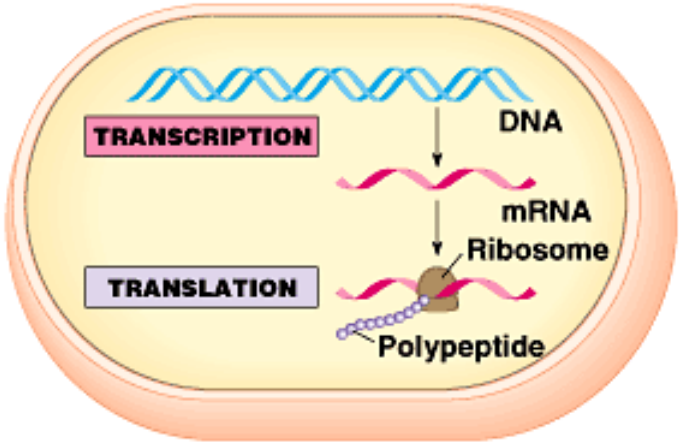
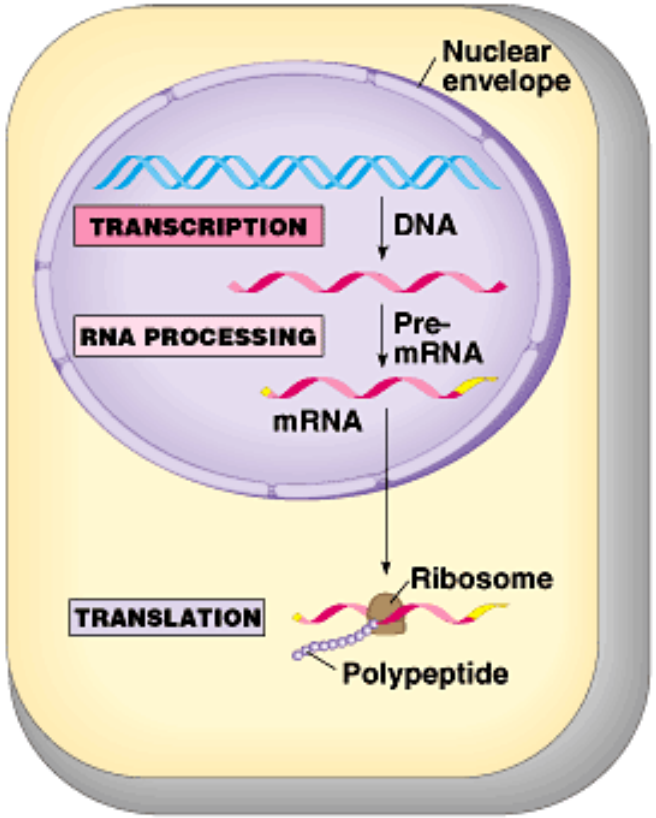
Gene Expression and Protein Synthesis

- **Gene Expression and Protein Synthesis**
- In order to take the coded instructions of the DNA sequence and take that information and use it to create a protein with exactly the proper sequence of amino acids (therefore the proper structure therefore the proper information)….
- A mechanism must exist for "reading' the DNA and "transforming" the code.



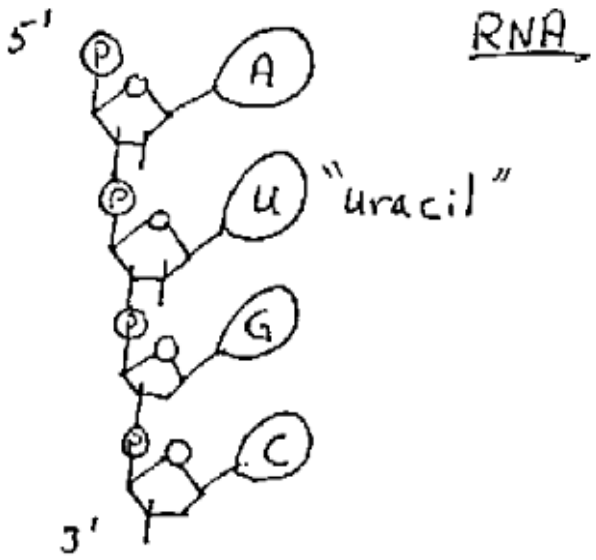
(a) Prokaryotic cell



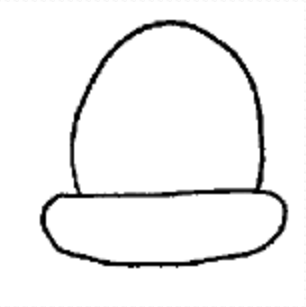
(b) Eukaryotic cell

RNA Structure

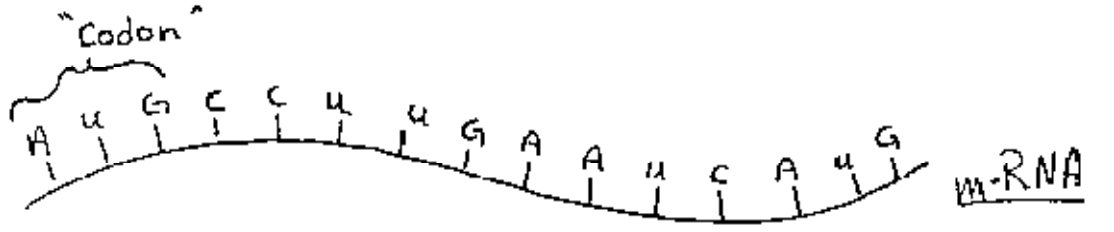
Recall the RNA is a type of nucleic acid with **only one strand** made with **ribose** instead of **deoxyribose** and using **uracil** instead of **thymine**.



- **There are three Types of RNA**
- **Type #1 Ribosomal RNA (rRNA)**
- This type of RNA is made in the **nucleotides** of the nucleus. These molecules of RNA are used to make **ribosomes**. Ribosomes are compassed of two subunits that join during protein synthesis. Many other proteins and enzymes are involved in the ribosome structure.

