Transcription & Translation

Protein Synthesis

- Genes direct the production of proteins- determine the characteristics of organisms.
- Proteins drive cellular processes such as metabolism
- Metabolism- all chemical reactions involved in maintaining the living state of the cells and the organism.

Metabolism can be conveniently divided into two categories:

- Catabolism - the breakdown of molecules to obtain energy
- Anabolism – the synthesis of all compounds needed by cells

The Central Dogma

- An organism’s genome is housed within the nucleus. Proteins are synthesized outside the nucleus, in the cytoplasm, on ribosomes.
- Since information for protein synthesis is specified by DNA (called the one gene-one polypeptide hypothesis), and DNA is not able to exist outside the nucleus, a problem exists as to how the blueprint of life is brought to the ribosomes.

DNA is too valuable to be allowed to exit the nucleus. This could lead to the death of the cell and possible the death of the organism.

- use of mRNA provides protection for the genetic information contained in DNA.

- more protein can be made simultaneously because many mRNA copies of a gene can be made.

- Each mRNA can be translated many times.

mRNA delivers the encoded genetic information to the ribosomes.

Ribosomes translate the message into polypeptide chains, which are processed into proteins.

This entire sequence is described as the Central Dogma of Molecular Genetics first stated by Francis Crick in 1958.

Transcription vs Translation

Transcription involves the copying of the information in DNA into mRNA.

Translation involves ribosomes using the Messenger RNA as a blueprint to synthesize a protein composed of amino acids.

