BHARATHIDASAN UNIVERSITY

Tiruchirappalli- 620024,
Tamil Nadu, India

Programme: M.Sc., Biomedical science

Course Title : Molecular Biology

Course Code : BM35C5

Unit-IV

TOPIC: Mechanism of protein synthesis

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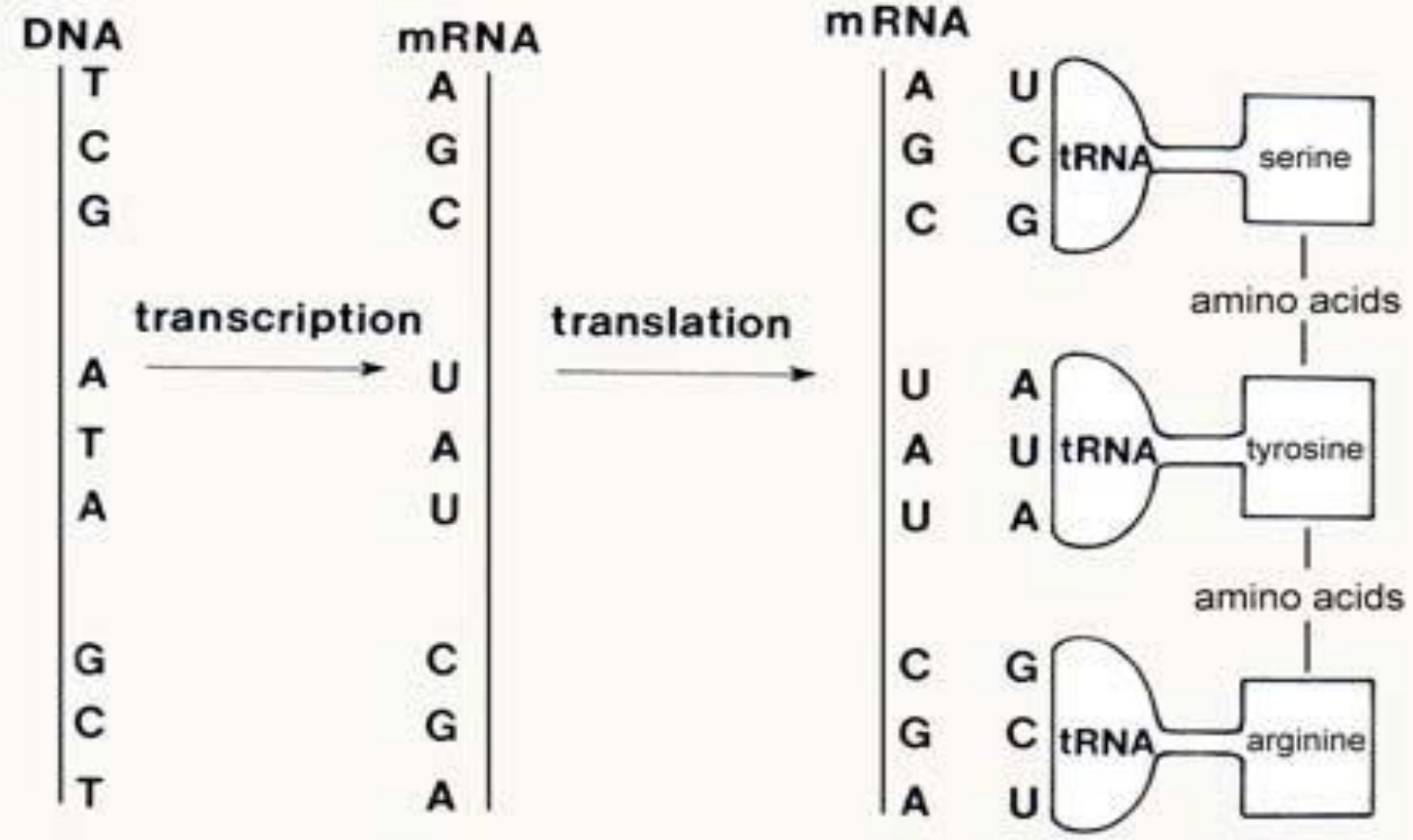
Protein Synthesis Notes

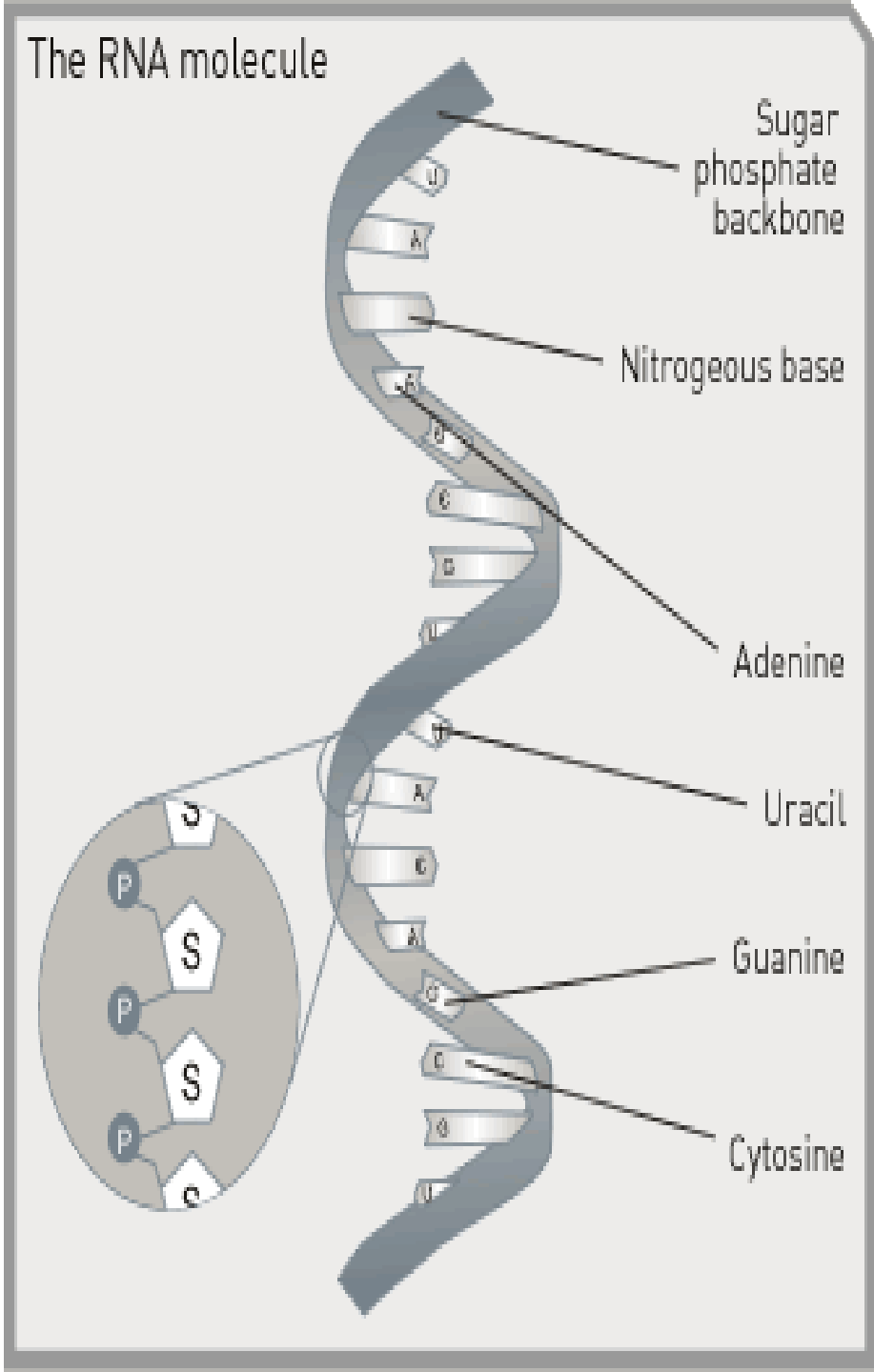


Genetic information (genes) coded in DNA provide all the information needed to assemble proteins.

If DNA <u>cannot</u> leave the nucleus – How can it get the instructions out to make the proteins needed to survive??????

