



**SPLICEOSOME ENZYMES**

**SPLICE EXON**

**NUCLEOTIDE BASES**

**SPLICESOME ENZYMES**



# MODIFICATION

**NON-MODIFIED M-RNA**

A U G C G U C G A U A A U C A A G U C A A A C

**EXON  
NUCLEOTIDE BASES**

**INTRON  
NUCLEOTIDE BASES**



 = **SPLICEOSOME ENZYMES**

**SPLICEOSOME ENZYMES  
SPLICE EXON NT-BASES**



# MODIFICATION

**NON-MODIFIED M-RNA**

A U G C G U C G A U A A U C A A G U C A A A C

**EXON  
NUCLEOTIDE BASES**

**INTRON  
NUCLEOTIDE BASES**

A U G C ● U A A ● C A A A C

● = **SPLICEOSOME ENZYMES**

**SPLICEOSOME ENZYMES  
SPLICE EXON NT-BASES**



**M-RNA  
MODIFICATION  
SPECIFICS  
OUTCOME**

# MODIFICATION

**NON-MODIFIED M-RNA**

A U G C G U C G A U A A U C A A G U C A A A C

**EXON  
NUCLEOTIDE BASES**

**INTRON  
NUCLEOTIDE BASES**

A U G C A U A A C A A A C U A

**MODIFIED M-RNA CONSISTS:**

?