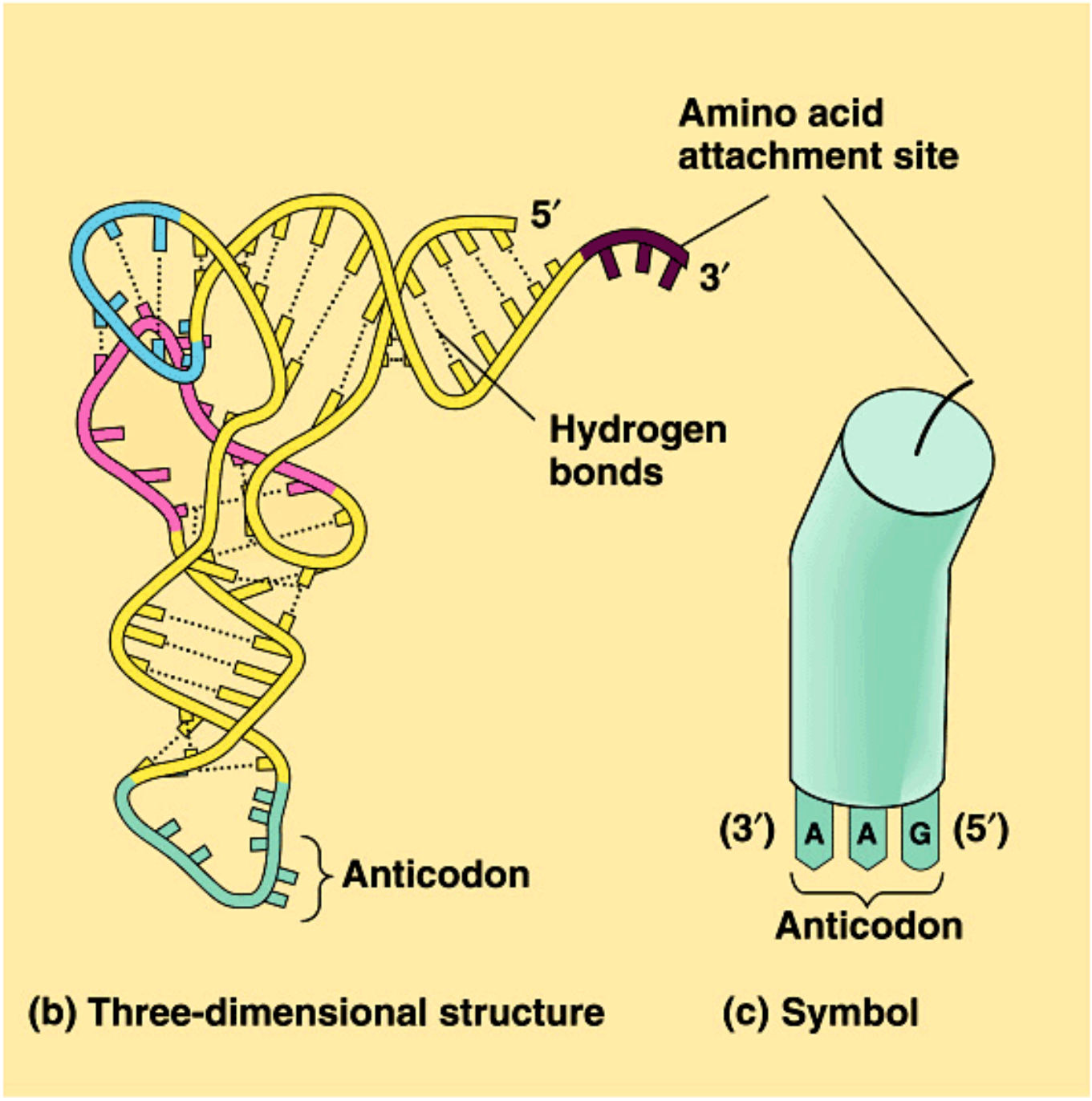


- Ribosomes are found attached to the endoplasmic reticulum (rough) and in the cytoplasm and are the site of protein polymerisation (synthesis).
- **Type #2 Messenger RNA (mRNA)**
- Messenger RNA carries the specific information that has been stored in the sequence of nucleotides in the DNA



- The mRNA carries the genetic message in the form of 3 letter "words" or **codons**.

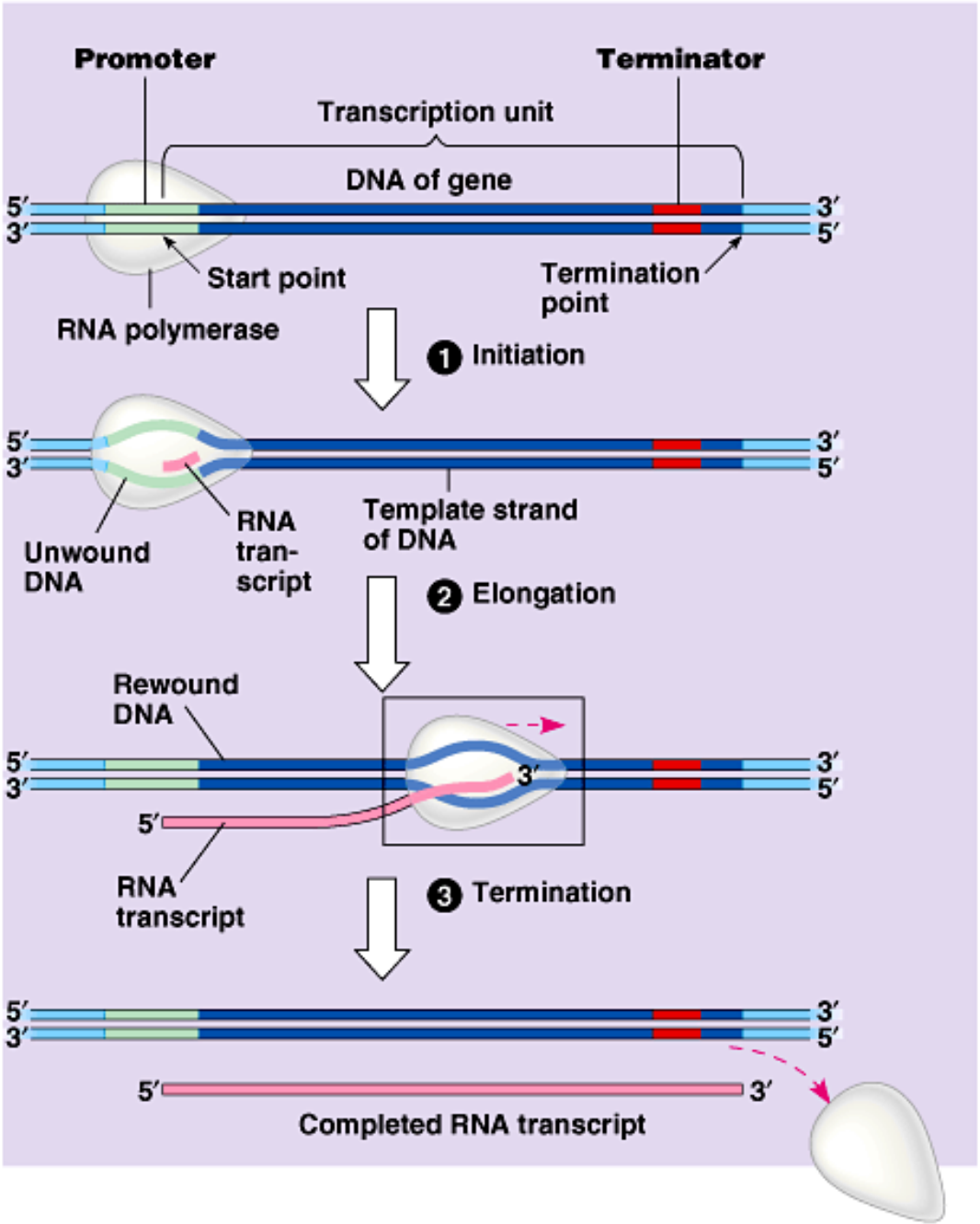
- **Type #3 Transfer RND (tRNA)**
- Transfer RNA's are small, folded chains of nucleotides which have a specific 3 letter anticodon which complementary base pairs with the codon word in the mRNA. Each tRNA also carries a specific **amino acid**, which it brings to the ribosome when the **mRNA** is "read".