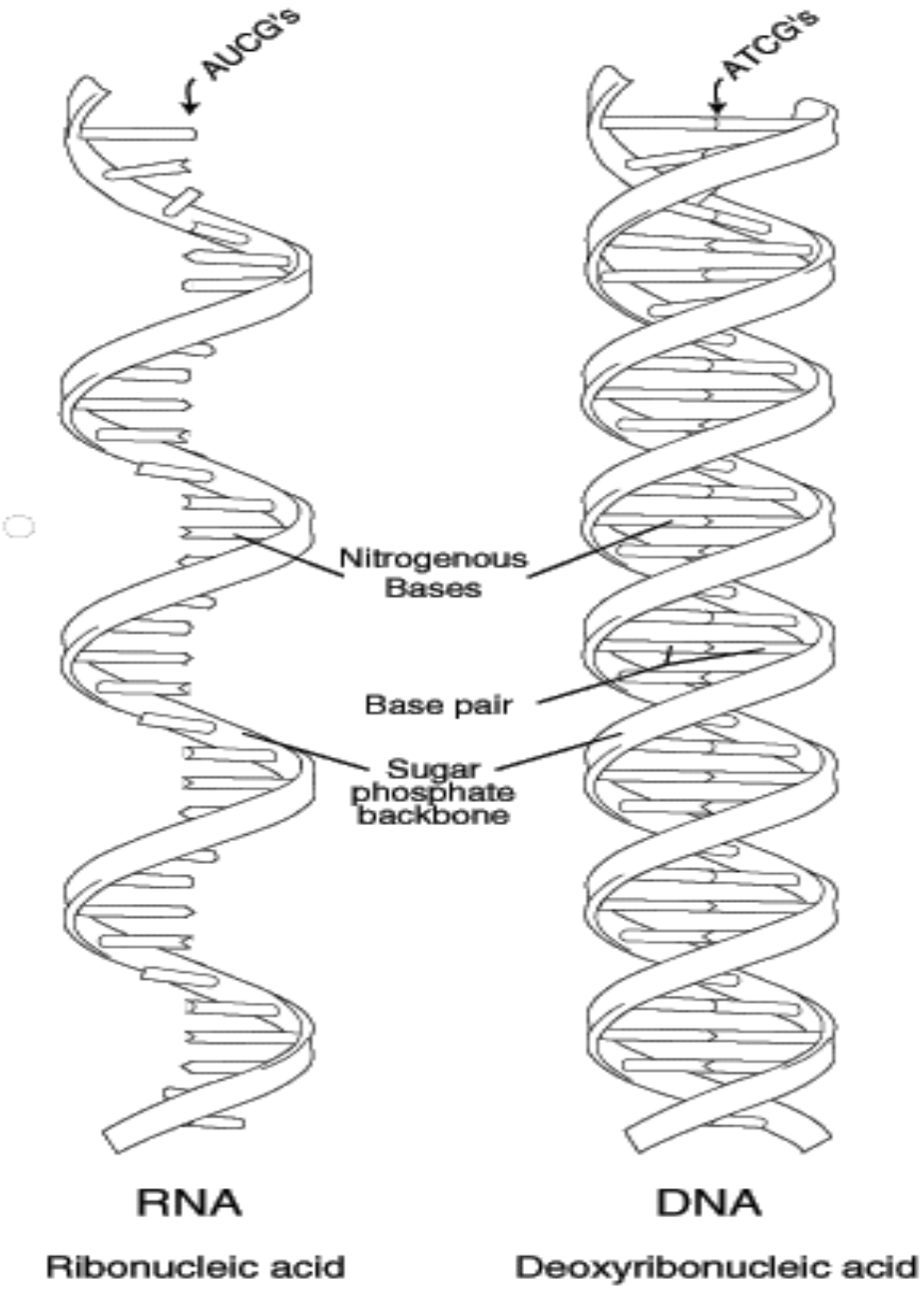
RNA

1. Contains the <u>sugar ribose</u> instead of deoxyribose.
2. <u>Single-stranded</u> instead of double stranded.
3. <u>Contains uracil</u> in place of thymine.



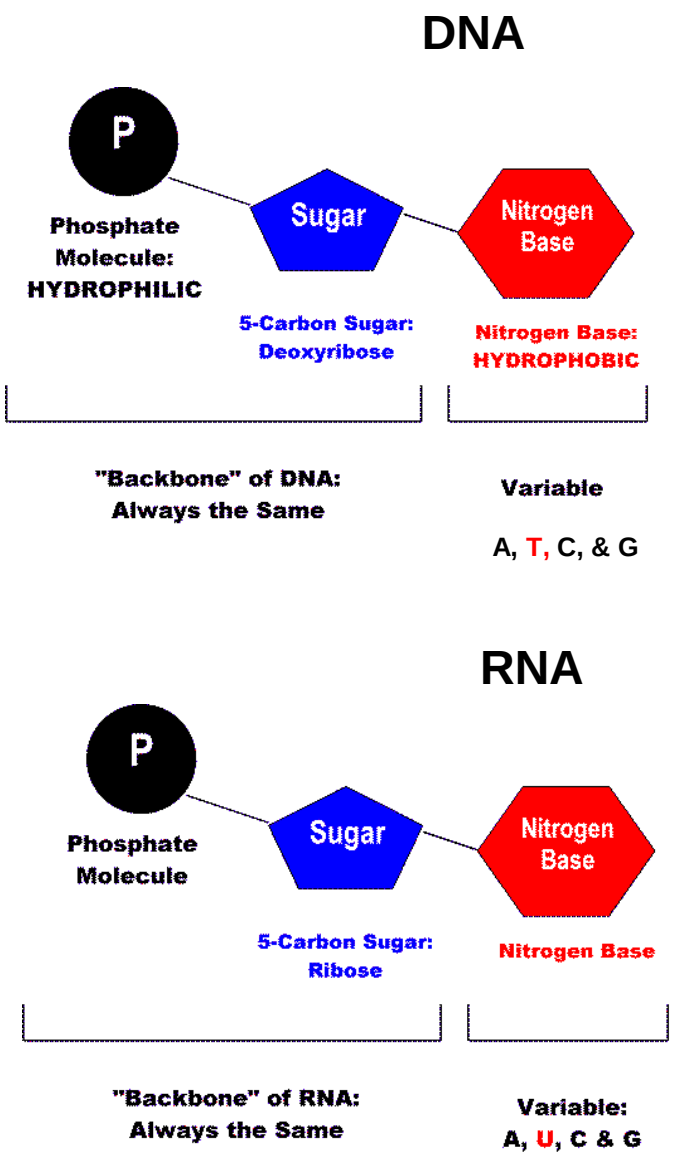
RNA Contains:

1. Adenine
2. Cytosine
3. Guanine
4. Uracil (not Thymine)



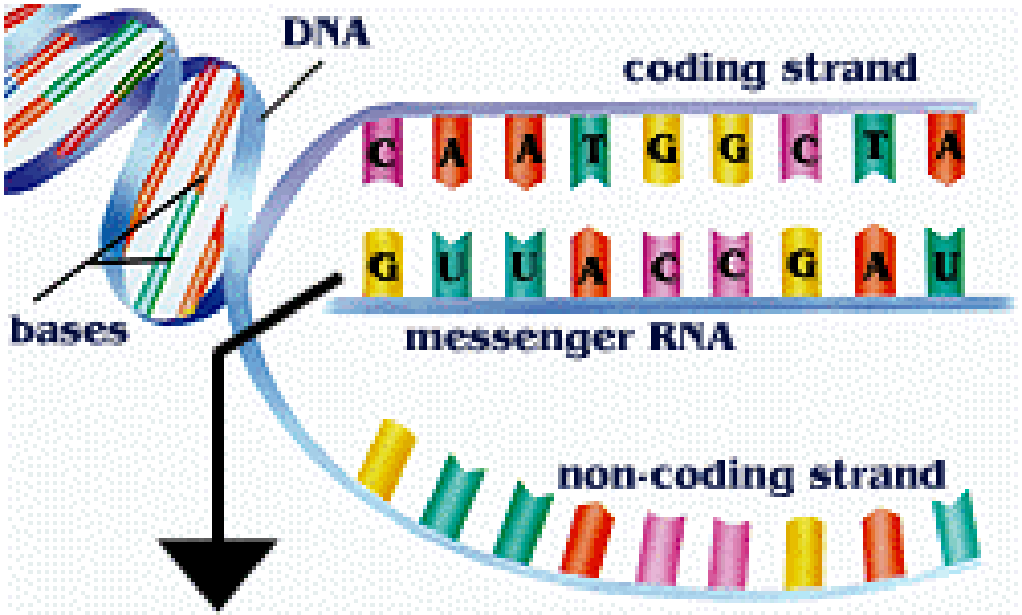
Comparison of DNA and RNA

- 3 Main differences between DNA & RNA
  1. Sugar:
     a. DNA: Deoxyribose
     b. RNA: Ribose
  2. Nitrogen Bases:
     a. DNA: A, T, C, G
     b. RNA: A, **U**, C, G
        – U = **uracil**
  3. Number of strands that make up the molecule:
     a. DNA: two strands
     b. RNA: one strand



