

# Translation

## Protein Synthesis

# Agenda

- ▶ Transcription recap
- ▶ What is translation?
  - Initiation
  - Elongation
  - Termination
- ▶ Short Video
- ▶ Activity
  - Short Quiz on Thursday! 6.1 and 6.2

# Transcription

1. RNA polymerase attaches to promoter region
2. Unwinds/unzips section of DNA
3. Reads antisense strand in 3' to 5' direction
4. Synthesizes complementary mRNA strand in 5' to 3' direction
5. Addition of 5' cap and 3' poly-A tail
6. Splicing

# Translation

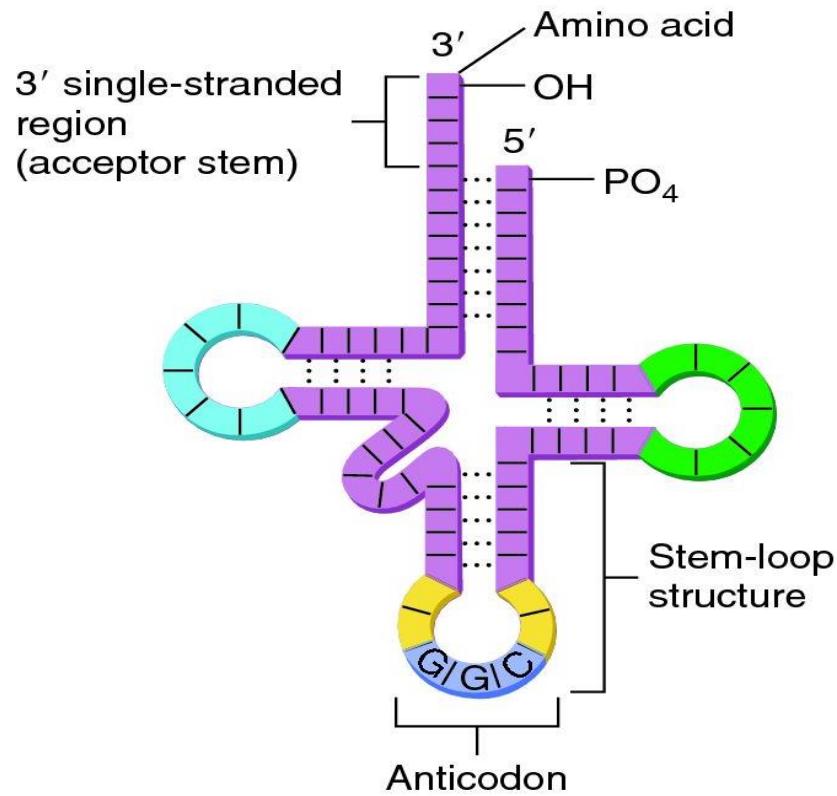
- ▶ Second stage of gene expression
- ▶ Translate nucleic acid code of mRNA into amino acid code of protein
- ▶ Requires complex assembly of different nucleic acid and protein components

# Translation Machinery

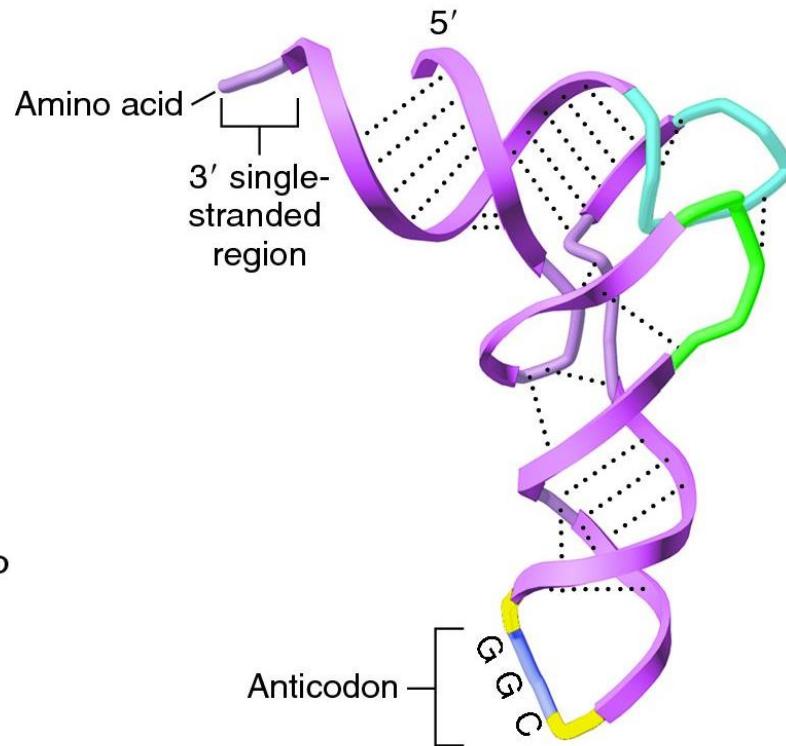
Component	Function
mRNA	Contains genetic information that determines amino acid sequence of a protein
tRNA	Contains anticodon that base-pairs with codon on mRNA and has the corresponding amino acid attached to it
Ribosomes	Composed of rRNA and proteins; involved in process of protein synthesis
Translation factors	Proteins that act as accessory factors; needed at each stage of translation