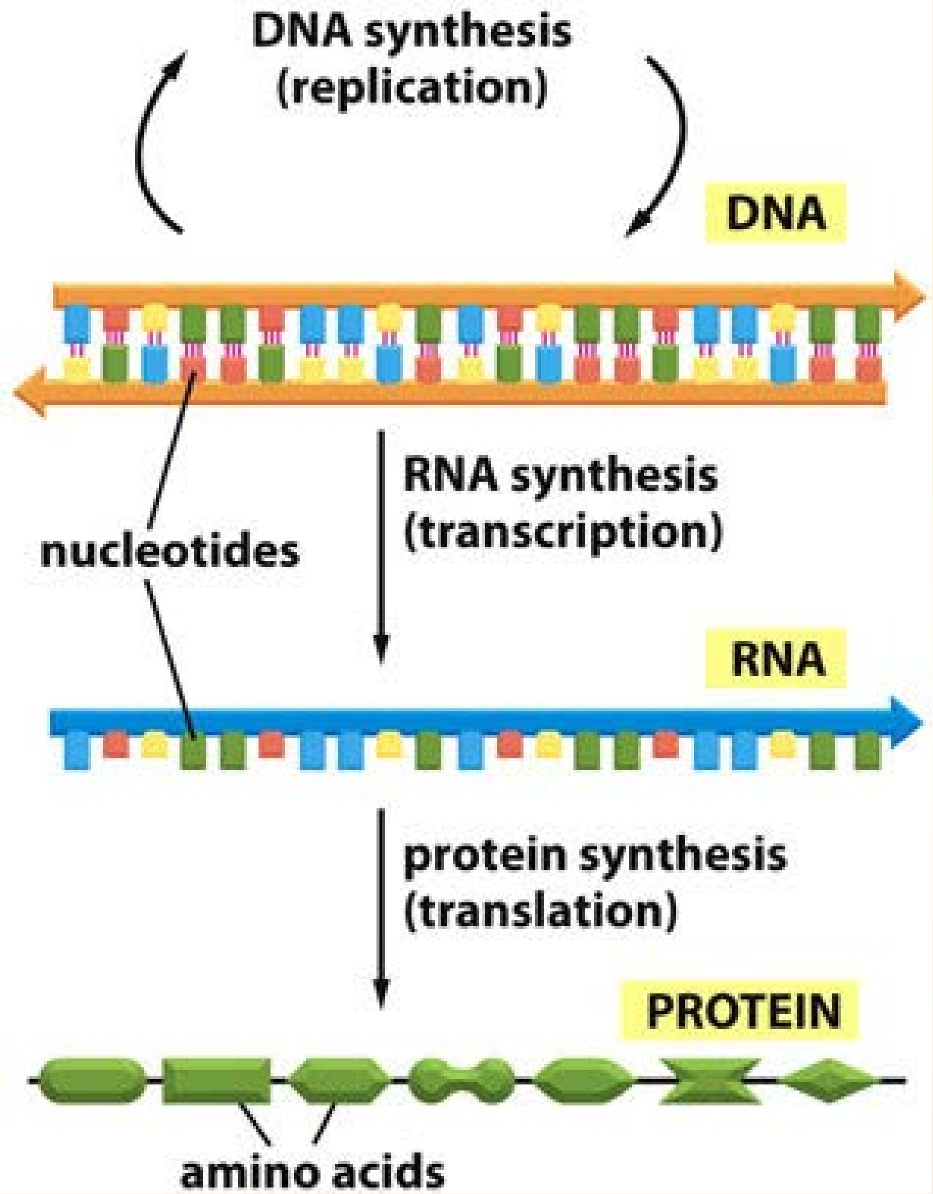
Transcription

Transcription	
Nucleus	**Location**
DNA	**Template (What is read)**
To change DNA into a form that can make a protein	**Purpose**
Messenger RNA (mRNA)	**Outcome (End result)**

Translation

	Translation
Location	Cytoplasm (by ribosome)
Template (What is read)	mRNA
Purpose	Amino acids assembled in particular order to make a protein
Outcome (End result)	Protein (polypeptide)

Central Dogma



- In nucleus

- Produced in nucleus
- Travels to cytoplasm

- Produced in cytoplasm

3 types of RNA:

Messenger RNA: mRNA

Copy of DNA brought to ribosome- translated into protein by tRNA & rRNA

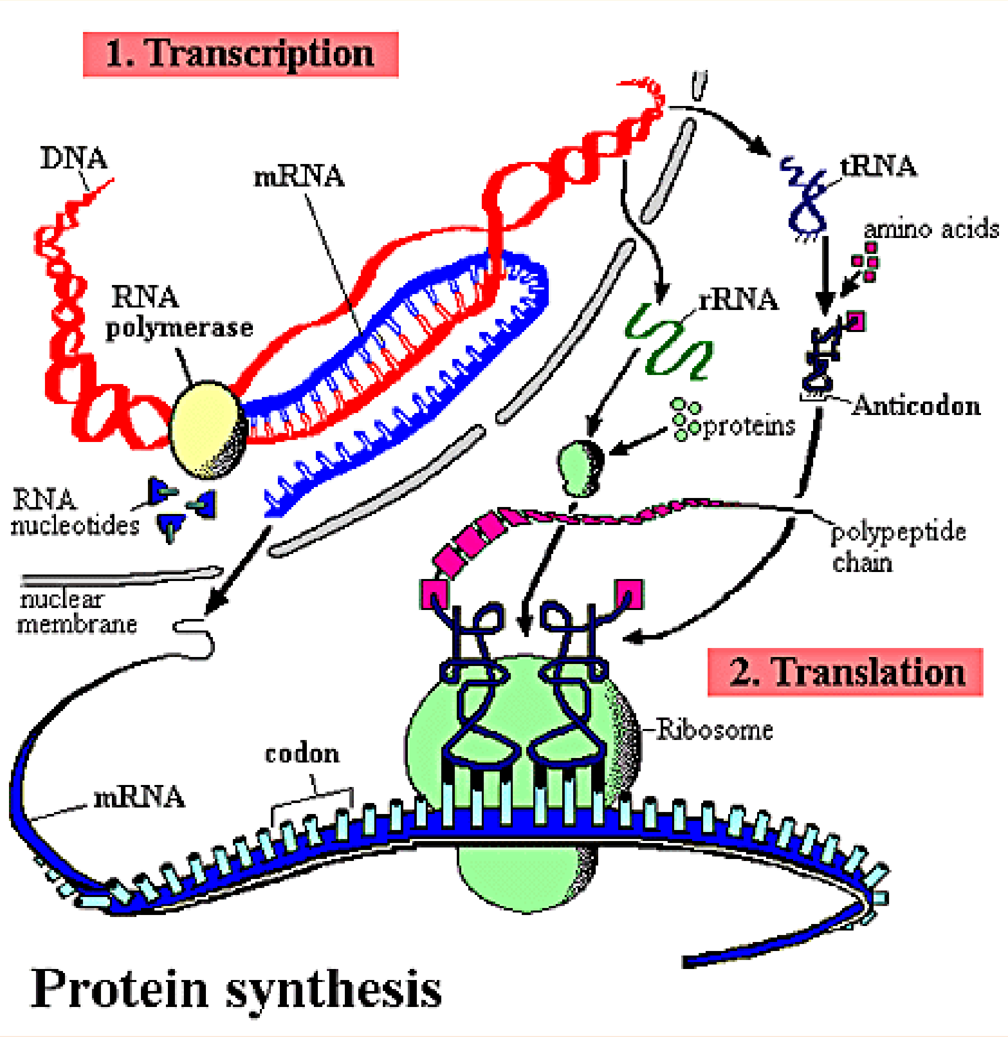
Varies in length, the longer the gene the longer the mRNA.