Three Main Types of RNA

1. Messenger RNA (mRNA) - Carries copies of instructions, for the assembly of amino acids into proteins, from DNA to the ribosome (serve as “messenger”)
   * Made in the nucleus



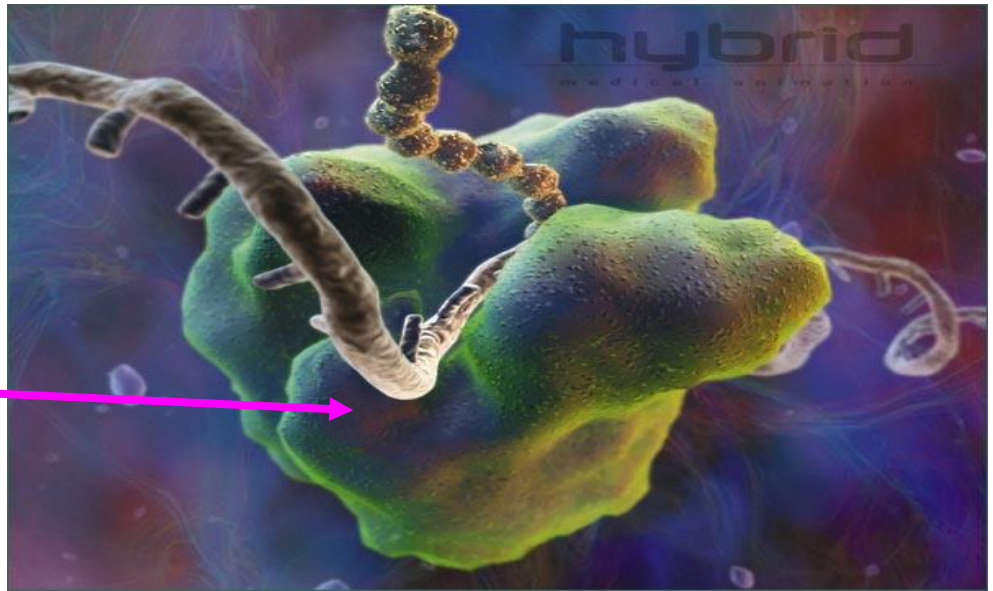
Three Main Types of RNA

2. <u>Ribosomal RNA (rRNA)</u> – Makes up the major part of ribosomes, which is where proteins are made.

* made in the nucleolus

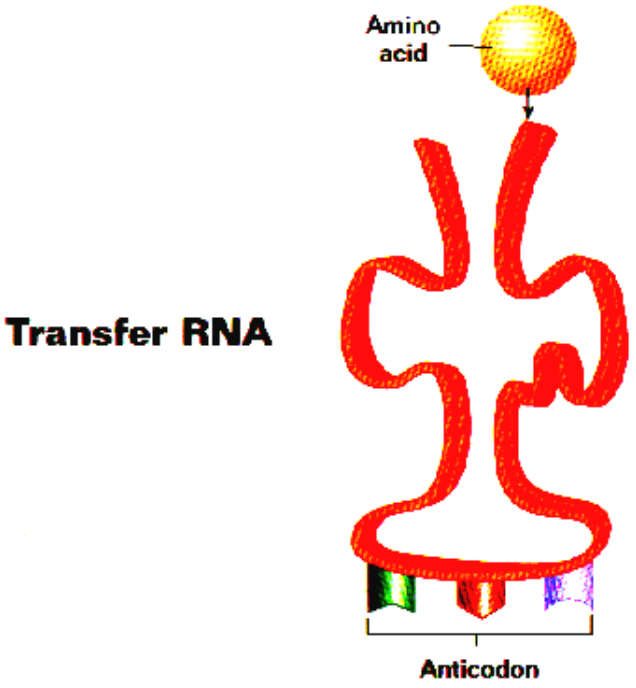
1 ribosome = 4 molecules of rRNA and 82 proteins