# MODIFICATION



# MODIFICATION

**NON-MODIFIED M-RNA**

A U G C G U C G A U A A U C A A G U C A A A C

**EXON  
NUCLEOTIDE BASES**

**INTRON  
NUCLEOTIDE BASES**



**MODIFIED M-RNA CONSISTS:**

**EXON NT-BASES**

# MODIFICATION

# CELL

## PROTEIN / SYNTHESIS



### NUCLEUS

**CHROMOSOME**



**DNA/GENE**

**TRANSCRIPTION**



**NON-MODIFIED M-RNA**

**MODIFICATION**



**MODIFIED M-RNA**

CYTOSOL

# CELL

## PROTEIN / SYNTHESIS



### NUCLEUS

**CHROMOSOME**



**DNA/GENE**

**TRANSCRIPTION**



**NON-MODIFIED M-RNA**

**MODIFICATION**



**MODIFIED M-RNA**



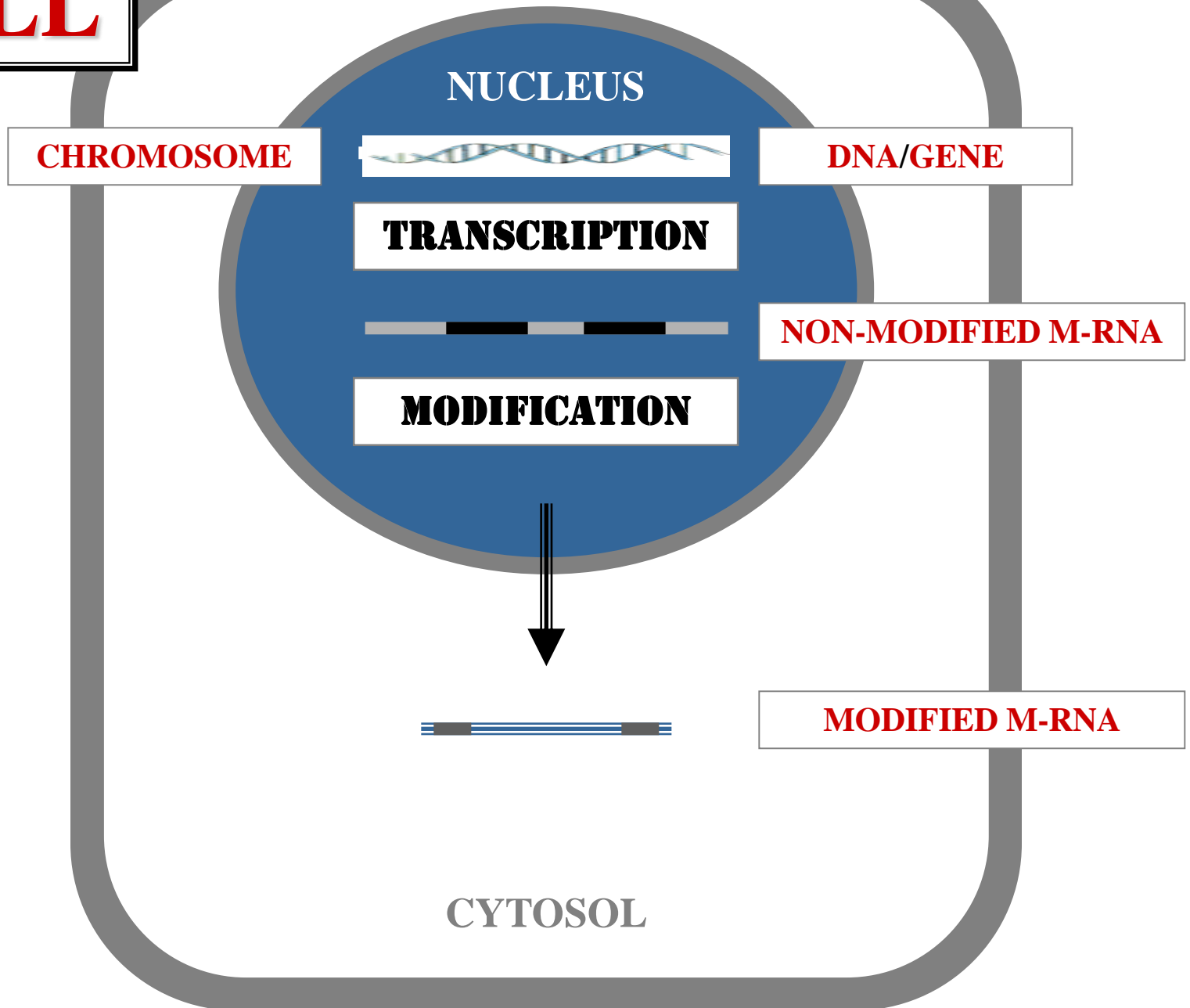
**CYTOSOL**



# CELL

T

## PROTEIN / SYNTHESIS



# CELL

## PROTEIN / SYNTHESIS



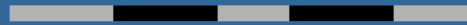