Transfer RNA: tRNA

Brings the amino acid to the ribosome

Ribosomal RNA: rRNA

Most RNA in cells is associated with ribosomes- the site of **translation**.



Translation: ‘new language’

Initiation:

- Ribosome binds at a specific sequence on the mRNA.
- Ribosome moves along the mRNA **three** nucleotides at a time- called a **codon**.

Each codon codes for an amino acid. Why?

There are only 4 bases but 20 amino acids.

$4^1 = 4$ (1 base=1 acid) $4^2 = 16$ $4^3 = 64$

AUG codon codes for Methionine amino acid but it also indicates the start of a translation.

Some amino acids are coded for by two or more codons but a given codon ALWAYS only codes for one amino acid.

Example:
GAA and GAG both code for glutamic acid

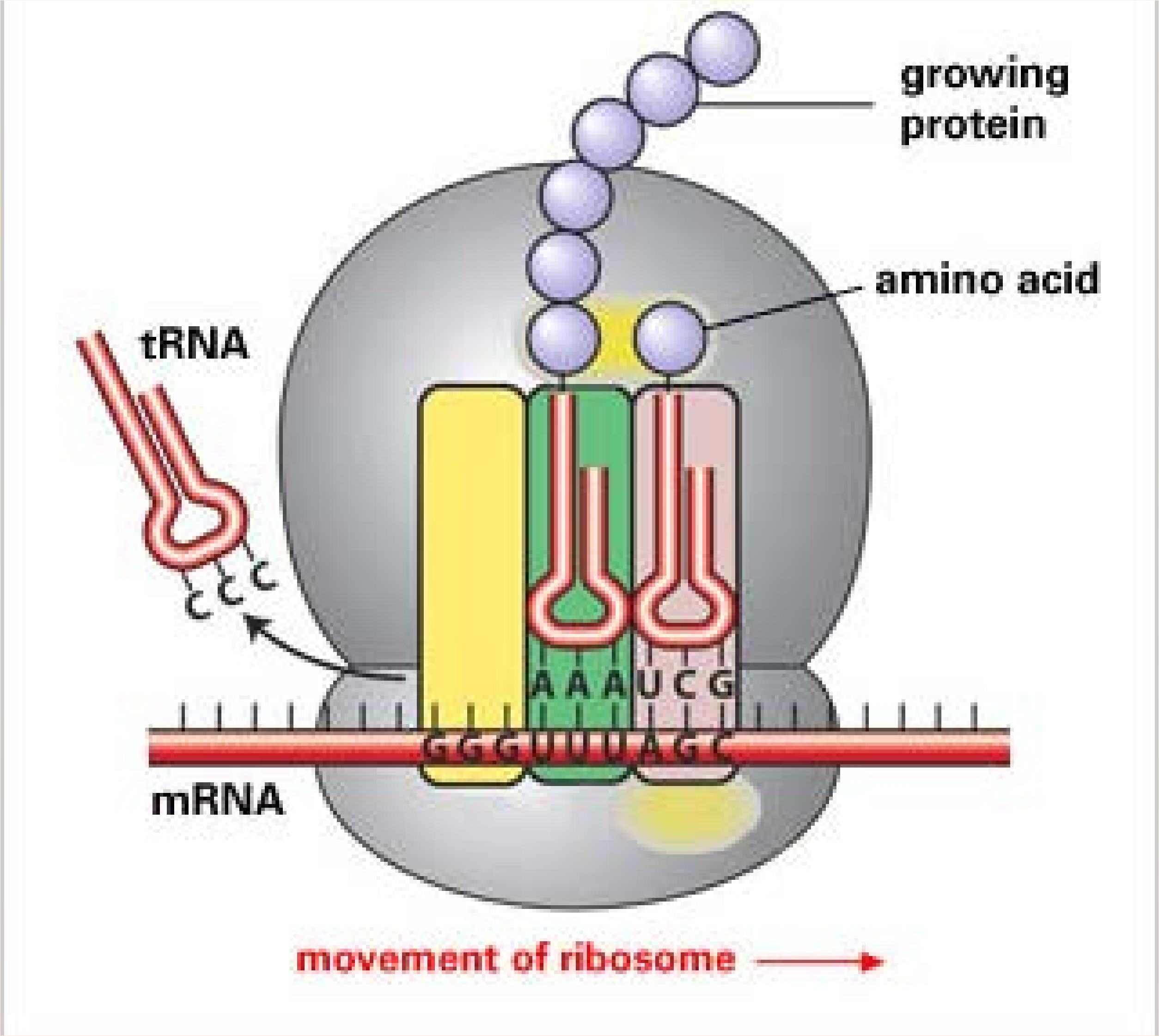
Elongation:

- Ribosome moves along mRNA from mRNA 5' end (3 nucleotides of mRNA = codon = amino acid)
- tRNA delivers the proper complimentary amino acid to the ribosome by matching anticodons that **attach to the mRNA.**

Example: UUU codon on a mRNA binds to a tRNA with an AAA anticodon

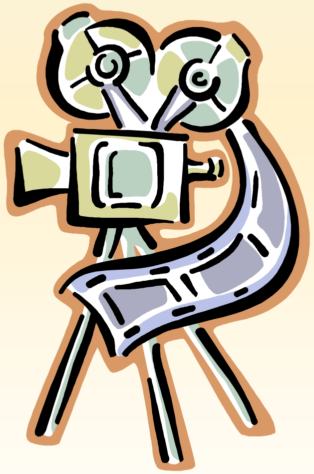
Ribosome links adjacent amino acids with a peptide bond, causing the amino acid to let go of it tRNA.

Finished protein has a sequence of amino acids that have been determined by the mRNA base sequence which has been translated by the tRNA.



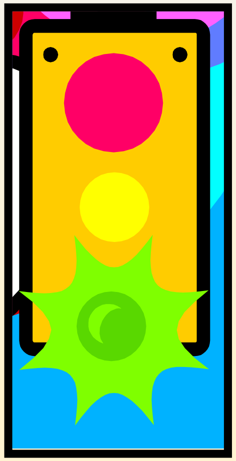
Elongation occurs until a stop signal occurs.