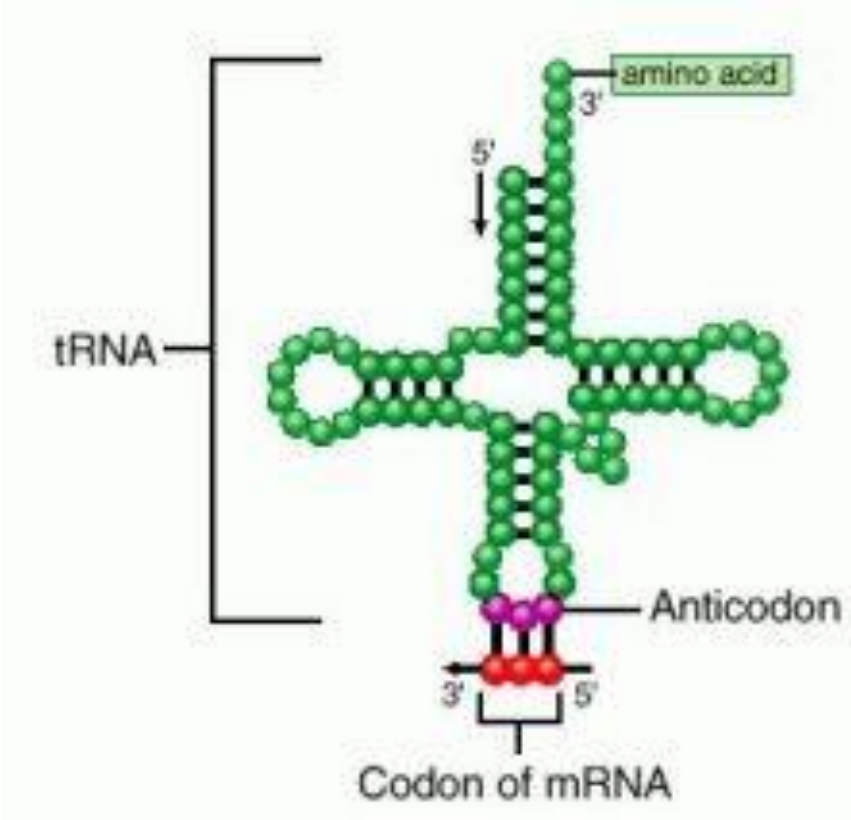
Ribosomal RNA



Three Main Types of RNA

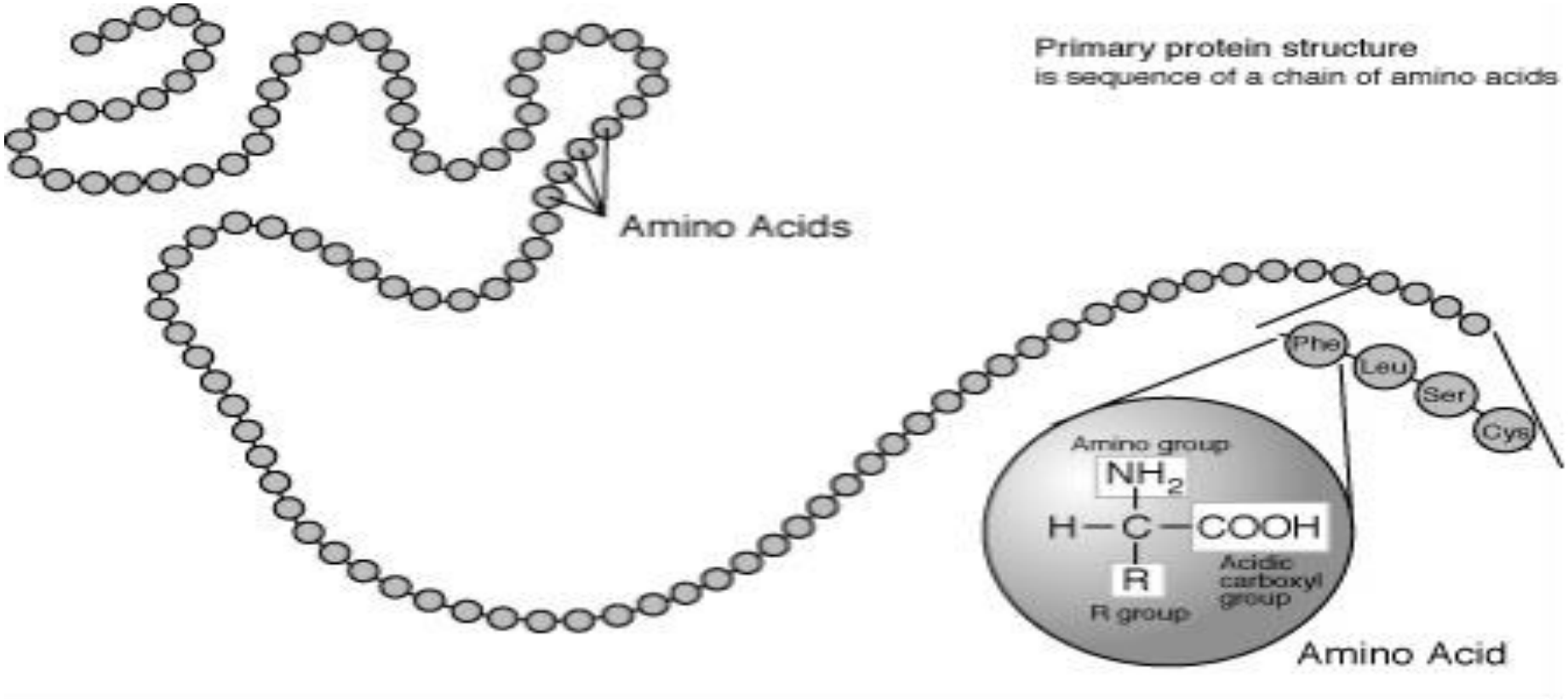
3. <u>Transfer RNA (tRNA)</u> – Transfers (carries) amino acids to ribosomes as specified by codons in the mRNA





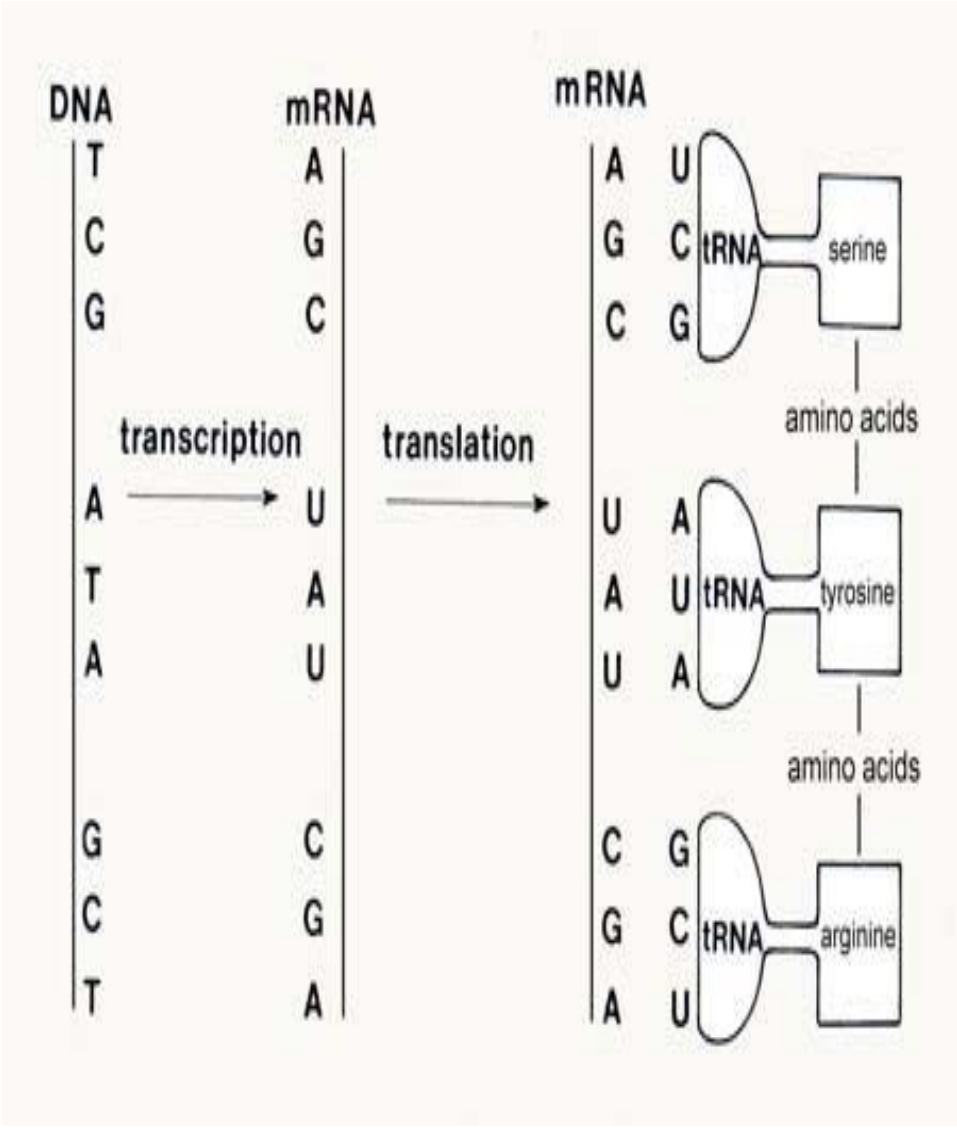
Proteins

- Proteins are made up of a chain of amino acids.