### NUCLEUS

**CHROMOSOME**



**DNA/GENE**

**TRANSCRIPTION**



**NON-MODIFIED M-RNA**

**MODIFICATION**



**MODIFIED M-RNA**

**TRANSLATION**

CYTOSOL



**PROTEIN  
SYNTHESIS  
SPECIFICS  
TRANSLATION**

# CELL

L

## PROTEIN / SYNTHESIS

### NUCLEUS

CHROMOSOME



DNA/GENE

**TRANSCRIPTION**



NON-MODIFIED M-RNA

**MODIFICATION**



MODIFIED M-RNA



MODIFIED M-RNA

CYTOSOL

# CELL

T

## PROTEIN / SYNTHESIS

### NUCLEUS

CHROMOSOME



DNA/GENE

**TRANSCRIPTION**



NON-MODIFIED M-RNA

**MODIFICATION**



MODIFIED M-RNA



MODIFIED M-RNA

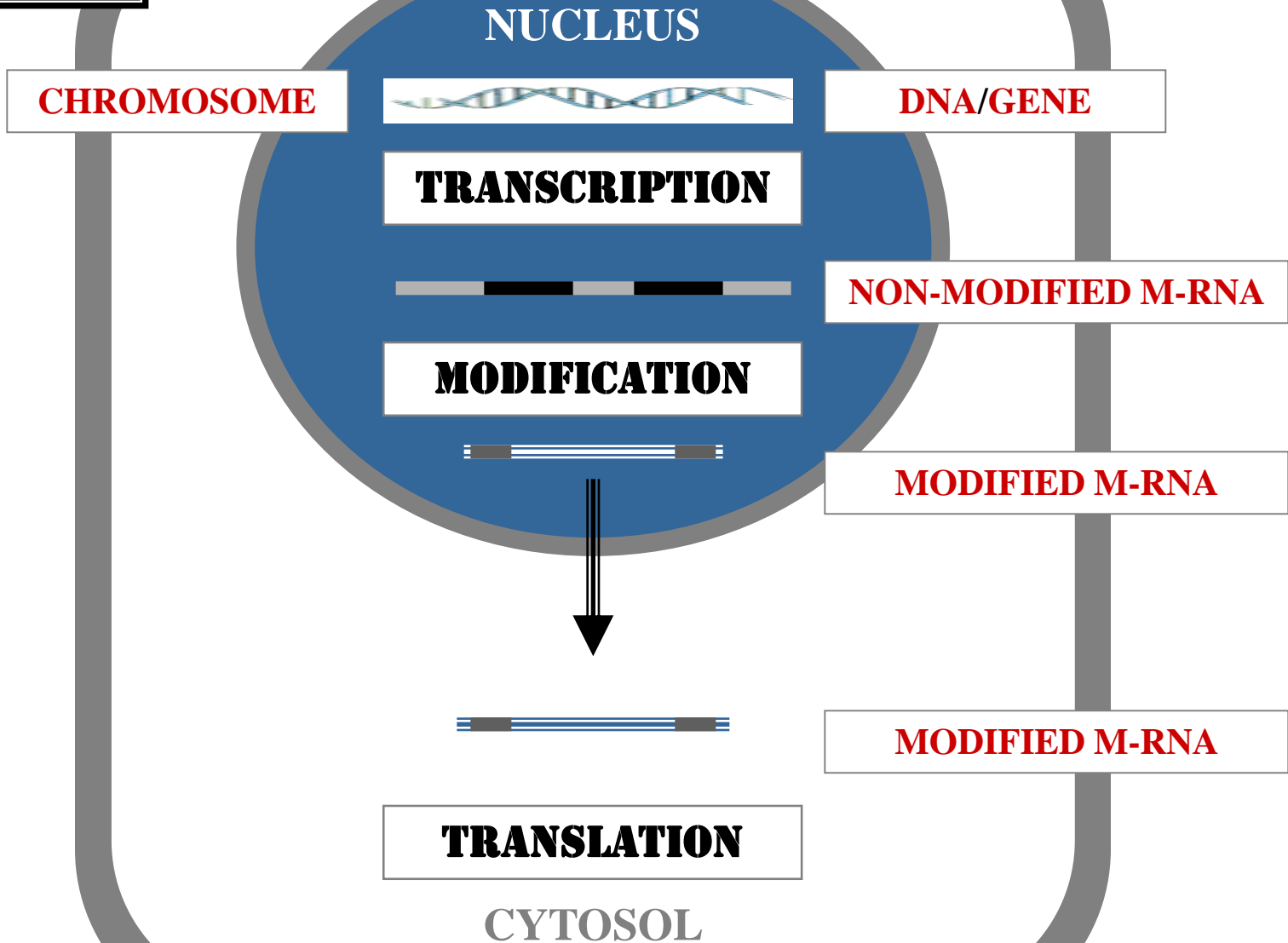
LOCATION

CYTOSOL

# CELL

## PROTEIN / SYNTHESIS

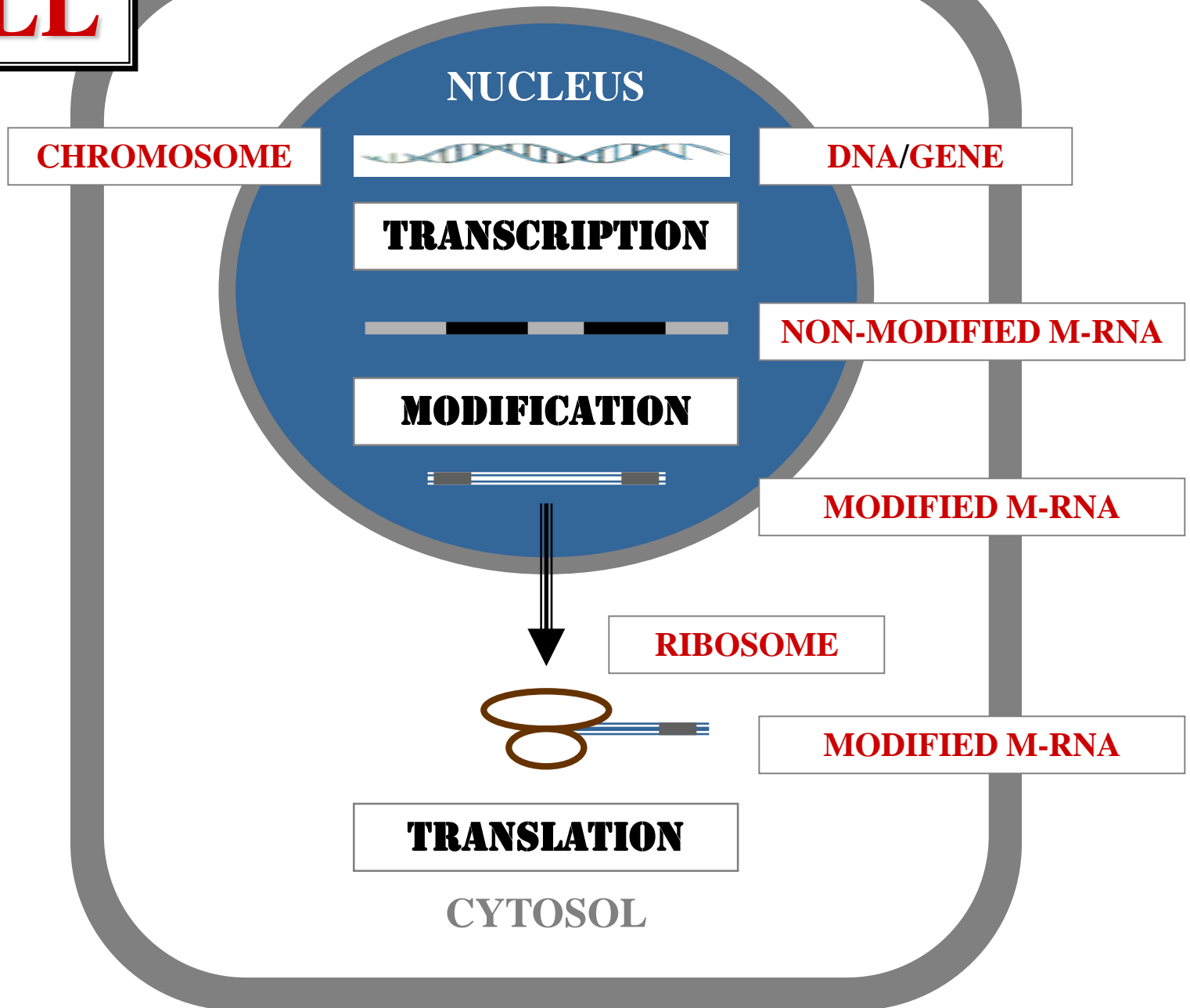
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# CELL