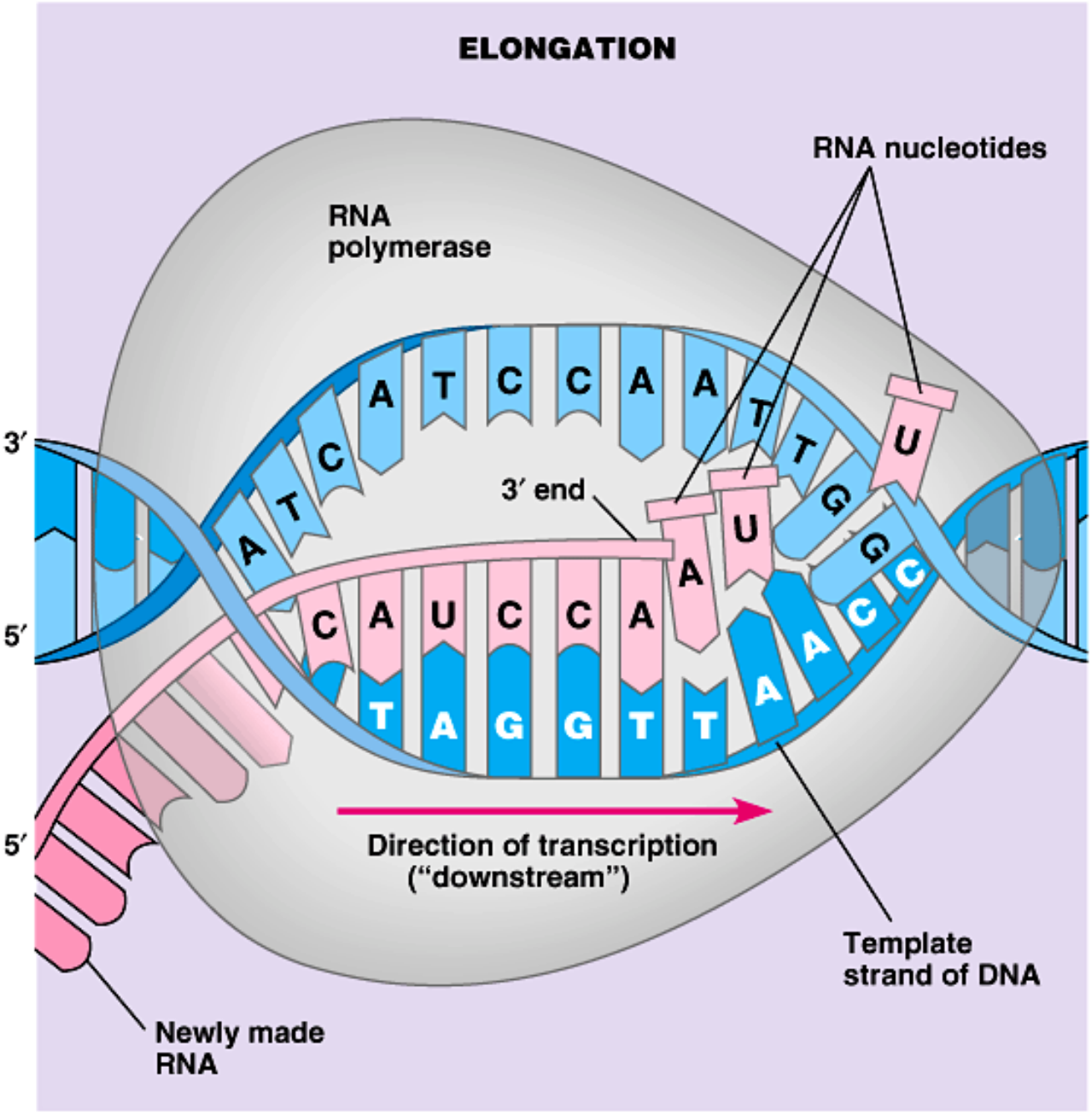
Protein Synthesis

1. Transcription

- Creation of a strand of **mRNA** from the DNA template. DNA is unwound and one strand is exposed to be used as a template. This is called the "sense strand".
- This transcription of the DNA into a mRNA strand is accomplished by a **transcription complex** that consists of the enzyme helicase (which unwinds the DNA and the enzyme **RNA polymerase**).