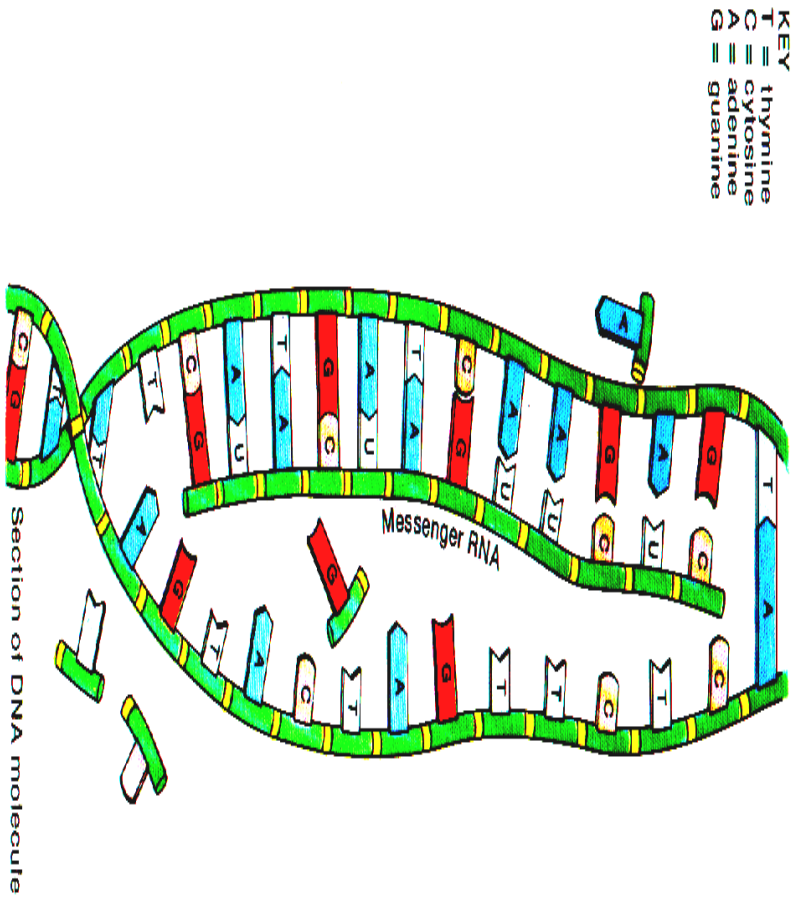
2 Steps to Make a Protein

1. Transcription
   - DNA → RNA
2. Translation
   - RNA → Protein (Chain of amino acids)



Step 1: Transcription

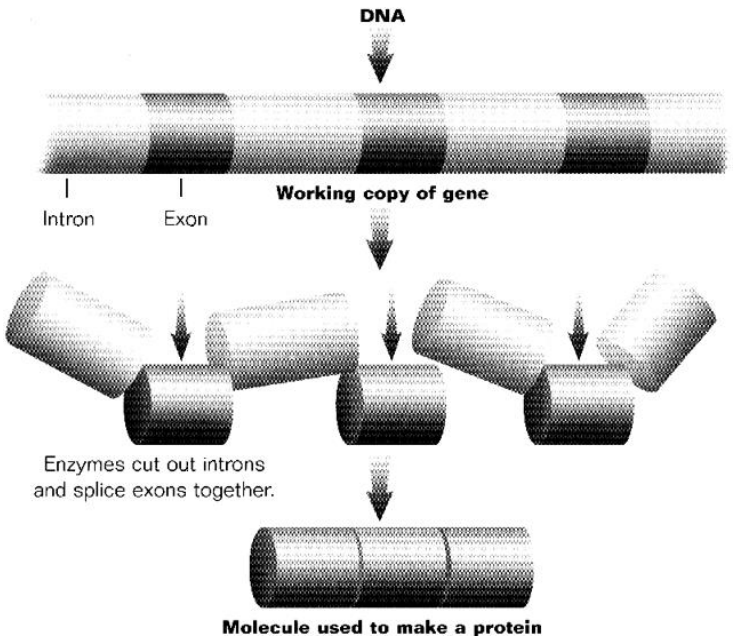
1. Transcription: a complementary single strand of mRNA is copied from part of the DNA in the nucleus
   a. **RNA Polymerase**, an enzyme, unwinds DNA strand
   b. RNA polymerase "reads" one strand of DNA bases and makes the RNA strand
      - If DNA is TACCAGTTT
      - mRNA will be AUGGUCAAA



c. mRNA leaves and DNA strands will coil back up

Step 1b: mRNA editing

1. mRNA editing: cutting and splicing mRNA before it leaves the nucleus
   a. Introns- (intruders) "junk DNA" that doesn't code for proteins are cut out
   b. Exons- "good DNA" that code for proteins stay and are expressed
2. Introns are removed and exons are spliced together.
3. Edited mRNA is sent out of nucleus to ribosome



(the exons can be spliced together in different sequences to produce different mRNA's = different proteins)

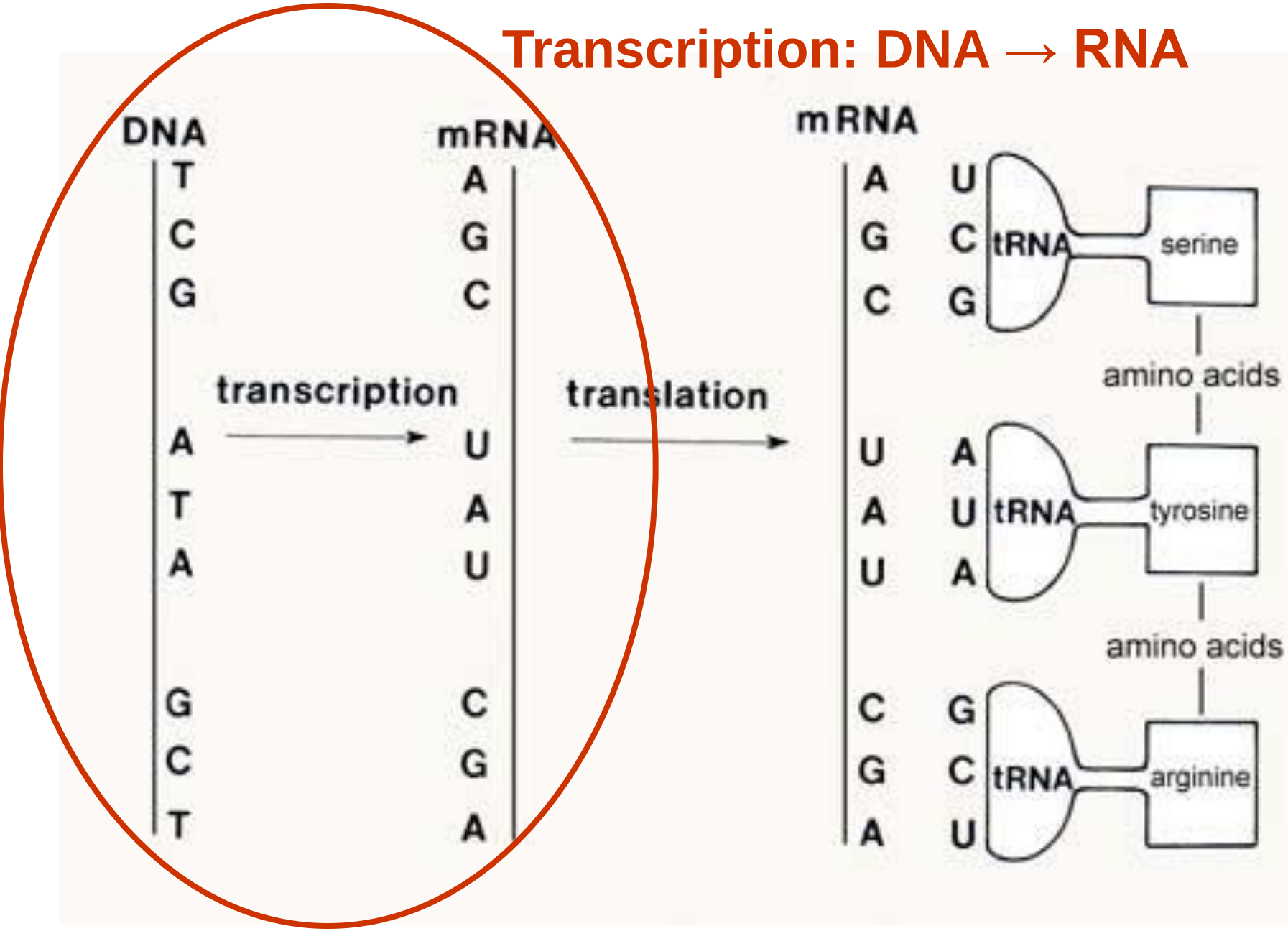
Fun FACT:

- Over 98% of the human genome is noncoding DNA (introns)… Evolution perhaps?!?