R

## PROTEIN / SYNTHESIS



**RIBOSOME**



**RIBOSOME**

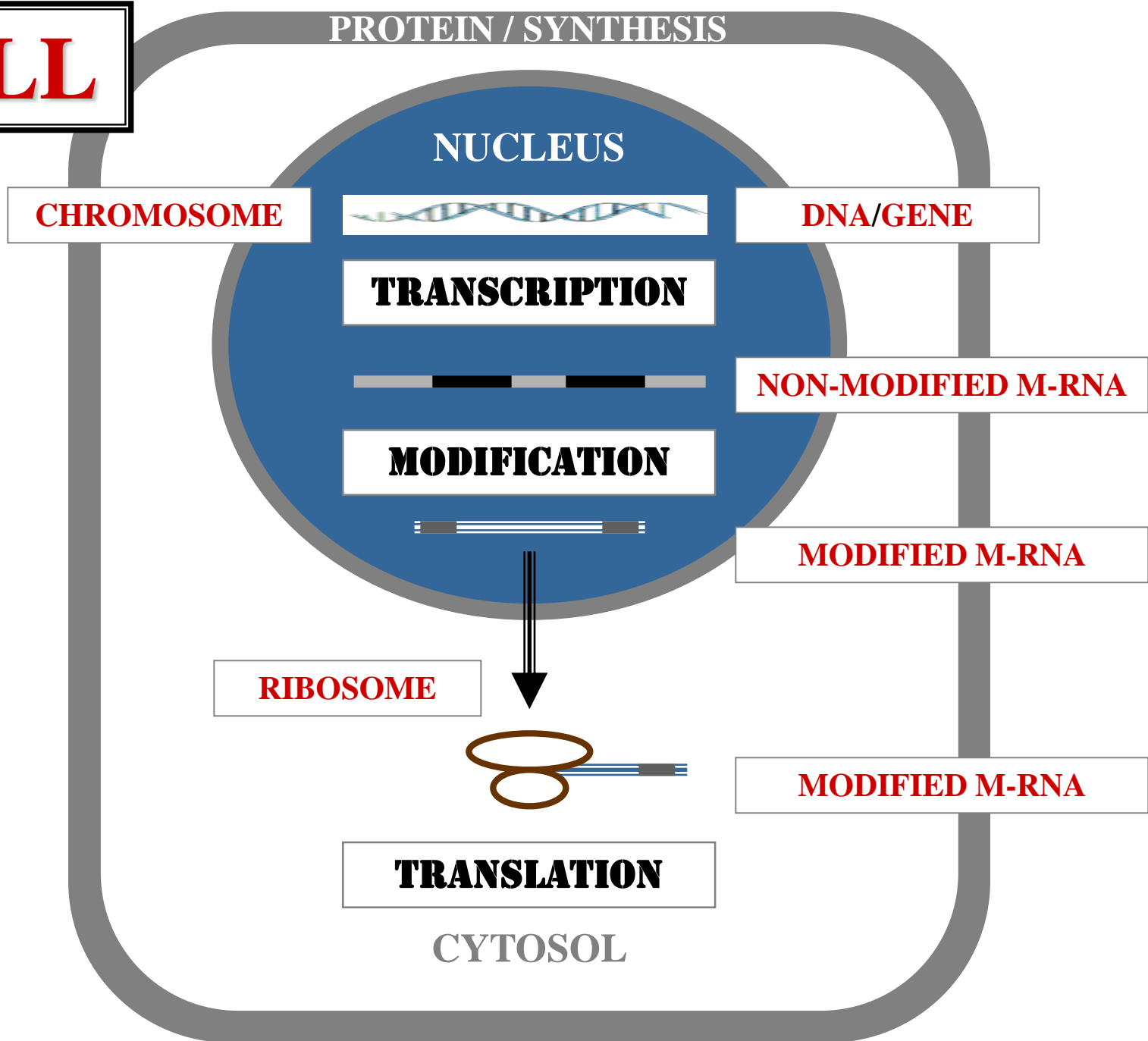


**SITE**  
**M-RNA**  
**TRANSLATION**

**RIBOSOME**

# CELL

T  
G



# CELL

## PROTEIN / SYNTHESIS



### NUCLEUS

CHROMOSOME



DNA/GENE

**TRANSCRIPTION**



NON-MODIFIED M-RNA

**MODIFICATION**



MODIFIED M-RNA

RIBOSOME



TRANSLATES *GENETIC CODE*



MODIFIED M-RNA

**TRANSLATION**

CYTOSOL

# GENETIC CODE

# **GENETIC CODE**

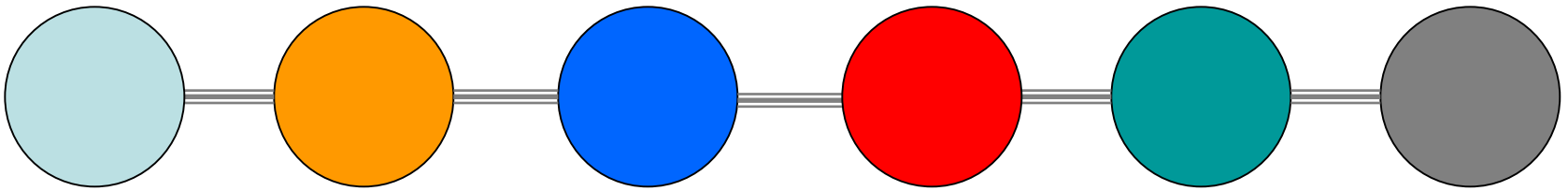


# **GENETIC CODE**

**Dictates protein  
amino acid  
sequence**

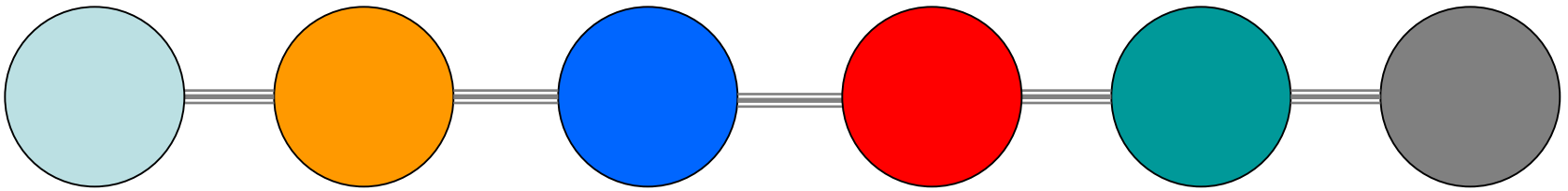