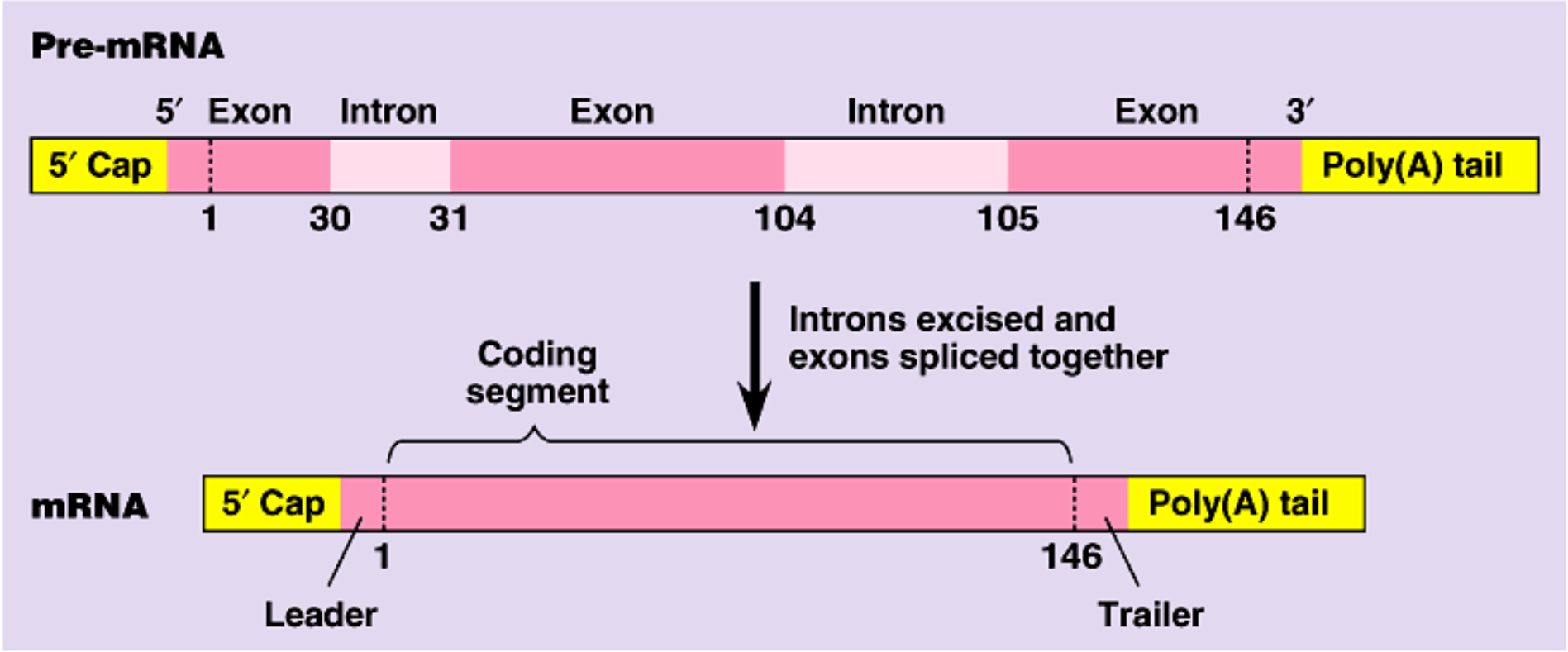


- Transcription begins at special DNA sequences known as "**promoters**".
- As mRNA is created A is paired with U and G with C on the RNA strand.