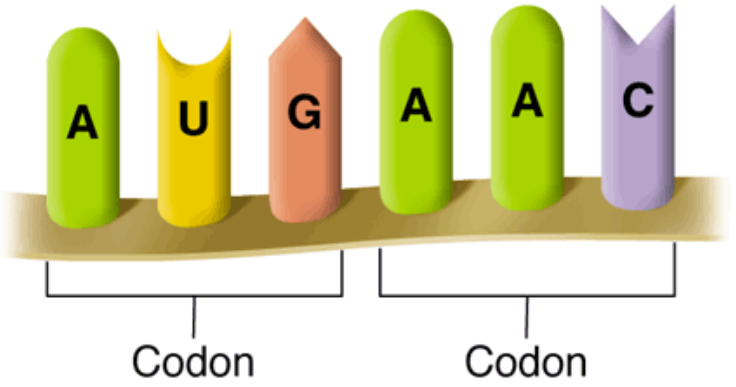
We have 25,000 genes but produce more than 100,000 diff proteins = splicing

Protein	Chrom	Gene	Length	Exons	Exon length	Intron length	Alt splicing
Breast cancer type 2 susceptibility protein	13	BRCA2	83,736	27	11,386	72,350	yes
Cystic fibrosis transmembrane conductance regulator	7	CFTR	202,881	27	4,440	198,441	yes

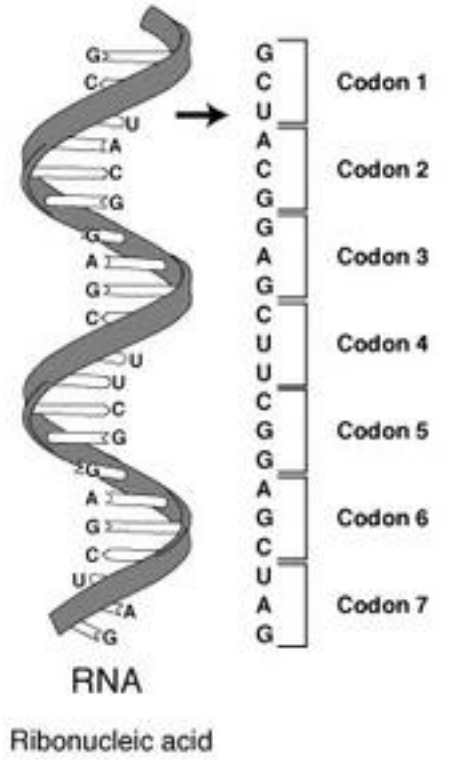
Transcription: DNA → RNA



Step 2: Translation



1. How the code is read:
    a. Every 3 bases on mRNA represents a code for an amino acid = <u>codon.</u>
    b. Amino acids are abbreviated most times by using the first 3 letters of the amino acid's name.
        - Met = methonine
        - Leu = leucine



Reading the Codon Chart

Examples:

AUG = Methionine

CAU = Histidine

UAG = Stop

Codon Chart

First Position	Second Position: U	Second Position: C	Second Position: A	Second Position: G	Third Position
U	Phenylalanine	Serine	Tyrosine	Cysteine	U
	Phenylalanine	Serine	Tyrosine	Cysteine	C
	Leucine	Serine	Stop	Stop	A
	Leucine	Serine	Stop	Tryptophan	G
C	Leucine	Proline	Histidine	Arginine	U
	Leucine	Proline	Histidine	Arginine	C
	Leucine	Proline	Glutamine	Arginine	A
	Leucine	Proline	Glutamine	Arginine	G
A	Isoleucine	Threonine	Asparagine	Serine	U
	Isoleucine	Threonine	Asparagine	Serine	C
	Isoleucine	Threonine	Lysine	Arginine	A
	Methionine	Threonine	Lysine	Arginine	G
G	Valine	Alanine	Aspartic acid	Glycine	U
	Valine	Alanine	Aspartic acid	Glycine	C
	Valine	Alanine	Glutamic acid	Glycine	A
	Valine	Alanine	Glutamic acid	Glycine	G

Try these:

GCU:

UAC:

CUG:

UUA:

Answers:

Alanine

Tyrosine

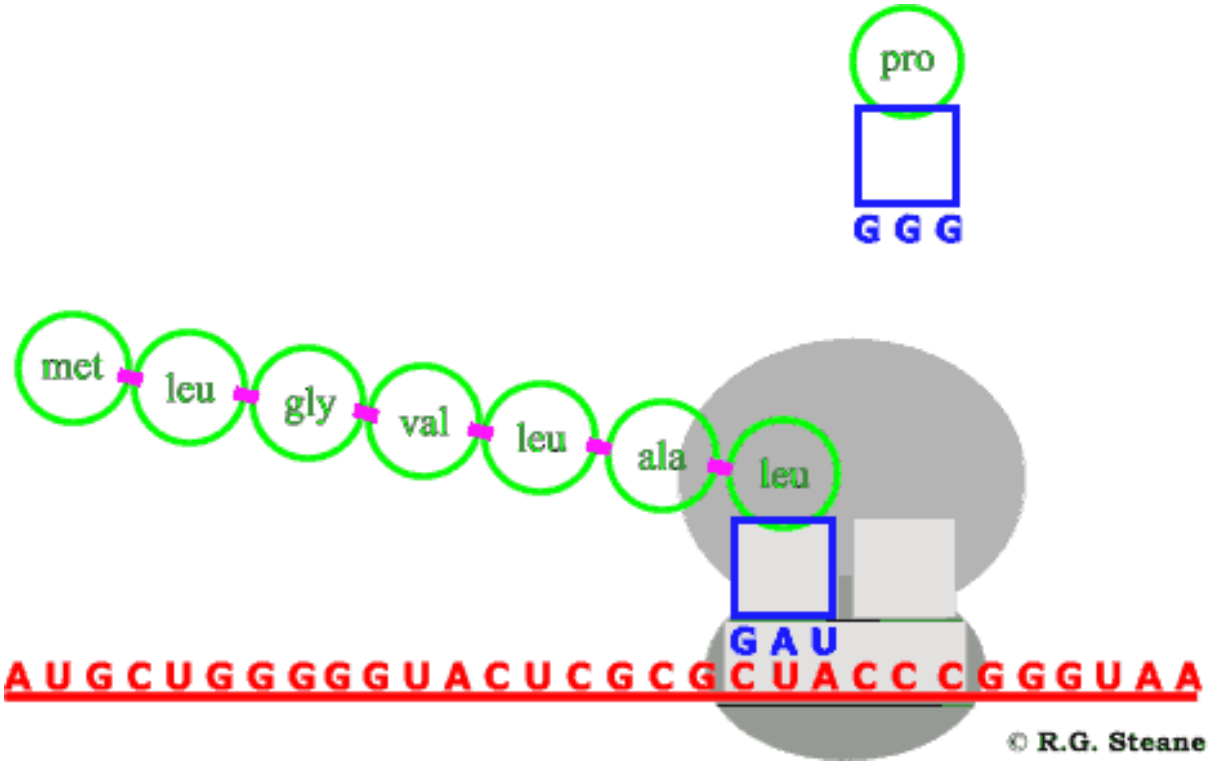
Leucine

Leucine

This chart only works for mRNA codons.

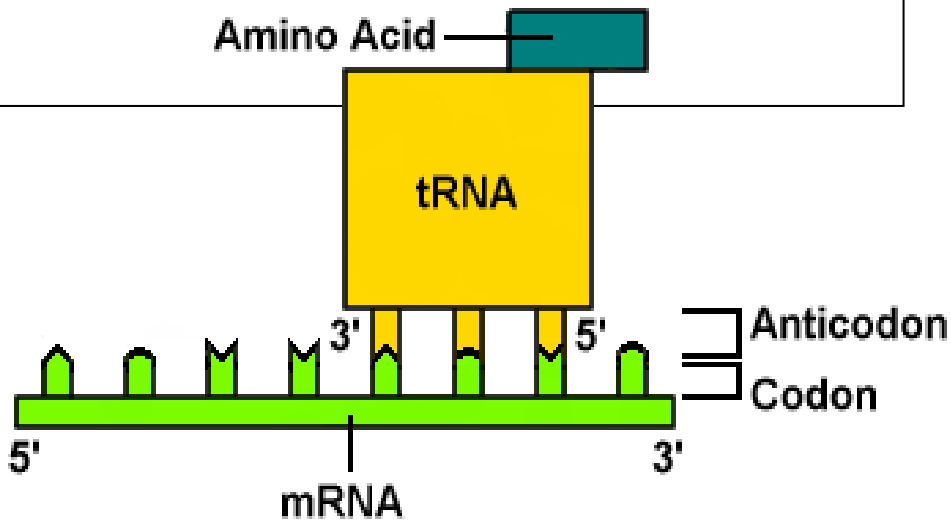
Step 2: Translation

- Translation - Translating of a mRNA codons into a protein (amino acid chain)
  - Takes place on ribosomes in cytoplasm