- **Termination:-**



1. Ribosome reaches stop codon
2. Ribosome falls off mRNA
3. Protein (polypeptide chain) is released

Start and Stop Codons

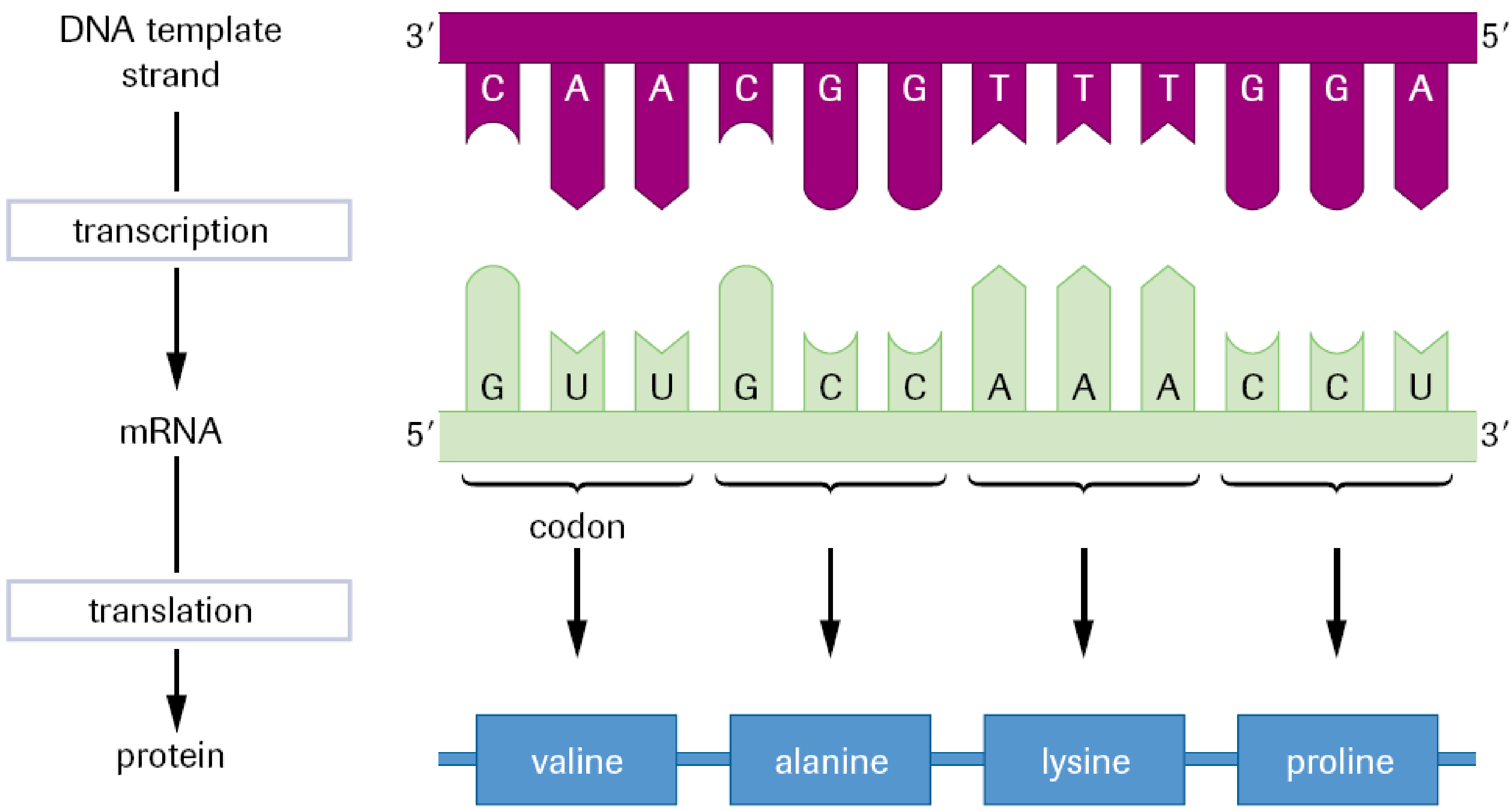


Start Codon:

- Begins translation
  - AUG (universal start codon)
    - ALSO Codes for methionine (Met)
  - Can also start with GUG or UUG

Stop Codon:

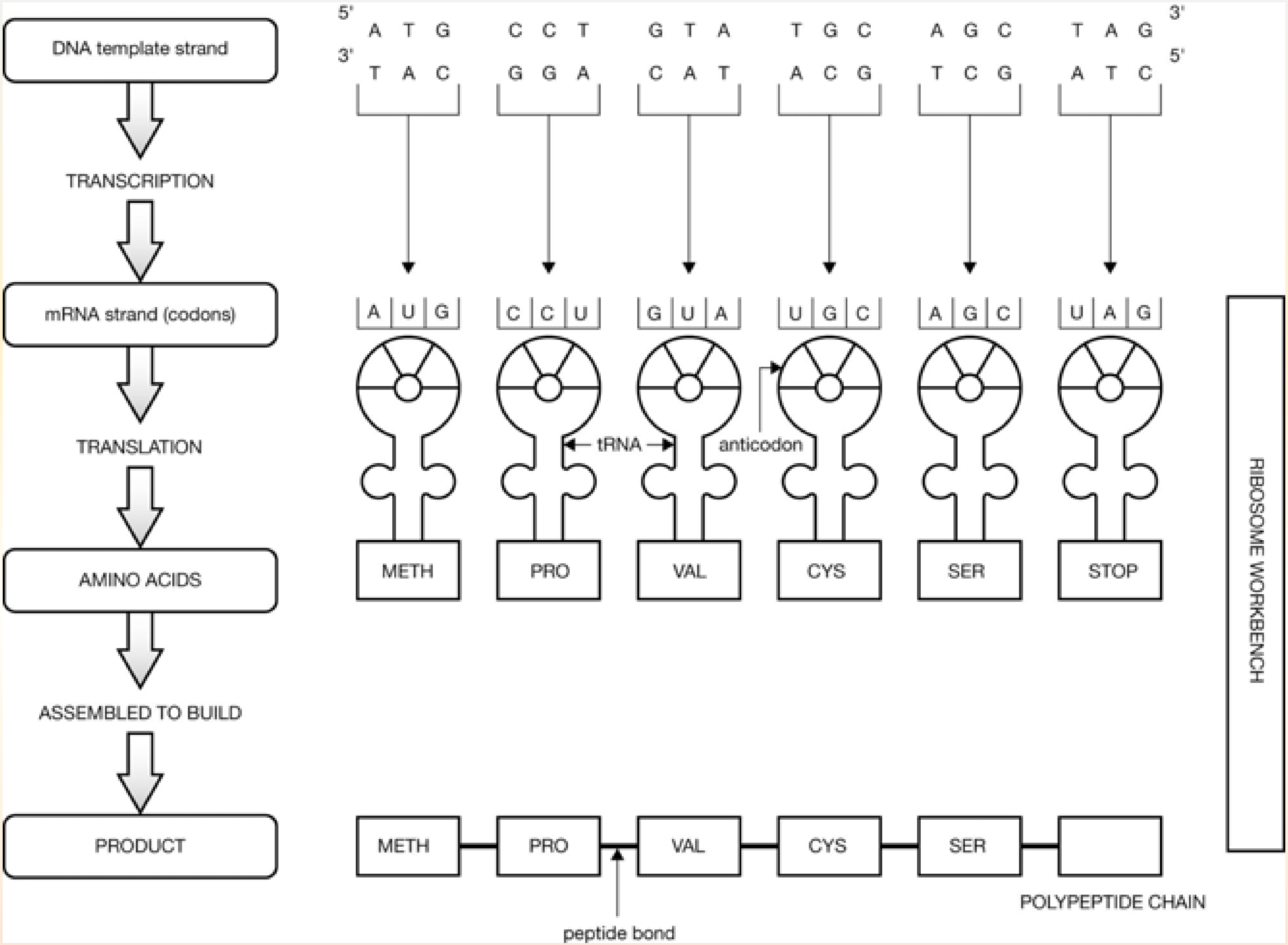
- Ends translation
  - UGA, UAA, UAG


DNA template strand
transcription
mRNA
translation
protein
3′
5′
C A A C G G T T T G G A
G U U G C C A A A C C U
5′
3′
codon
valine
alanine
lysine
proline

Example

- DNA template:
  3' TAC ACA CGG AAT GGG TAA AAA ACT 5'

- Complimentary DNA
  - Read from DNA template (start reading at 3')
- mRNA codon
  - Read from DNA template (start reading at 3')
- tRNA anticodon
  - Read from mRNA
- Amino Acids (protein)
  - Read from mRNA


DNA template strand
TRANSCRIPTION
mRNA strand (codons)
TRANSLATION
AMINO ACIDS
ASSEMBLED TO BUILD
PRODUCT
5' A T G C C T G T A T G C A G C T A G 3'
3' T A C G G A C A T A C G T C G A T C 5'
A U G C C U G U A U G C A G C U A G
tRNA
anticodon
METH PRO VAL CYS SER STOP
METH PRO VAL CYS SER
peptide bond
POLYPEPTIDE CHAIN
RIBOSOME WORKBENCH

Change in **3rd** Base May Not Result in Error

- Why not?
  - Amino acids have more than one codon

- Example: proline
  - Codons CCU, CCC, CCA, and CCG
  - CC - always codes for proline
  - Third base/nucleotide does not matter

Anticodons

Amino Acid	Possible Codon	Corresponding Possible Anticodon
Threonine	ACU ACC ACA ACG	UGA UGG UGU UGC
Alanine	GCU GCC GCA GCG	CGA CGG CGU CGC
Proline	CCU CCC CCA CCG	GGA GGG GGU GGC