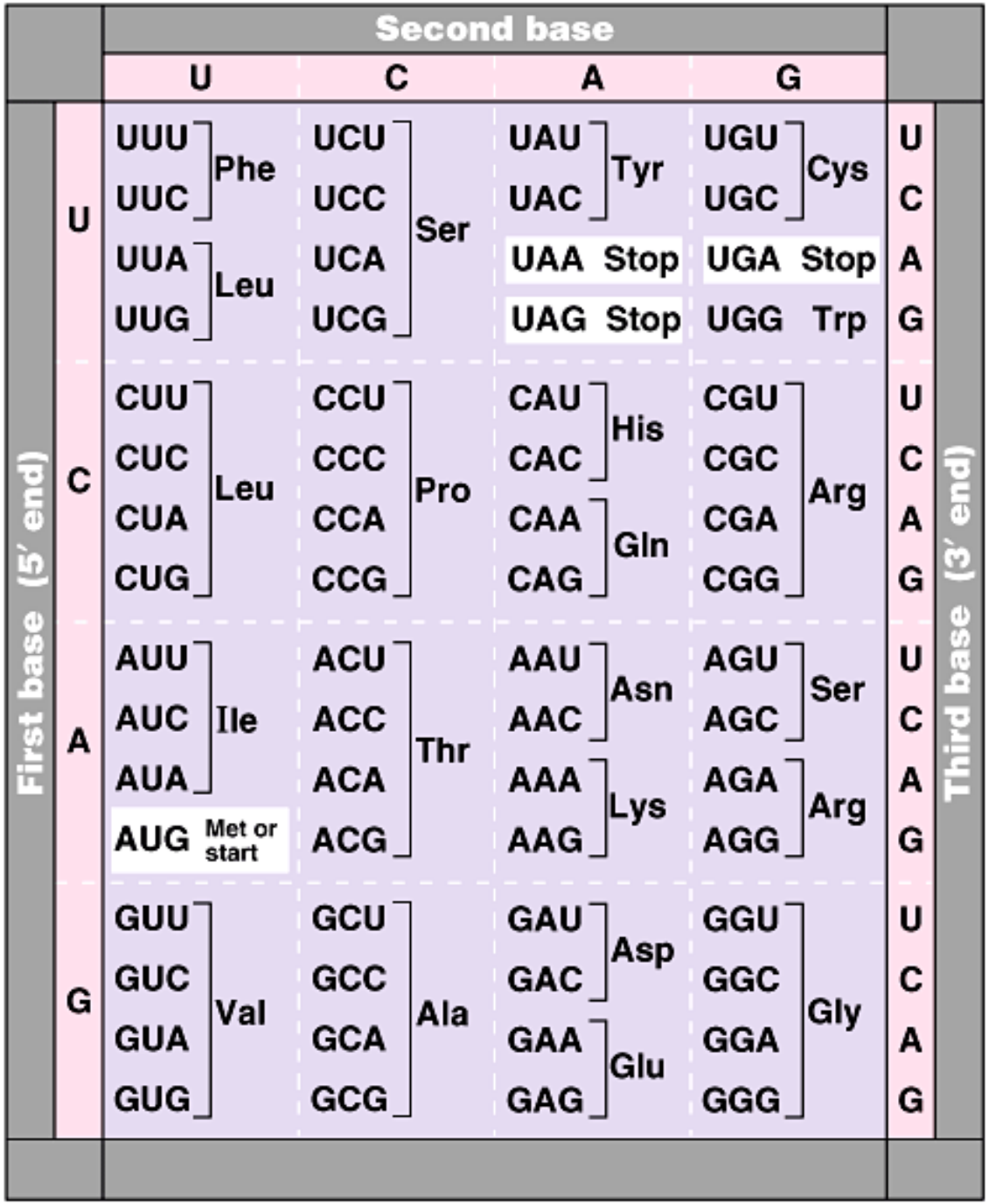
2. Processing of the mRNA Strand

- The long DNA template of one **gene** contains long stretches of a nucleotide sequence that **DO NOT CODE FOR ANY PART OF THE POLYPEPTIDE**. These nontranslated portions are called **intervening sequences** or **introns**.
- **Introns must be excised.**



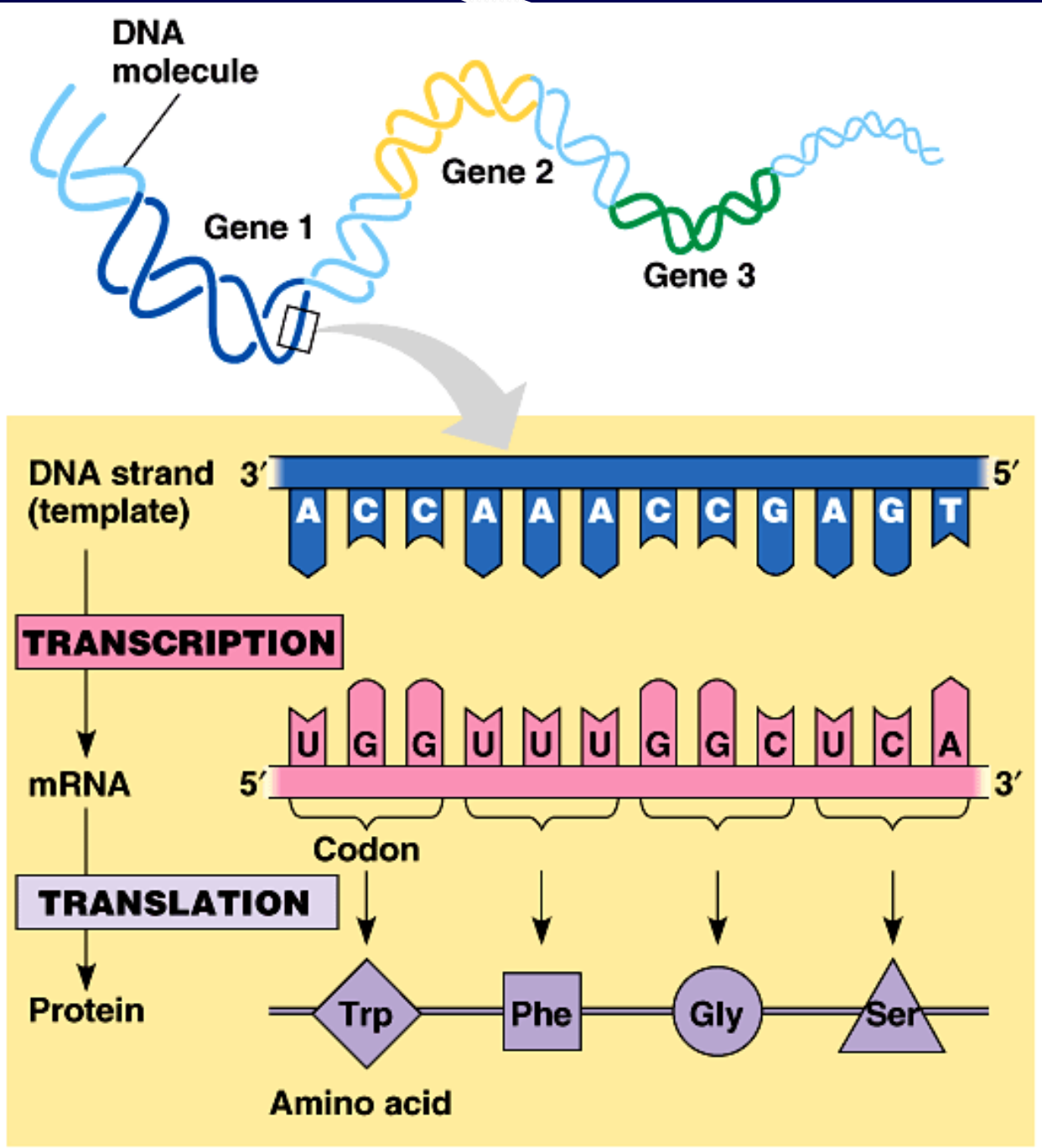
- Exons are now ready for transport into the cytoplasm to begin **translation**.
- The intron, which does not code for any portion of protein after it has been removed, simply degenerates, the nucleotides returning to the nucleotide pool.

- **The Sequence of mRNA**
- **The Message of the Genetic Code**
- The mRNA in the form of 3 letter "words" called codons carries the genetic message.



- Each codon specifies one of 20 different amino acids
- There are 64 codons (representing all the ways [illegible] groups of
- 3). Some amino acids have more than one codon, which specifies them.
- Eg.:
- Serine = UCU or UCC or UCA or UCG.
- Or
- Leucine = UUA or UUG
- **Some codons do not actually code for an amino acid BUT** are in a sense "**punctuation marks**".
- Eg.:
- UAA, UAG , UGA = "STOP"
- That is when any of these three codons appear in the message the "reading" process is stopped.
- **There is also a "START" codon - AUG**
- However the AUG also codes for methionine (Met) therefore, all polypeptides will begin with Met as their first amino acid. **BUT** not all proteins have Nut at the first position therefore, it may be removed, by enzymes later if need be. If AIUG in appears in the middle of a message it is simply coded by the system as Met.

