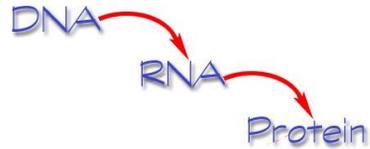


# PROTEIN SYNTHESIS

## Central Dogma of Biology



## RNA (ribonucleic acid)

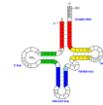
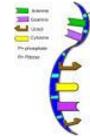
The diagram shows a double-stranded DNA molecule on the left and a single-stranded RNA molecule on the right. Labels include 'Cytosine', 'Guanine', 'Adenine', 'Thymine', 'Uracil', 'Nitrogenous Bases', 'Deoxyribonucleic acid', 'Ribonucleic acid', 'Base pair', and 'Sugar phosphate backbone'. A table titled 'DIFFERENCES' compares DNA and RNA.

DIFFERENCES	
DNA	RNA
deoxyribose sugar	ribose sugar
double strand	single strand
bases A,T,C,G	bases A,U,C,G
found in: nucleus, mitochondria, chloroplasts	found in: nucleus, cytosol, ribosomes (2/3 rRNA, 1/3 protein)

Image adapted from: National Human Genome Research Institute.

## 3 types RNA

- messenger RNA (mRNA)**  
single uncoiled long strand
  - transmits DNA's message
  - serves as template to assemble amino acids
- transfer RNA (tRNA)**  
- carries amino acids to ribosome
- ribosomal RNA (rRNA)**  
makes up large part of ribosome
  - globular



## PROTEIN SYNTHESIS/GENE EXPRESSION

Formation of proteins using information coded on DNA and carried out by RNA.

**DNA:** the president

**RNA:** the vice president

**PROTEINS:** the workers that carry out the jobs

### Functions of Proteins

- cell structure, repair, and growth
- cell movement
- control biochemical pathways (enzymes)
- direct synthesis of lipids and carbohydrates

**\*\*most important biomolecule for life\*\***

How is information necessary for creating proteins encoded in the RNA?

The genetic code from DNA is transcribed onto mRNA by **Codons**.

**Code Word/Codon** (triplet):

specific group of 3 successive bases on DNA and mRNA

- codes for a specific amino acid to be placed on the protein chain
- 20 biological amino acids, but more than 20 codons

Like "genetic words"

DNA code words: ACA, GCA, TTA

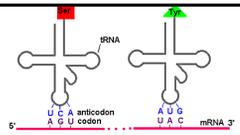
RNA codons: TGU, CGU, AAU



How many combinations of code words/codons can we make from 4 bases?

64 combinations (  $4^3 = 64$  )

\*\* each code word always codes for same amino acid\*\*



1st base in codon	2nd base in codon			3rd base in codon
	U	C	A	
U	Phe Ser Leu Leu	Ser Tyr STOP STOP	Tyr Cys STOP Trp	U C G U
C	Leu Leu Leu Leu	Pro His Pro Gln	Arg Arg Arg Gln	T C A G
A	Ile Ile Thr Met	Thr Asn Lys Asp	Asn Ser Arg Asp	U C A G
G	Val Val Val Val	Ala Ala Glu Glu	Gly Gly Gly Gly	U C A G

The Genetic Code

Ala: Alanine	Cys: Cysteine	Asp: Aspartic acid	Glu: Glutamic acid
Phe: Phenylalanine	Gly: Glycine	His: Histidine	Ile: Isoleucine
Lys: Lysine	Leu: Leucine	Met: Methionine	Asn: Asparagine
Pro: Proline	Gln: Glutamine	Arg: Arginine	Ser: Serine
Thr: Threonine	Val: Valine	Trp: Tryptophane	Tyr: Tyrosine

How do these code words affect protein synthesis?