**GENETIC CODE**

# PROTEIN STRUCTURE



**PROTEIN**

# PROTEIN STRUCTURE

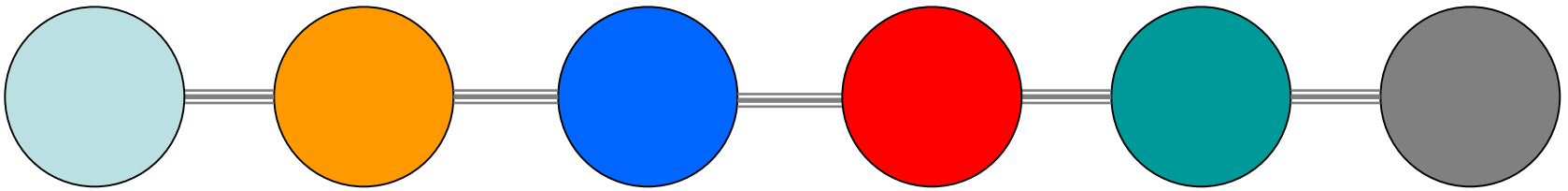


**BUILDING  
BLOCK**

**POLYMER**



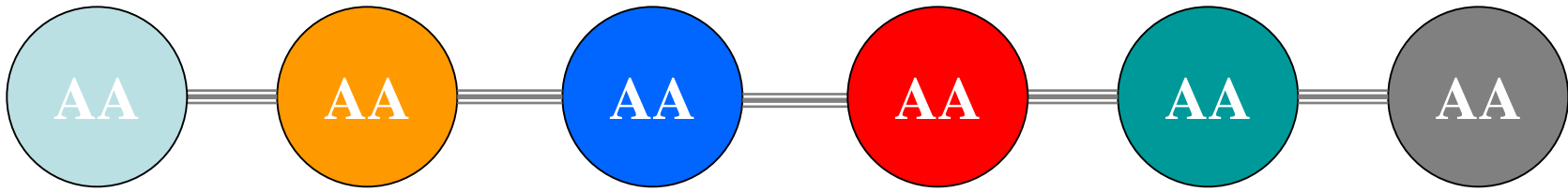
# PROTEIN STRUCTURE



**MONOMER**

**PROTEIN / POLYMER**

# PROTEIN STRUCTURE



  
**AMINO ACID**

**GENETIC CODE  
DICTATES PROTEIN  
AMINO ACID  
SEQUENCE**

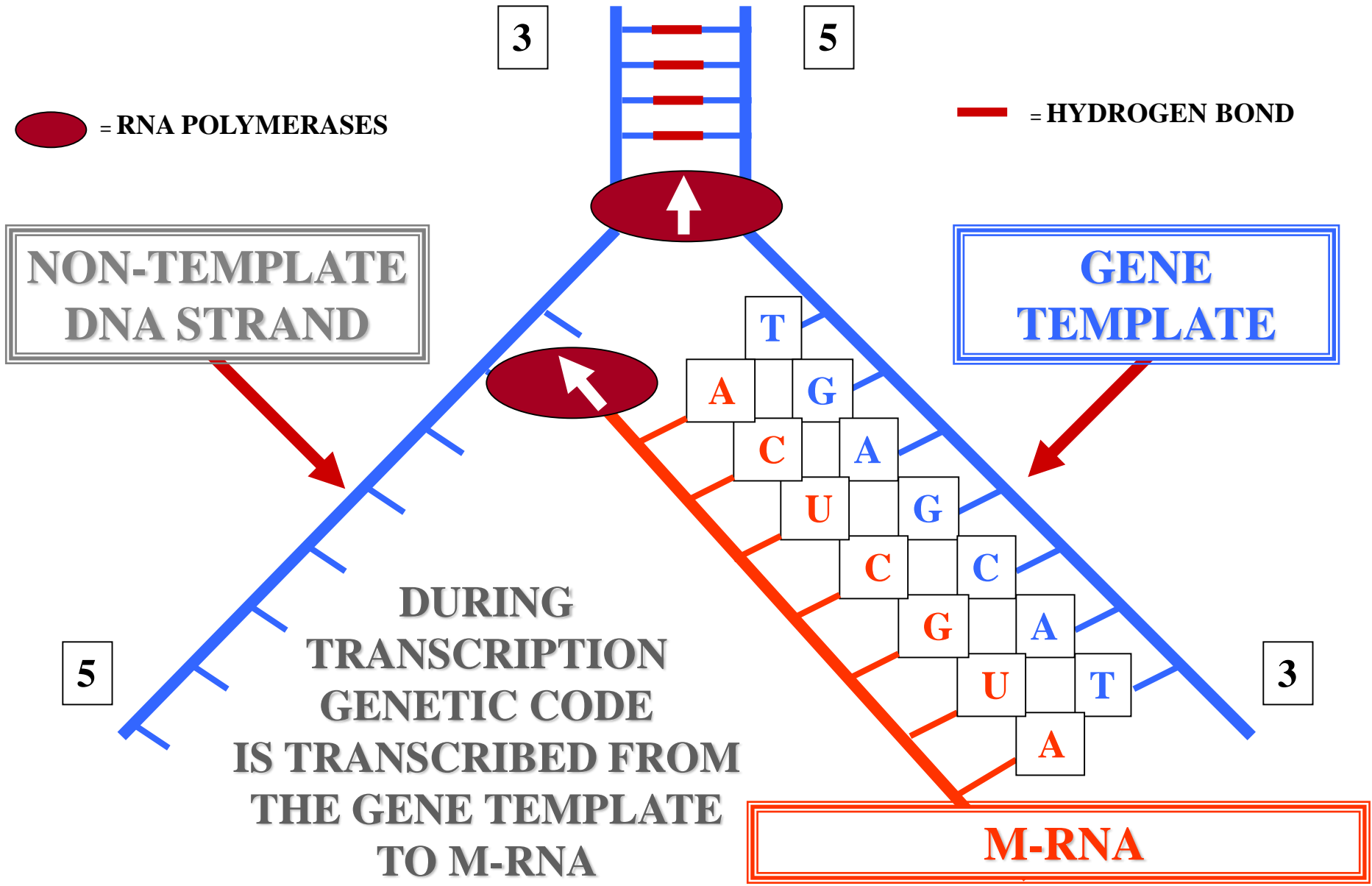


**PROTEIN**

# TRANSCRIPTION

AUG

+



# GENETIC CODE

M-RNA AUGCAUAACAAACUUCCCUAA



DURING  
TRANSCRIPTION GENETIC CODE  
IS TRANSCRIBED FROM  
THE GENE TEMPLATE  
TO M-RNA

# GENETIC CODE

# GENETIC CODE

M-RNA AUGCAUAACAAACUUCCCUAA



RIBOSOME READS

M-RNA (GENETIC CODE)