# Transfer RNA

- ▶ Single strand of RNA that folds into 2-D cloverleaf shape or 3-D boot shape



(a) Two-dimensional structure of tRNA



(b) Three-dimensional structure of tRNA

# Transfer RNA

- ▶ tRNA is an RNA molecule that links codons on mRNA to corresponding amino acid for protein synthesis
- ▶ 3 stem loops (double stranded RNA)
- ▶ 2 functional regions
  - Anticodon loop: sequence of 3 nucleotides complementary to a specific mRNA codon
  - Acceptor stem: site of specific amino acid attachment at the 3' end of tRNA

# Transfer RNA

- ▶ Aminoacyl-tRNA synthetase enzymes responsible for attaching amino acid to tRNA according to anticodon.
- ▶ 20 enzymes, 1 enzyme for each amino acid

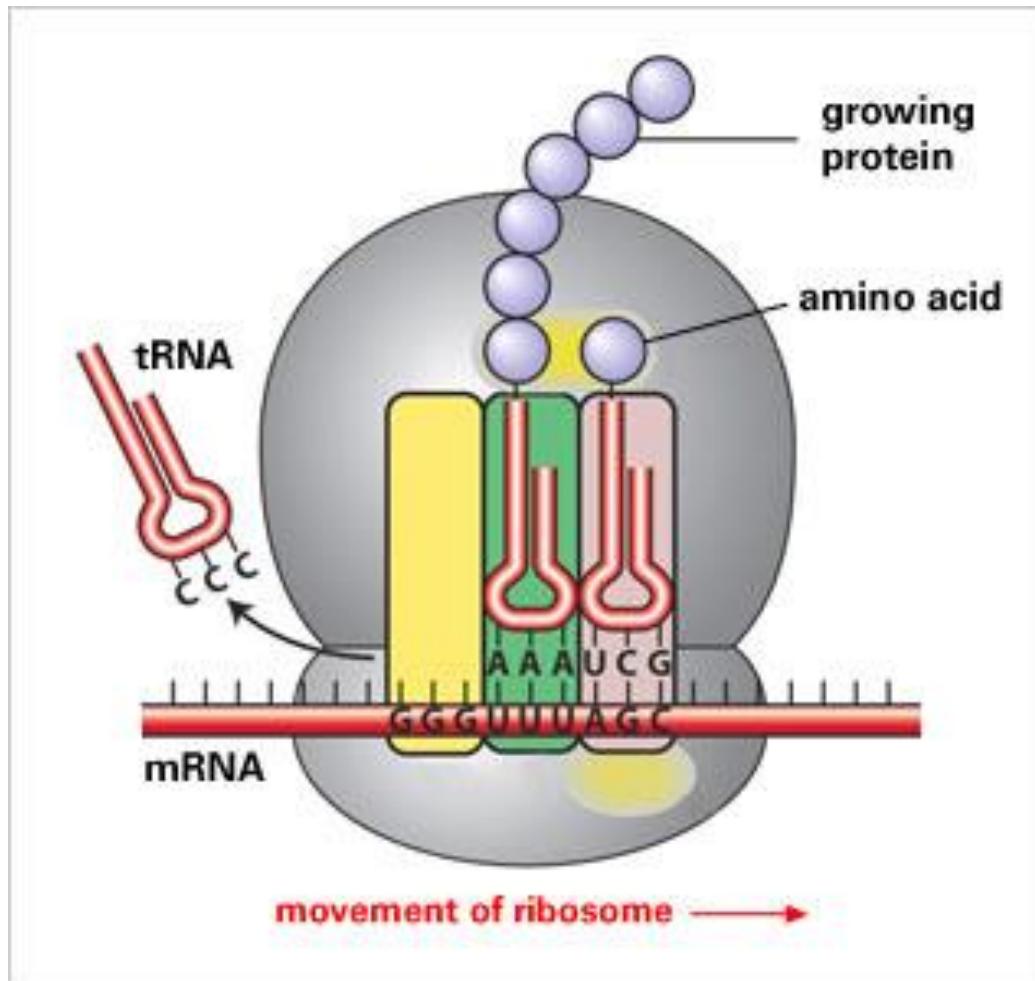
# Ribosome

- ▶ Cytoplasmic structures made up of proteins and ribosomal RNAs
- ▶ Composed of 2 sub-units
- ▶ Ribosome has one binding site for mRNA and three binding sites for tRNA molecules
- ▶ One mRNA can be translated by several ribosomes at a time
- ▶ Several copies of a polypeptide can be synthesized from the same mRNA at once