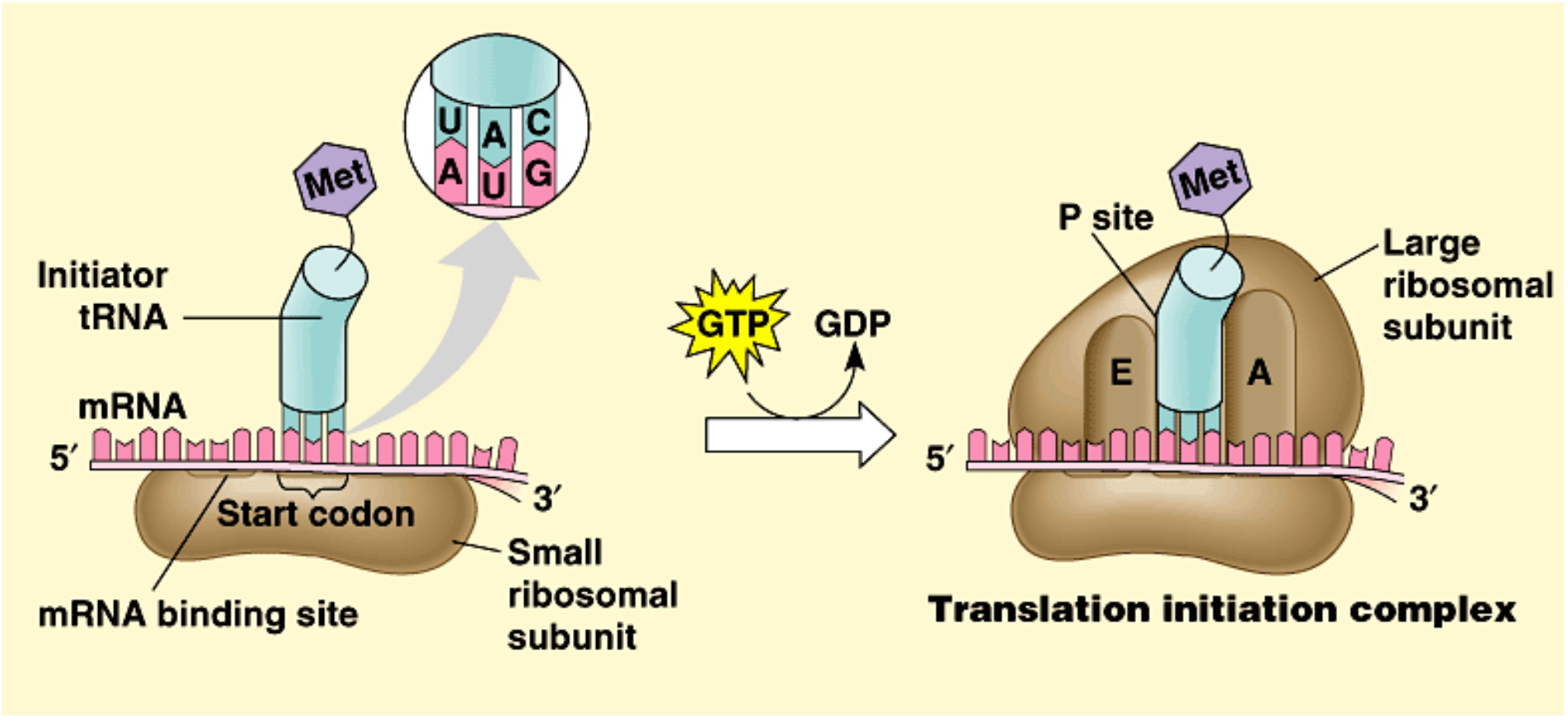
- **Principle of Co-linearity**
- "The linear order if the DNA nucleotides (determines) corresponds to the order of the mRNA nucleotides which determines the order of the amino acids in the polypeptide.



3. Translation of mRNA

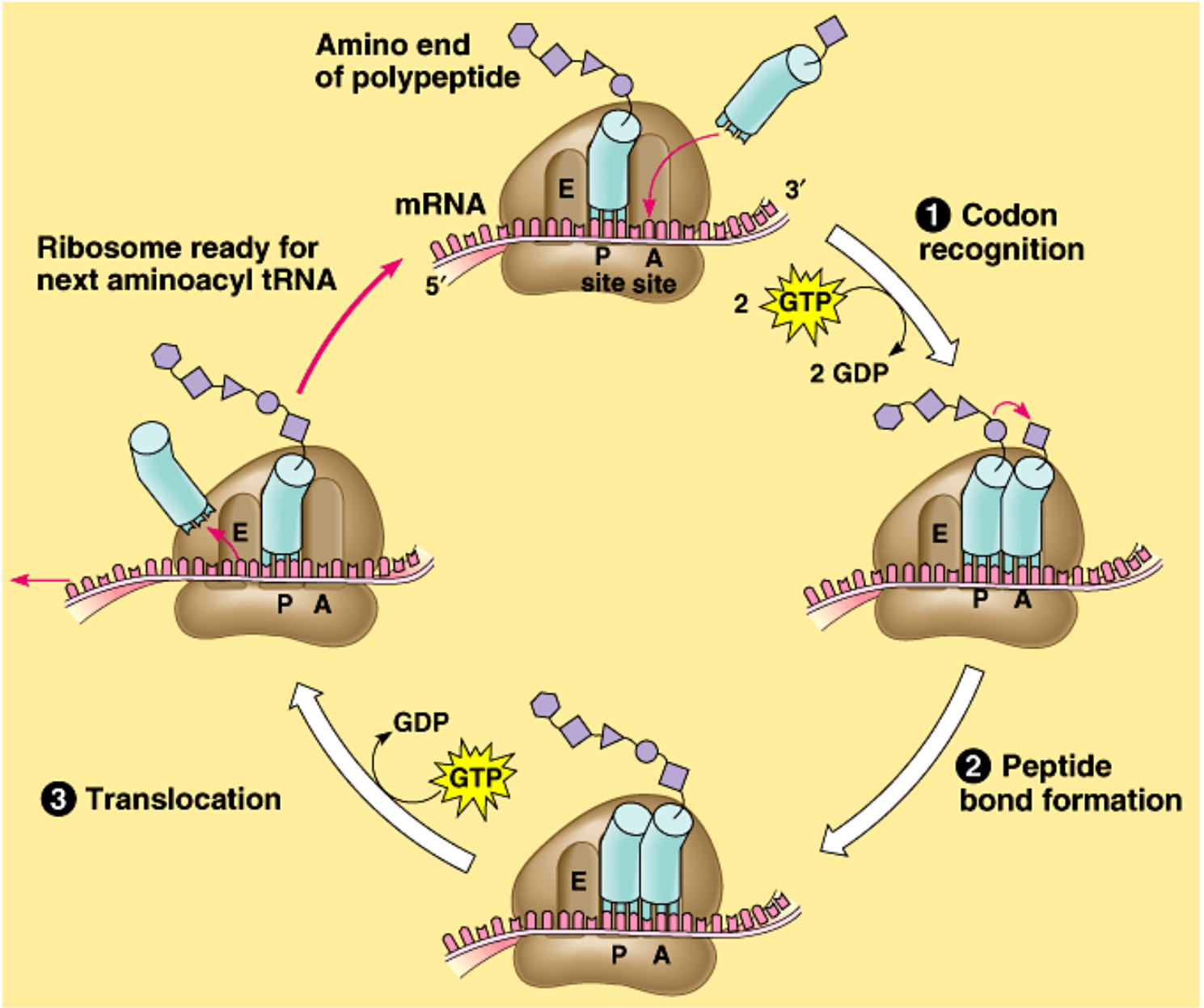
- How to "translate" the mRNA message into amino acid sequence of the polypeptide.
- **"Ribosomes are the vital organising centres for assembling polypeptides. mRNA is "read" and transferred RNA brings specific amino acids to the ribosome for insertion into the protein."**