AS CODONS

# GENETIC CODE

**CODON**

**CODON**

**3 NUCLEOTIDE BASES  
ALONG M-RNA**

**CODON**

# GENETIC CODE

M-RNA AUGCAUAACAAACUUCCCUAA



RIBOSOME READS M-RNA AS  
CODONS

3 NUCLEOTIDE BASES  
ALONG M-RNA

# GENETIC CODE





# GENETIC CODE

**M-RNA AUGCAUAACAAACUUCCCUAA**

**M-RNA AUG CAU AAC AAA CUU CCC UAA**  
**CODON CODON CODON CODON CODON CODON CODON**



**RIBOSOME READS M-RNA AS  
CODONS  
3 NUCLEOTIDE BASES  
ALONG M-RNA**



# GENETIC CODE

# CODONS



# MARSHALL NIRENBERG

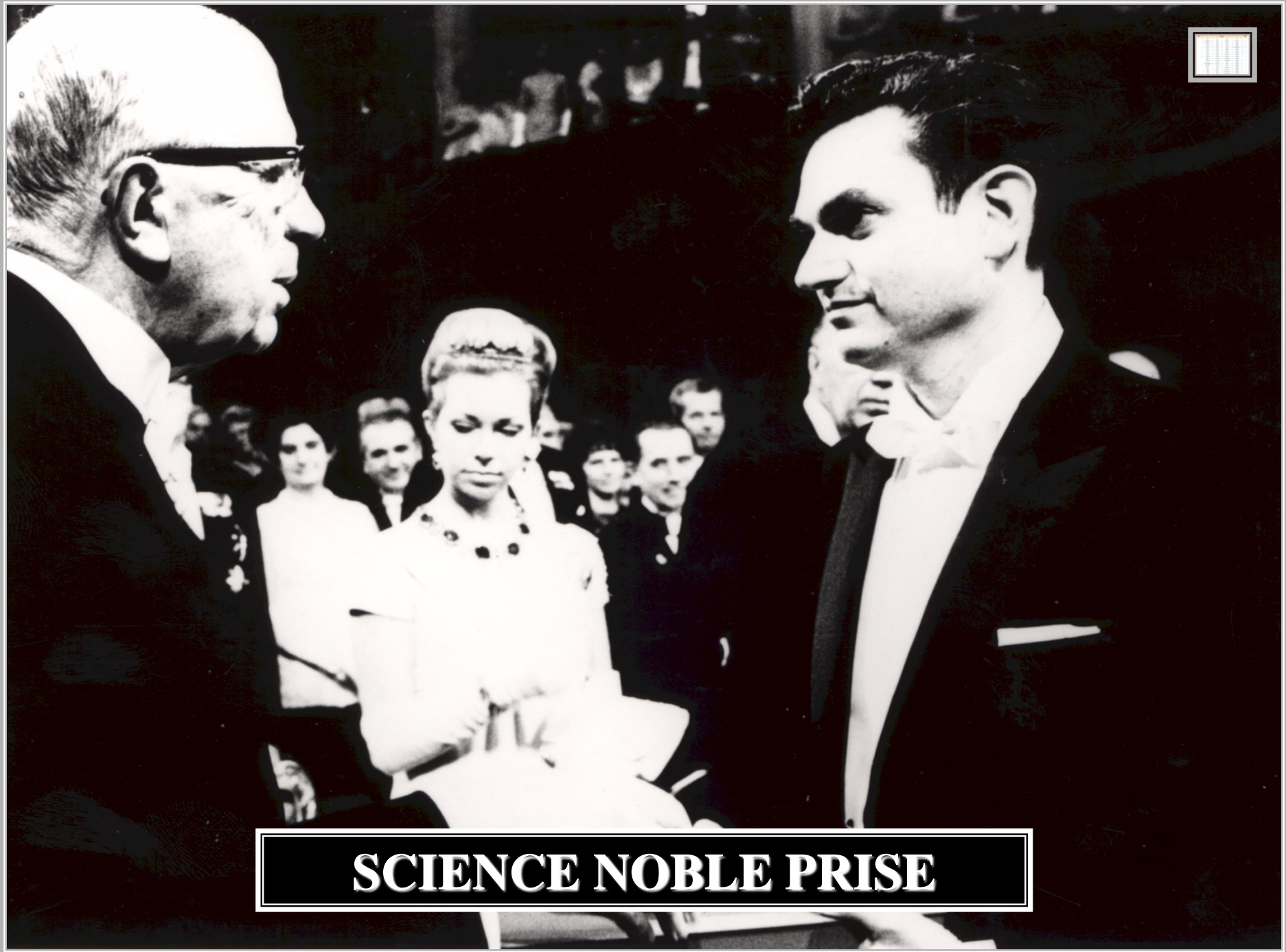


**MARSHALL NIRENBERG**

**ELICITATED GENETIC CODE**

# ELICITED GENETIC CODE





**SCIENCE NOBLE PRISE**

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	<b>64</b> U C A G U C
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	
	UUA Leucine	UCA Serine	UAA <i>STOP</i>	UGA <i>STOP</i>	
	UUG Leucine	UCG Serine	UAG <i>STOP</i>	UGG Tryptophan	
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C

# GENETIC CODE

A	Isoleucine	Threonine	Asparagine	Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG ( <i>START</i> ) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	<b>1</b> U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC	CCC	CAC	CGC	

# GENETIC CODE

## 64 DIFFERENT CODONS

A	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G



**1 START CODON**

**START CODON**



**INITIATES  
TRANSLATION**

**START CODON**

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	M U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA	CCA	CAA	CGA	

# START CODON

A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	3 U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	
	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC	CCC	CAC	CGC	

# START CODON CODES FOR METHIONINE

A	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	<b>AUG (START) Methionine</b>	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

**3 STOP CODONS**



**STOP CODONS**

**TERMINATE  
TRANSLATION**

**STOP CODONS**

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	+
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA	CCA	CAA	CGA	

## 3 STOP CODONS

A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA	CCA	CAA	CGA	

## 3 STOP CODONS

A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G



First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA	CCA	CAA	CGA	

## 3 STOP CODONS

A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA	CCA	CAA	CGA	

**N**

## 3 STOP CODONS

A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	64 U C A G U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	
	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	

**3 STOP CODONS CODE FOR  
NO  
AMINO ACIDS**

G	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	3 U C A G
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	
	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC	CCC	CAC	CGC	

# GENETIC CODE

## 64 DIFFERENT CODONS

A	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	61 U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U

**3 STOP CODONS CODE FOR  
NO  
AMINO ACIDS**

G	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC	CCC	CAC	CGC	C

# 61 CODONS CODE FOR AMINO ACIDS

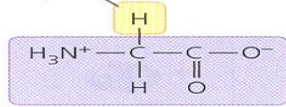
A	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

# ? PROTEIN AMINO ACIDS

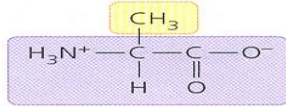
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## Nonpolar side chains; hydrophobic

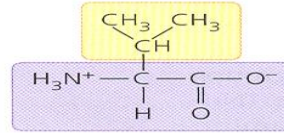
Side chain  
(R group)



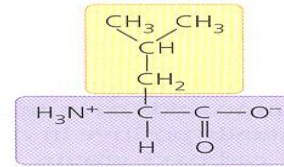
Glycine  
(Gly or G)



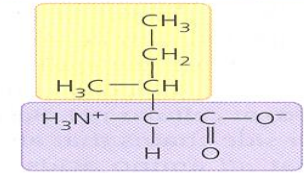
Alanine  
(Ala or A)



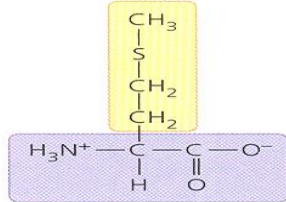
Valine  
(Val or V)



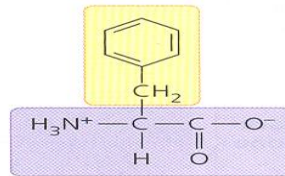
Leucine  
(Leu or L)



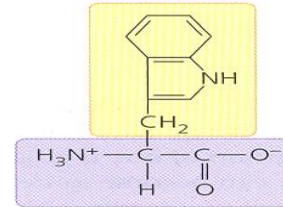
Isoleucine  
(Ile or I)



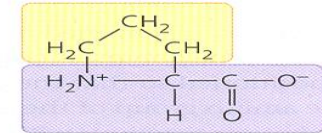
Methionine  
(Met or M)



Phenylalanine  
(Phe or F)

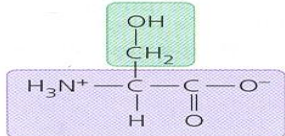


Tryptophan  
(Trp or W)

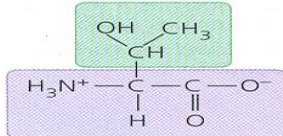


Proline  
(Pro or P)