Order of code words

codes for

Order of amino acids

codes for

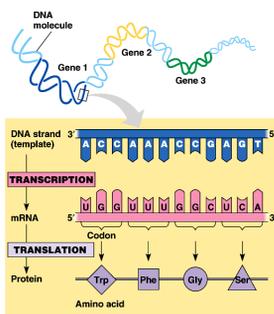
Specific type of protein

**Stages of Protein Synthesis**

- Building of proteins

2 Stages

1. Transcription (makes mRNA)
2. Translation (makes protein)



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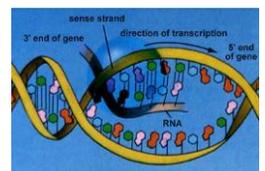
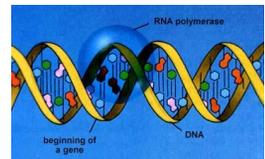
**Stages of Protein Synthesis**

I. Transcription (nucleus)

- first main stage
- mRNA made from DNA

Steps of transcription

1. The part of the DNA to be transcribed unzips (only one strand of DNA molecule needed for transcription)



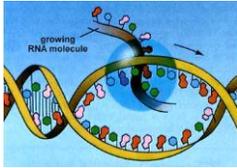
start codon: **AUG**

always codes for methionine

### Transcription, cont.

2. Complementary nucleotides are added to the end of RNA
3. A. Messenger RNA is made until a stop codon is reached.

(once RNA nucleotides are attached to DNA chain, codons are in proper order)

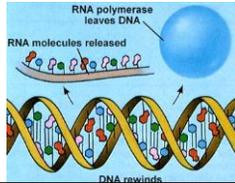


[transcription animation](#)

- **stop codons:**  
UAA, UAG, UGA

- B. Newly formed mRNA goes into cytoplasm to ribosomes

- C. DNA rewinds



### II. Translation (in cytoplasm at ribosome)

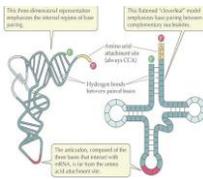
- second main stage
- process whereby protein is synthesized (created) from mRNA
- occurs in cytoplasm
- gene has 100x more nucleotides than the protein it makes

Ex: 100 a.a. = 300 nucleotides

### 2 Components of Translation

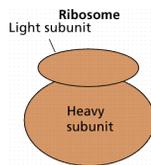
1. Transfer RNA (tRNA)

- function: transfers amino acids to ribosome
- 20 types - one for each amino acid (specific for each a.a.)
- found in cytosol



2. Ribosome

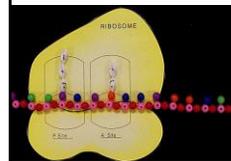
- 2 subunits make up ribosome
- normally apart in cytoplasm, come together during protein synthesis



### Steps of translation (second main stage)

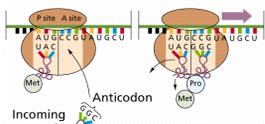
1. Subunits attach with mRNA in between them (ribosome ready for protein synthesis)

- Ribosome moves down mRNA and reads its message

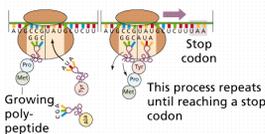


- amino acid 1 will always be **methionine**

### Elongation (translation)



### Elongation continues



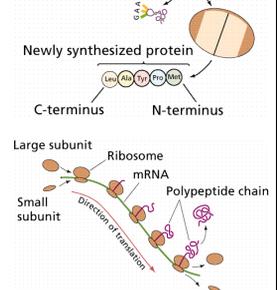
2. A. T-RNA with its amino acids bond to ribosomes
- B. first a.a. joins to second a.a.
- C. ribosome moves down mRNA and first tRNA is released to be used over again
- D. amino acids continue to be added to protein chain thru same mechanism

### Termination



3. stop codon is reached (UAA, UGA, or UAG).

- A. subunits separate (can be used over again)
- B. protein is released into cell
- C. mRNA is broken down by cell (not be used again)
- D. tRNA is released into cell (used over again)



[Protein synthesis animation](#)  
[Protein synthesis animation 2](#)