Step #1

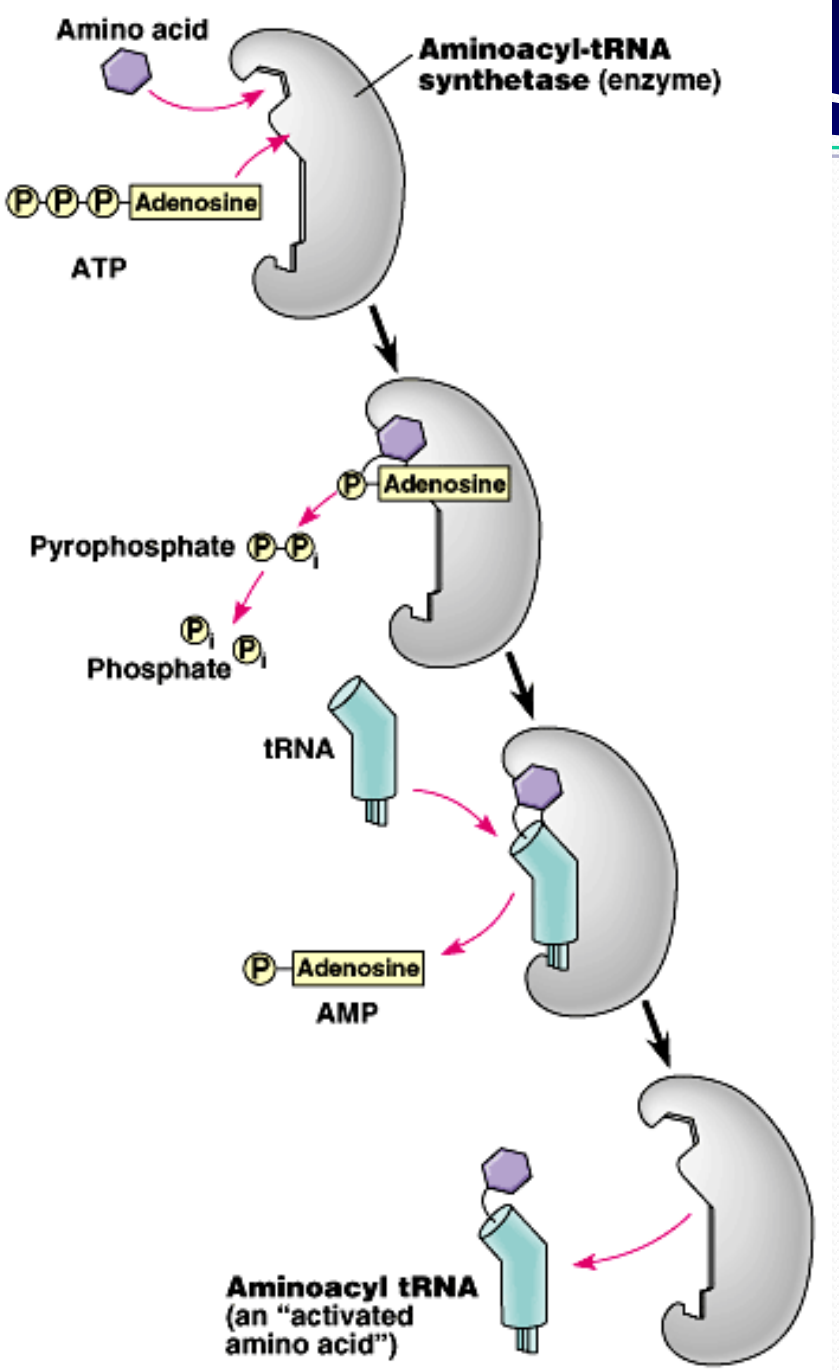


- The ribosome moves onto the messenger RNA and begins translation of the mRNA codons from the start AUG codon.