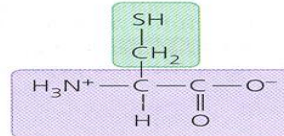
## Polar side chains; hydrophilic



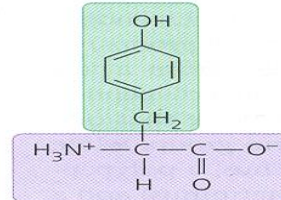
Serine  
(Ser or S)



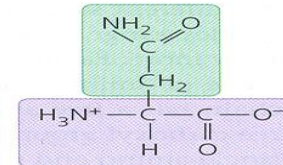
Threonine  
(Thr or T)



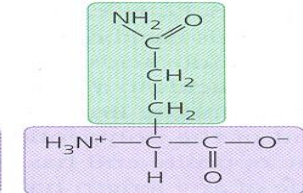
Cysteine  
(Cys or C)



Tyrosine  
(Tyr or Y)



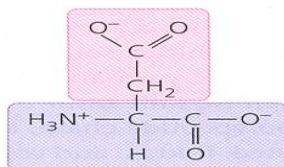
Asparagine  
(Asn or N)



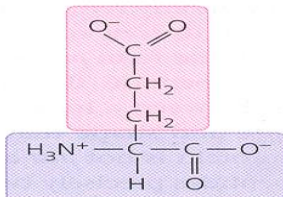
Glutamine  
(Gln or Q)

## Electrically charged side chains; hydrophilic

### Acidic (negatively charged)

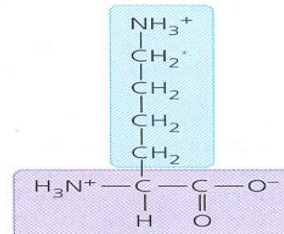


Aspartic acid  
(Asp or D)

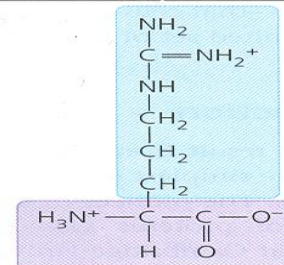


Glutamic acid  
(Glu or E)

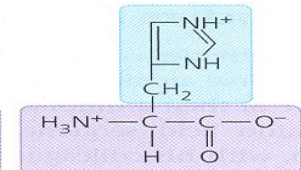
### Basic (positively charged)



Lysine  
(Lys or K)



Arginine  
(Arg or R)



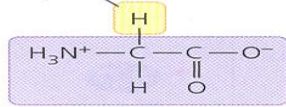
Histidine  
(His or H)

# 20 PROTEIN AMINO ACIDS

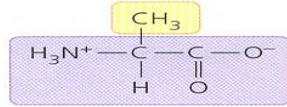
61

## Nonpolar side chains; hydrophobic

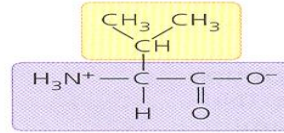
Side chain  
(R group)



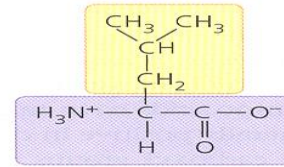
Glycine  
(Gly or G)



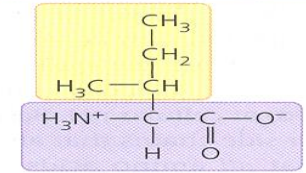
Alanine  
(Ala or A)



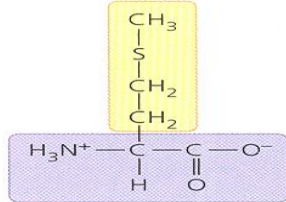
Valine  
(Val or V)



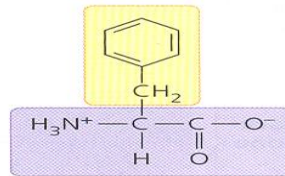
Leucine  
(Leu or L)



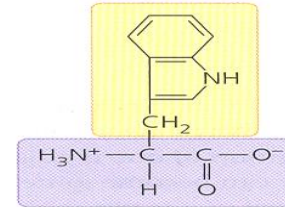
Isoleucine  
(Ile or I)



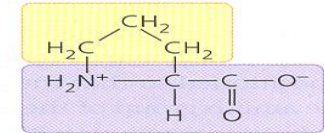
Methionine  
(Met or M)



Phenylalanine  
(Phe or F)

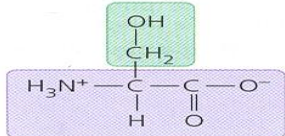


Tryptophan  
(Trp or W)

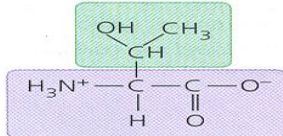


Proline  
(Pro or P)

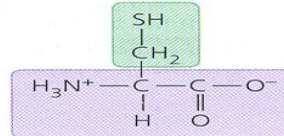
## Polar side chains; hydrophilic



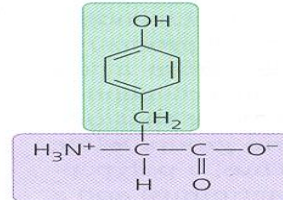
Serine  
(Ser or S)



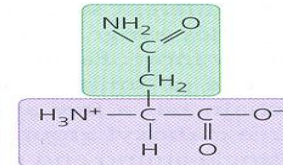
Threonine  
(Thr or T)



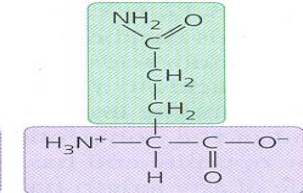
Cysteine  
(Cys or C)



Tyrosine  
(Tyr or Y)



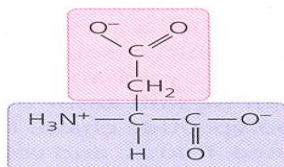
Asparagine  
(Asn or N)



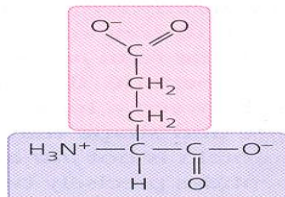
Glutamine  
(Gln or Q)

