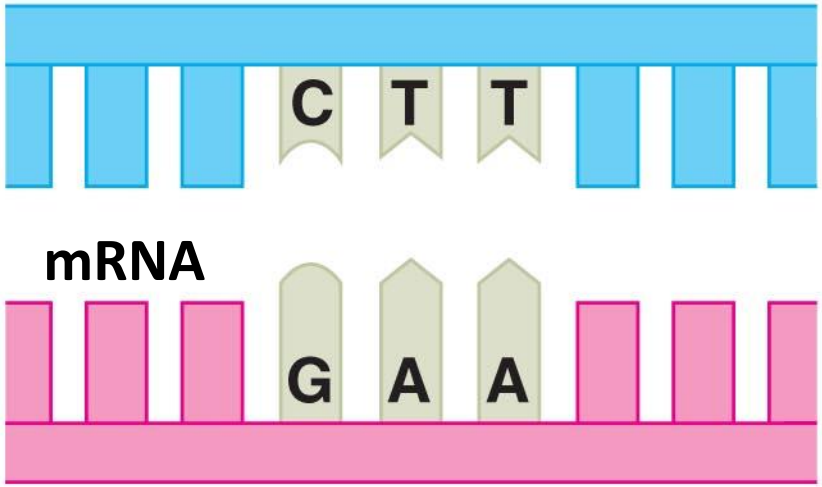
10.16 Mutations can change the meaning of genes

- A **mutation** is a change in the nucleotide sequence of DNA
  - Base substitutions: replacement of one nucleotide with another
    - Effect depends on whether there is an amino acid change that alters the function of the protein
  - Deletions or insertions
    - Alter the reading frame of the mRNA, so that nucleotides are grouped into different codons
    - Lead to significant changes in amino acid sequence downstream of mutation
    - Cause a nonfunctional polypeptide to be produced

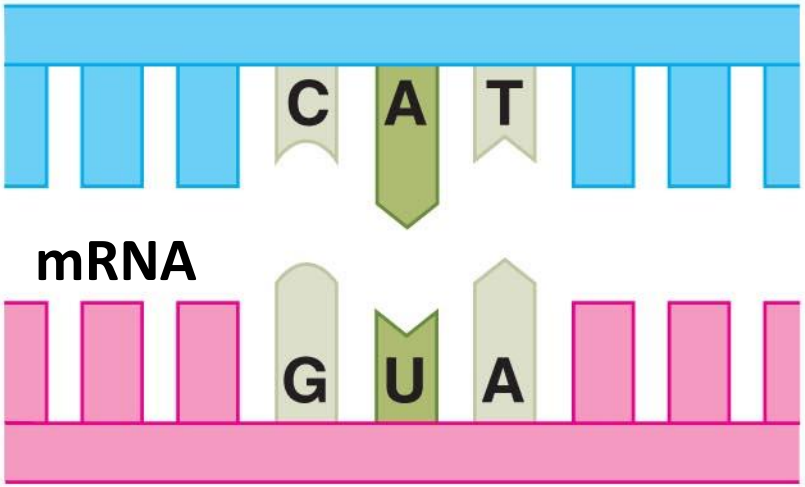
10.16 Mutations can change the meaning of genes

- Mutations can be
  - Spontaneous: due to errors in DNA replication or recombination
  - Induced by mutagens
    - High-energy radiation
    - Chemicals

Normal hemoglobin DNA



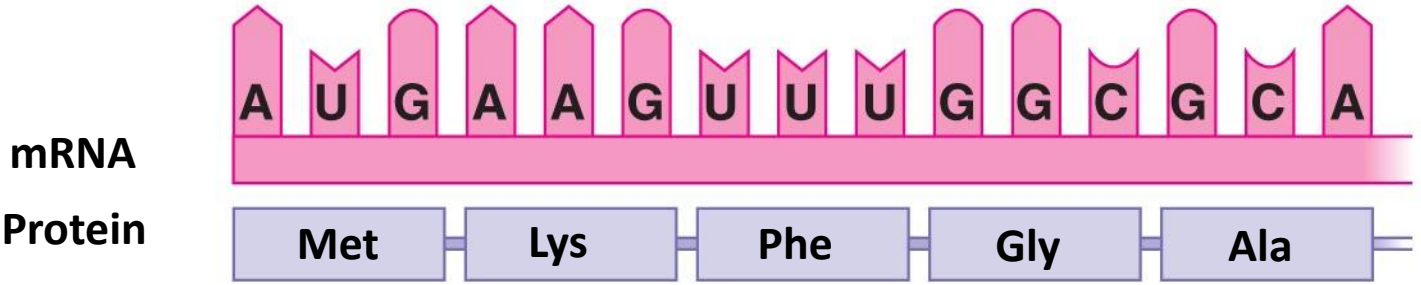
Mutant hemoglobin DNA



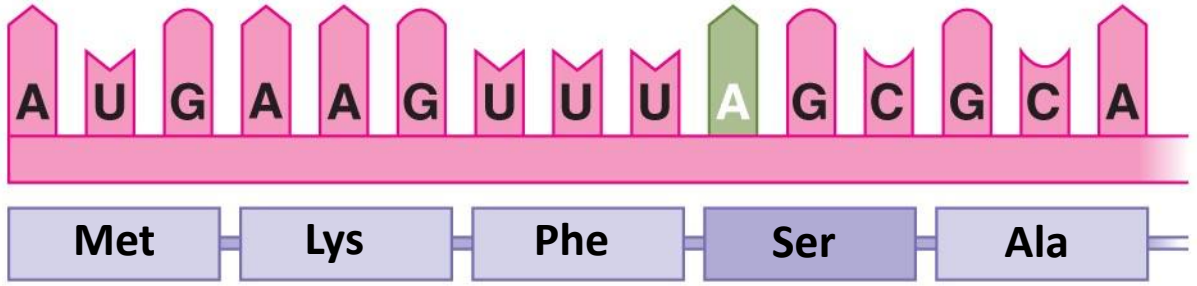
Normal hemoglobin

Sickle-cell hemoglobin

Normal gene



Base substitution



Base deletion