# Binding sites

- ▶ Small ribosome binds to the mRNA during initiation
- ▶ Large ribosome has 3 binding sites for tRNA
  - Peptide site: contains tRNA with growing polypeptide chain
  - Amino acid site: contains tRNA with next amino acid to be added to the chain
  - Exit site: contains uncharged tRNA to be ejected

# Ribosome



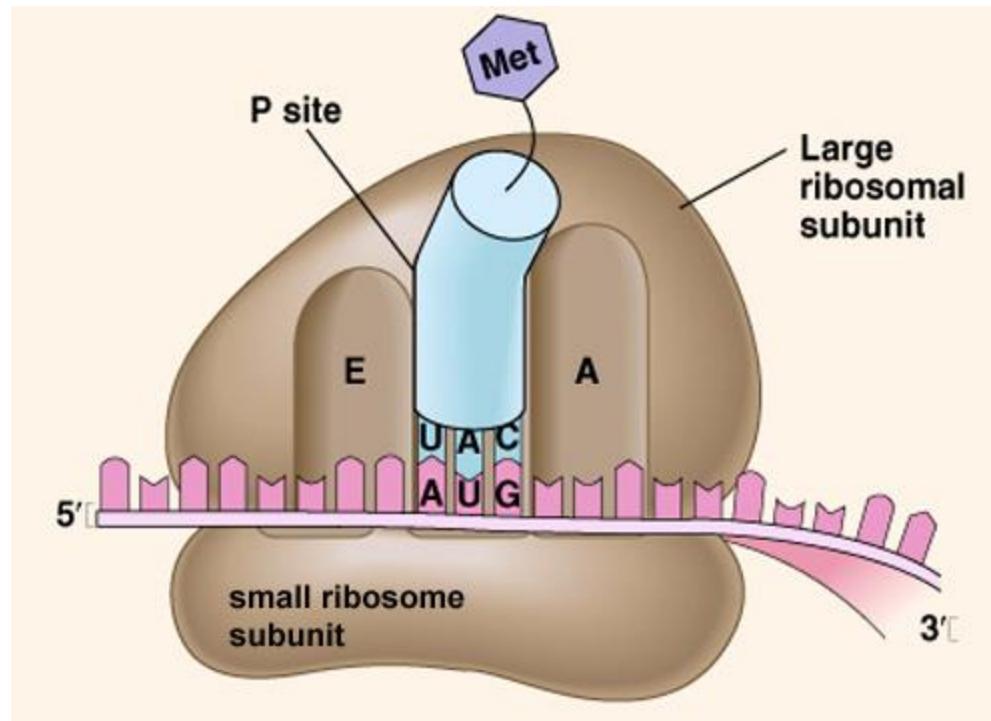
# Translation

- ▶ During transcription, mRNA is threaded through the ribosome, and tRNA with corresponding anticodons attach appropriate amino acids in the correct sequence
- ▶ Like transcription, translation can be divided into 3 phases
  - Initiation
  - Elongation
  - Termination

# Initiation

- ▶ Proteins called initiation factors assemble small ribosomal sub-unit, large ribosomal sub-unit, mRNA, initiator tRNA
- ▶ Small ribosomal sub-unit attaches to mRNA near start codon
- ▶ Initiator tRNA with UAC anticodon binds to mRNA start codon at P-site
- ▶ Large ribosomal sub-unit joins to form active ribosome
- ▶ \*Start codon sets reading frame that determines how the following codons in the sequence will be read