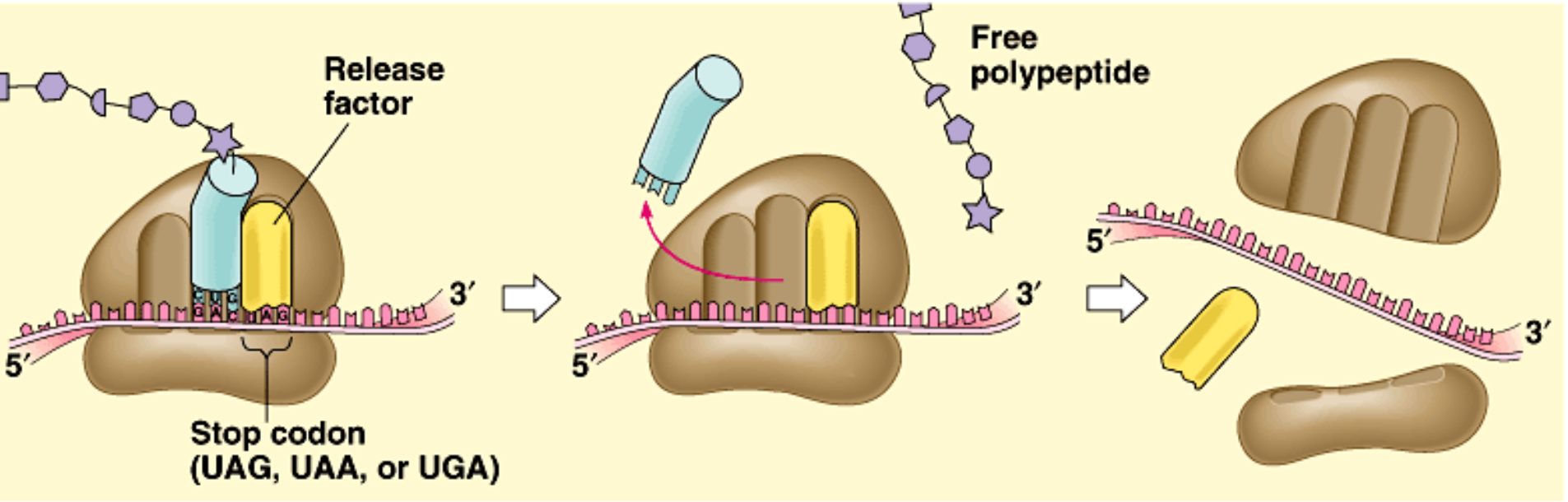
Step #2



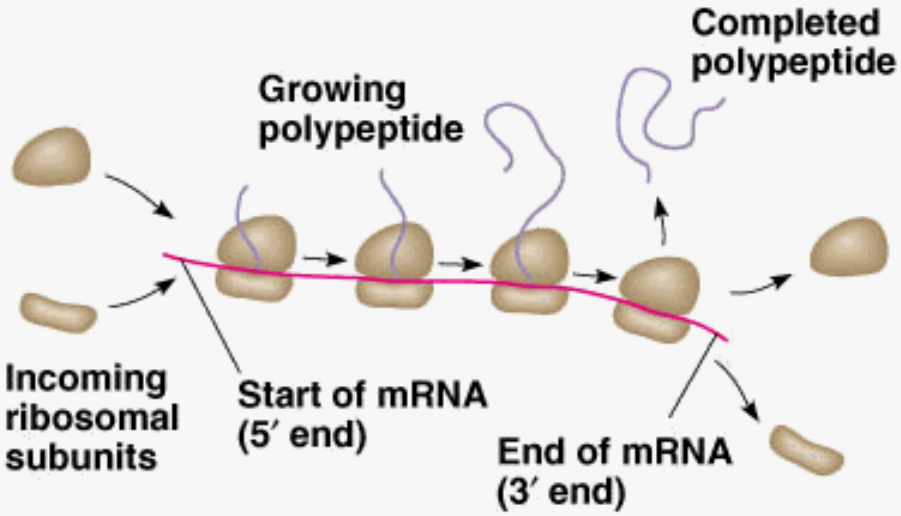
- The ribosome provided a location for the complementary **anticodon** of the +RNA to base pair with the codon of the mRNA.
- As the ribosome base pairs the appropriate codons (mRNA) with the tRNA anticodon a peptide bond is formed between the two adjacent amino acids.
- At this point the tRNA portion of the first amino acid falls off and returns to the tRNA pool to become charged with another Amino acid and the process continues…
- A transfer RNA molecule complete with its specific amino acid is referred to as a **charged tRNA**.



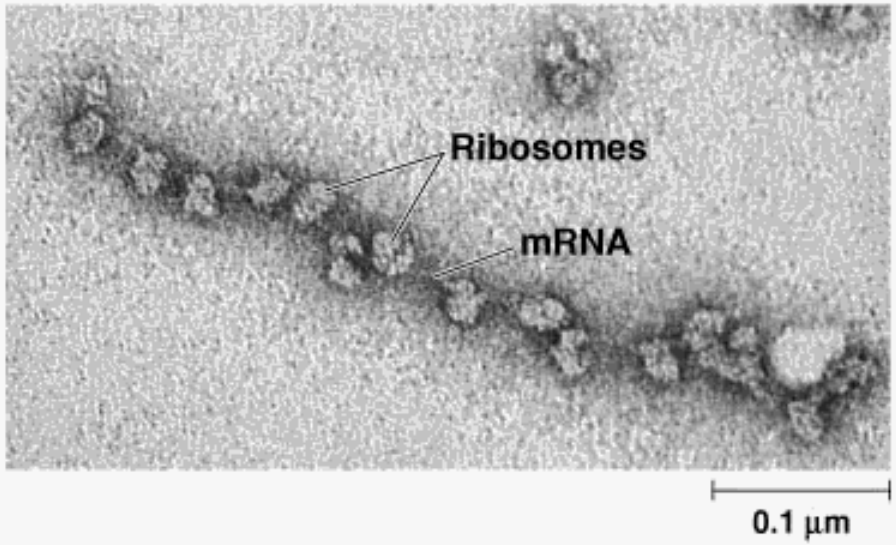
- **Final step (termination)**
- When the ribosome reaches the UAA terminator codon the translation process stops. Other ribosomes may also translate the mRNA into other copies of the protein **OR** the mRNA can be degraded and the nucleotides returned to the nucleotide pool.



- Many ribosomes can transcribe the same piece of mRNA creating many copies of the same protein.



(a) An mRNA molecule is generally translated simultaneously by several ribosomes in clusters called polyribosomes.



(b) This micrograph shows a large polyribosome in a prokaryotic cell (TEM).

http://kentsimmons.uwinnipeg.ca/cm1504/proteinsynth.htm