Step 2: Translation

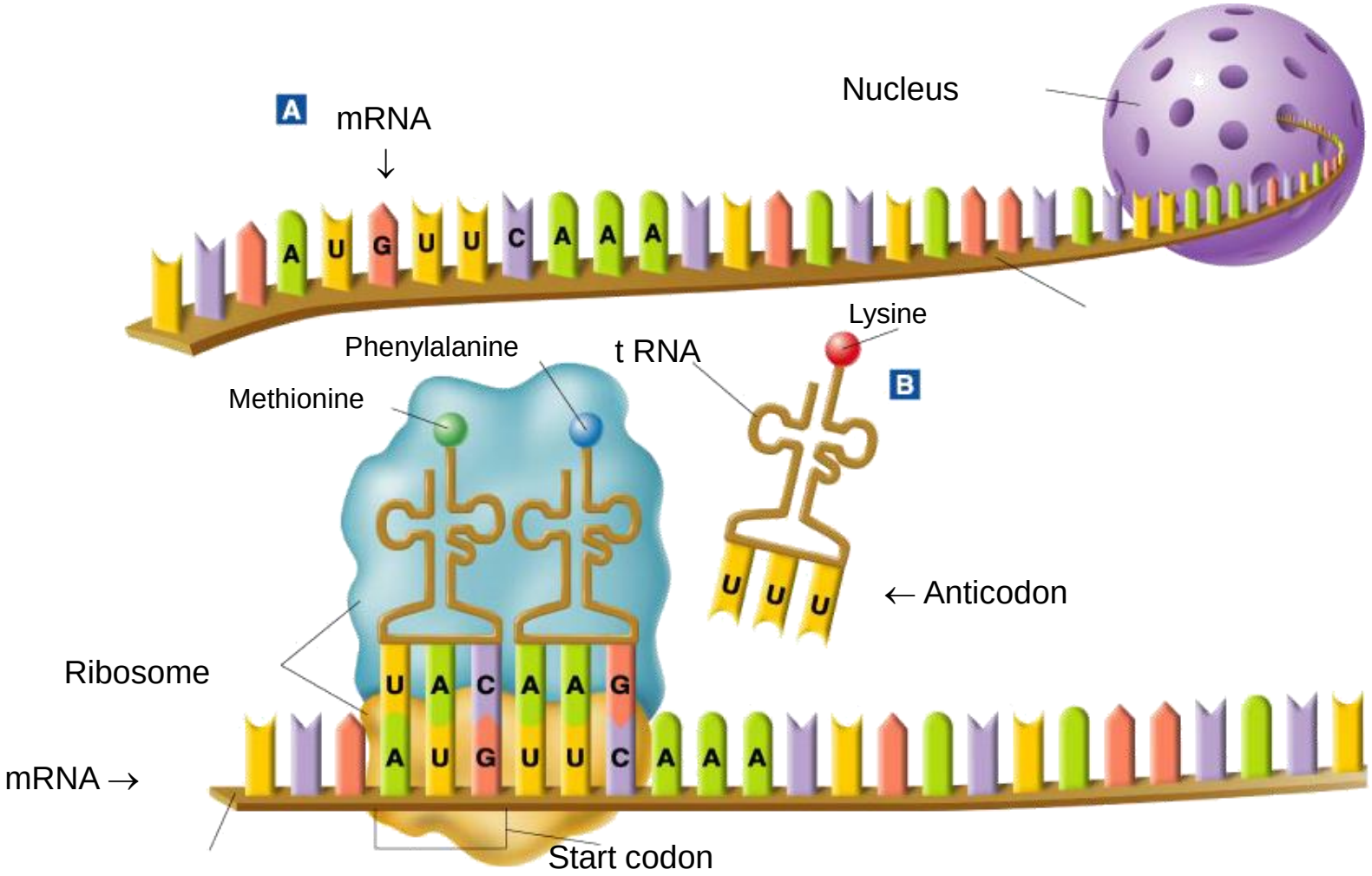
1. Edited mRNA attaches to a ribosome
2. As each codon of the mRNA molecule moves through the ribosome, the tRNA brings the proper amino acid to the ribosome.
   - Notice the anticodon on tRNA – it is complementary to the mRNA codon
   - The amino acids are joined together by chemical bonds called peptide bonds to build an amino acid chain called a "polypeptide"