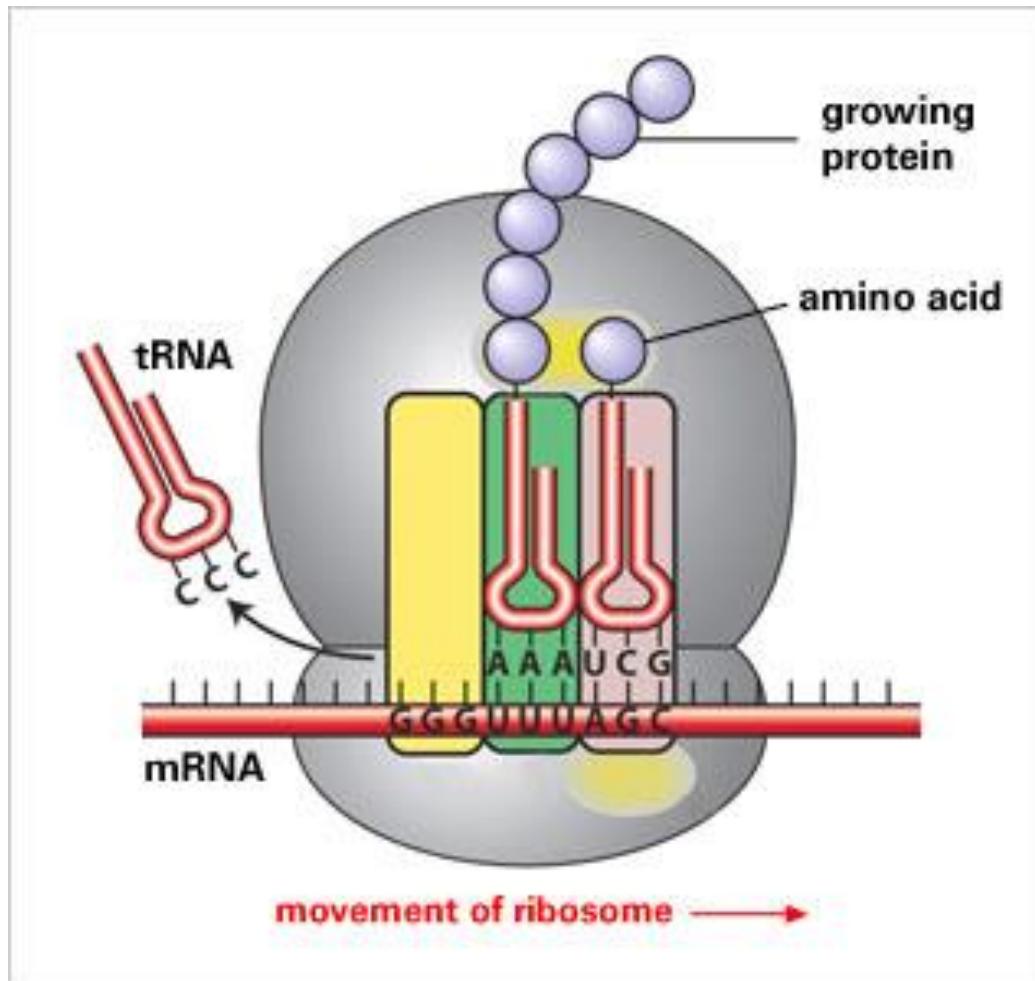
# Initiation



# Elongation

- ▶ During this phase, protein synthesis occurs
- ▶ Elongation factors enable tRNA anticodons to bind to mRNA codons
- ▶ Elongation Process:
  - tRNA with attached polypeptide is in P site, and tRNA carrying next amino acid enters A site
  - Polypeptide chain transferred to amino acid of tRNA in A site
  - mRNA moves forward by one codon, placing the polypeptide chain back at P-site and freeing A-site to accept the tRNA carrying the next amino acid. The empty tRNA is discarded through E-site

# Ribosome



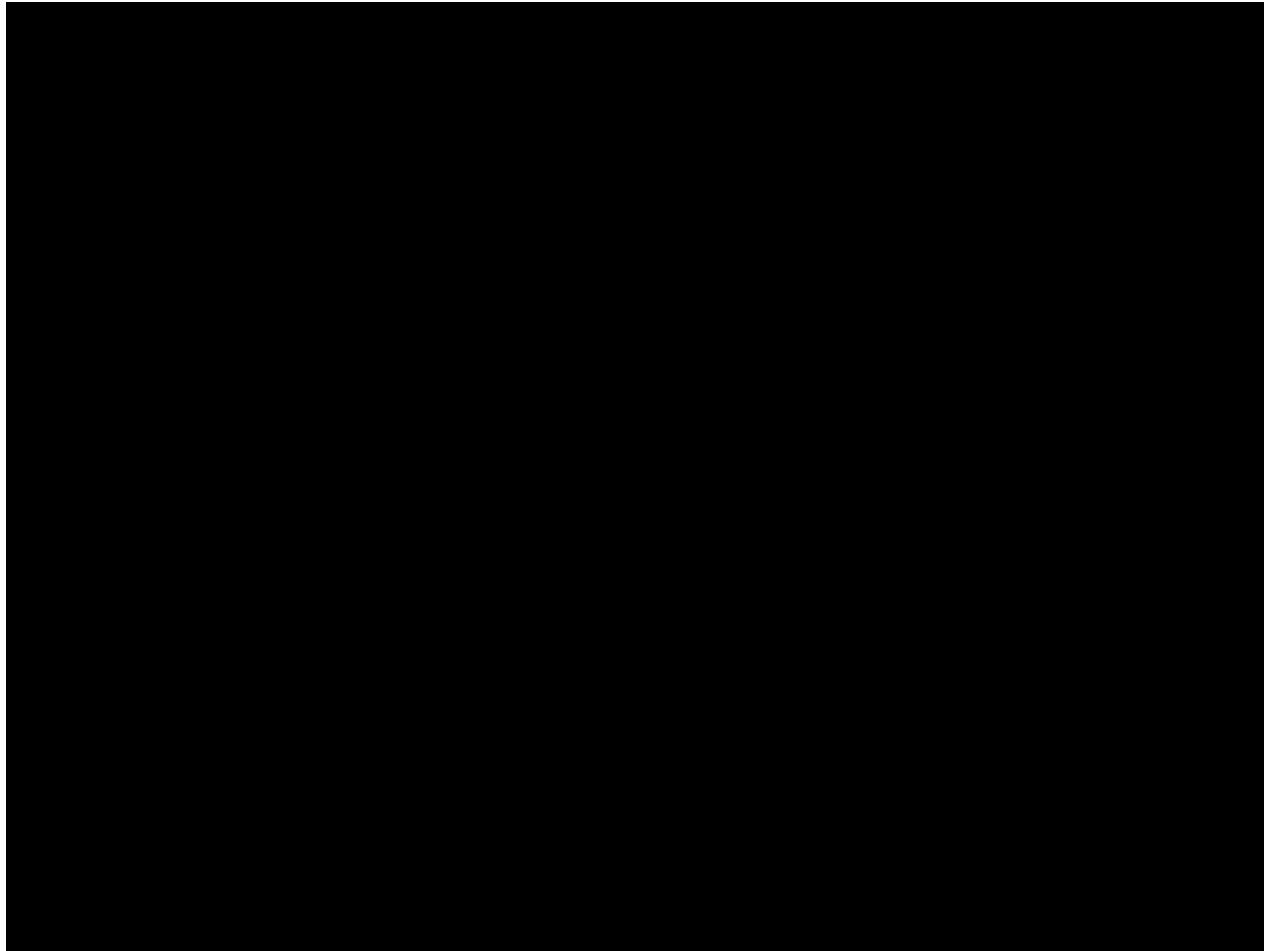
# Activity – 10 minutes

- ▶ Draw your own diagram illustrating the elongation process during translation
- ▶ Make sure to label the following elements:
  - ▶ E-site, P-site, A-site, polypeptide chain, ribosome, mRNA, incoming tRNA and outgoing tRNA

# Termination

- ▶ Termination occurs when stop codon is reached on mRNA
- ▶ A protein called the release factor cleaves polypeptide from last tRNA
- ▶ The components of the translation machinery are separated
- ▶ The released polypeptide will eventually fold into its 3-D shape, ready to perform its function

# Translation Video



# Activity Extended

- ▶ In groups of 3–4 come up with your own analogy for protein synthesis, including at least the following elements:
- ▶ gene, mRNA, transcription, cytoplasm, tRNA, ribosome, translation, amino acids, protein.
- ▶ You are free to include more terms if you want to.
- ▶ In 20 minutes, each group will present their analogy to the rest of the class.

# **Homework**

Pg. 260: #16, 18

**Study for your Quiz on Thursday!**