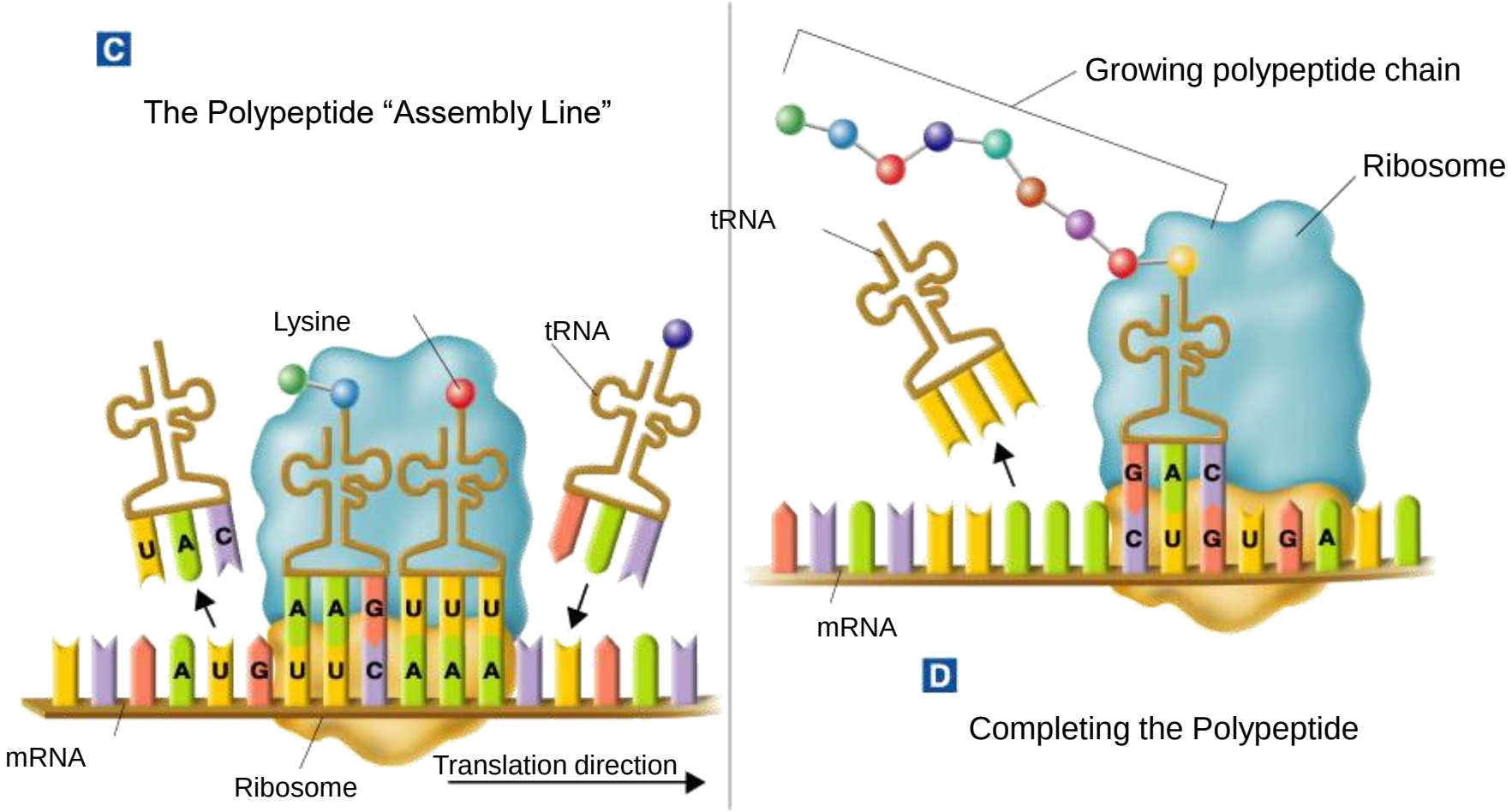
Regulation of Protein Synthesis

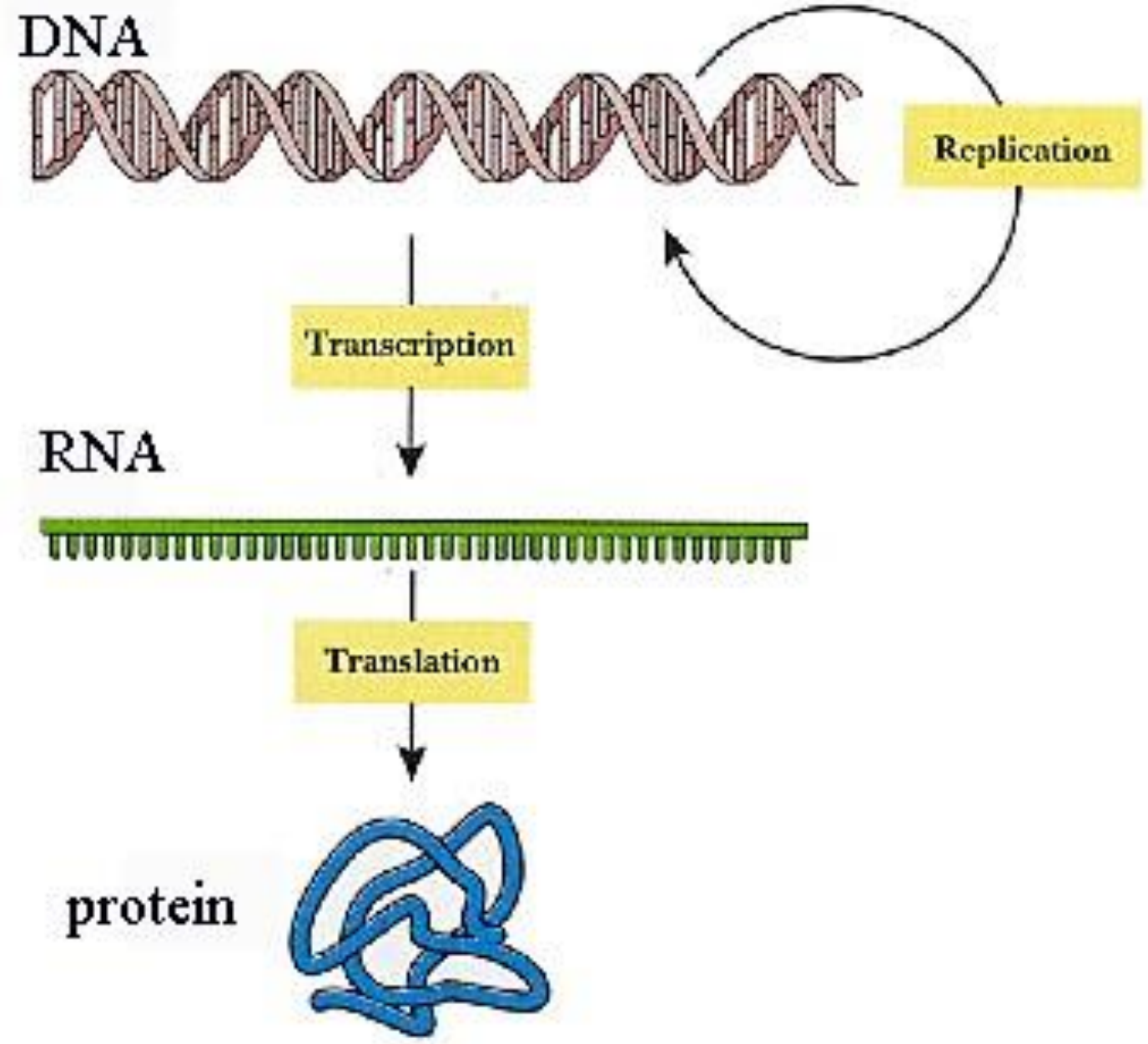
- **Start codons**: found at the beginning of a protein
  - Only one - AUG (methionine)
- **Stop codons**: found at the end of a protein (end of a polypeptide chain)
- Three stop codons that do not code for any amino acid therefore making the process stop : UAA, UAG,UGA

Translation



Translation




DNA
Replication
Transcription
RNA
Translation
protein

Roles of RNA and DNA

- The cell uses the vital DNA “master plan” to prepare RNA “blueprints.”
- The DNA molecule remains within the safety of the nucleus, while RNA molecules go to the protein-building sites in the cytoplasm—the ribosomes.

Regulation of Protein Synthesis

- **Start codons**: found at the beginning of a protein
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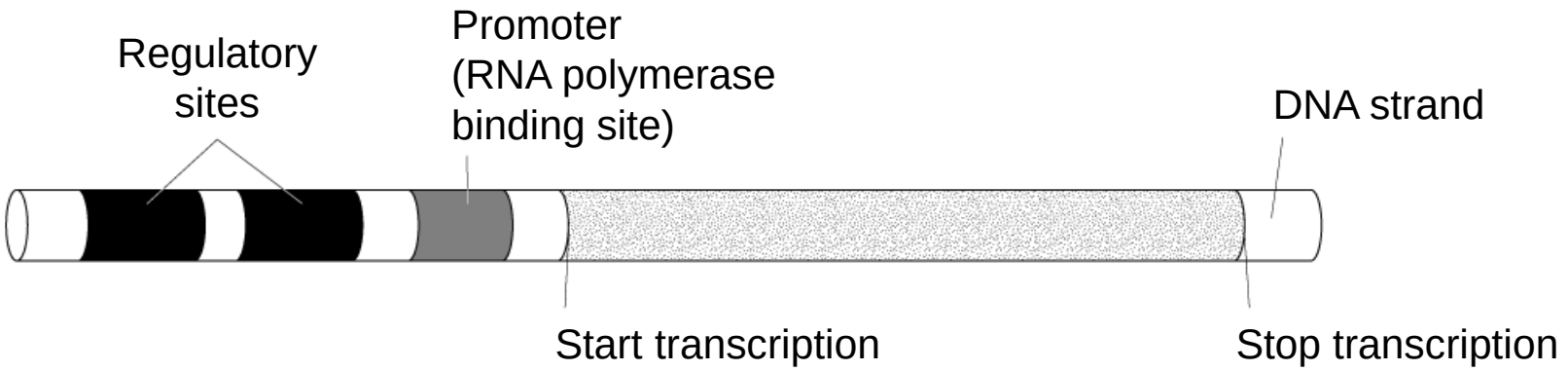
Gene Regulation

- Only a fraction of the genes in a cell are "expressed" at any given time
- (An "expressed" gene = exons= genes that are actually transcribed into RNA)
- How does the cell determine which gene will be expressed and which will remain 'silent'?
  - Promoters allow RNA polymerase to bind to begin transcription. Repressors prevent RNA polymerase from binding to go through transcription.
  - Other DNA sequences (regulatory sites) act to turn on/off a gene

Typical Gene Structure



GAATTCTAATCTCCCTCTCAACCCTACAGTCACCCATTTGGTATATTAAAGATGTGTT
GTCTACTGTCTAGTATCCCTCAAGTAGTGTCAGGAATTAGTCATTTAAATAGTCTGCA
AGCCAGGAGTGGTGGCTCATGTCTGTAATTCCAGCACTGGAGAGGTAGAAGTGGG
AGGACTGCTTGAGCTCAAGAGTTTGATATTATCCTGGACAACATAGCAAGACCTCG
TCTCTACTTAAAAAAAAAAAAATTAGCCAGGCATGTGATGTACACCTGTAGTCCCAG
CTACTCAGGAGGCCGAAATGGGAGGATCCCTTGAGCTCAGGAGGTCAAGGCTGC
AGTGAGACATGATCTTGCCACTGCACTCCAGCCTGGACAGCAGAGTGAAACCTTG
CCTCACGAAACAGAATACAAAAACAAACAAACAAAAAACTGCTCCGCAATGCGCTT
CCTTGATGCTCTACCACATAGGTCTGGGTACTTT

Gene Regulation

- The expression of genes can also be influenced by <u>environmental factors</u> such as temperature, light, chemicals, etc.

Gene Regulation

A. Not all genes are active (expressed) at the same time.

1. Why: **Because the cell would produce many molecules it did NOT need – waste of energy and raw materials**

2. Gene expression (protein synthesis) is when the product of a gene (specific protein) is being actively produced by a cell.

a. some genes are – **rarely expressed -- adrenaline**

b. some genes are – **constantly expressed – hair growth, blood pressure**

c. some genes are – **expressed for a time, then turned off (cyclical) -- estrogen**