## Electrically charged side chains; hydrophilic

### Acidic (negatively charged)

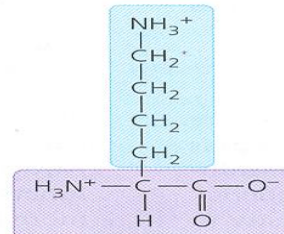


Aspartic acid  
(Asp or D)

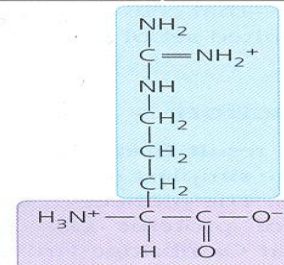


Glutamic acid  
(Glu or E)

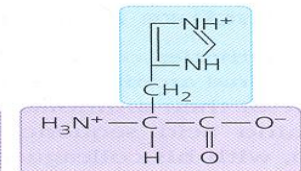
### Basic (positively charged)



Lysine  
(Lys or K)



Arginine  
(Arg or R)



Histidine  
(His or H)

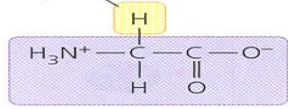


# 20 PROTEIN AMINO ACIDS

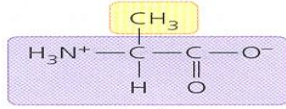
1+

## Nonpolar side chains; hydrophobic

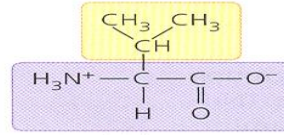
Side chain  
(R group)



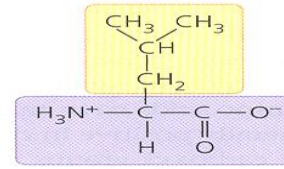
Glycine  
(Gly or G)



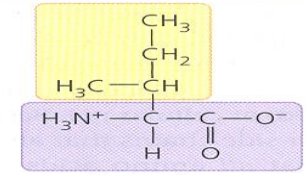
Alanine  
(Ala or A)



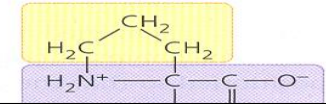
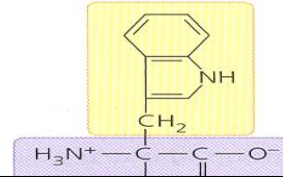
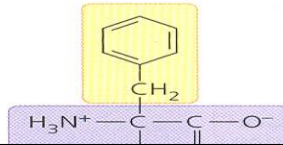
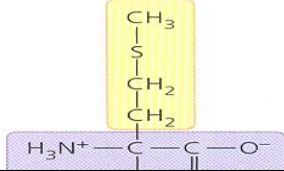
Valine  
(Val or V)



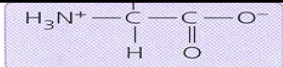
Leucine  
(Leu or L)



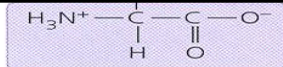
Isoleucine  
(Ile or I)



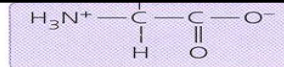
**61 CODONS CODE FOR AMINO ACIDS**



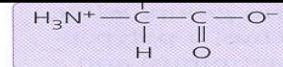
Serine  
(Ser or S)



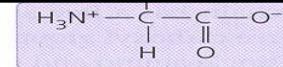
Threonine  
(Thr or T)



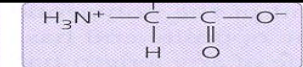
Cysteine  
(Cys or C)



Tyrosine  
(Tyr or Y)



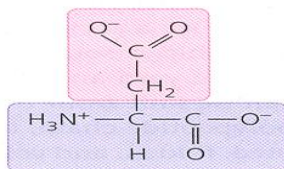
Asparagine  
(Asn or N)



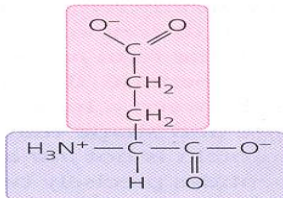
Glutamine  
(Gln or Q)

## Electrically charged side chains; hydrophilic

### Acidic (negatively charged)

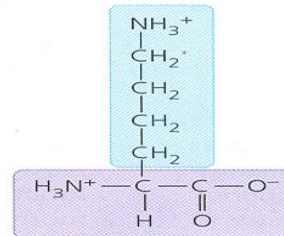


Aspartic acid  
(Asp or D)

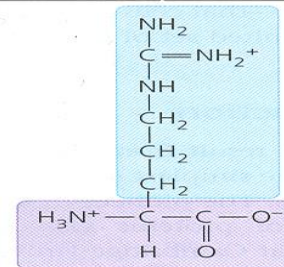


Glutamic acid  
(Glu or E)

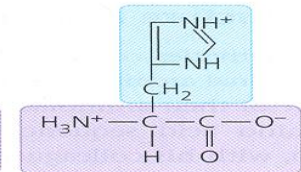
### Basic (positively charged)



Lysine  
(Lys or K)



Arginine  
(Arg or R)



Histidine  
(His or H)

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U



# GENETIC CODE

## 1+ CODON CODES FOR SAME AMINO ACID

	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U

# GENETIC CODE REDUNDANT

A	Isoleucine	Threonine	Asparagine	Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

# GENETIC CODE APPLIED



# GENETIC CODE

M-RNA AUGCAUAACAAACUUCCCUAA

M-RNA AUG CAU AAC AAA CUU CCC UAA  
CODON CODON CODON CODON CODON CODON CODON

\* = PEPTIDE BOND / POLYPEPTIDE CHAIN = PROTEIN

# GENETIC CODE

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	ST U C A G
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U C A G
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	
	CUA Leucine	CCA Proline	CAA Glutamine	CGA Arginine	
	CUG Leucine	CCG Proline	CAG Glutamine	CGG Arginine	
A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U C A G
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U C A G
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	AUG U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA Leucine	CCA Proline	CAA Glutamine	CGA Arginine	A
	CUG Leucine	CCG Proline	CAG Glutamine	CGG Arginine	G
A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G



# GENETIC CODE

M-RNA AUGCAUAACAAACUUCCCUAA

M-RNA AUG CAU AAC AAA CUU CCC UAA

CODON CODON CODON CODON CODON CODON CODON

MET

METHIONINE

\* = PEPTIDE BOND / POLYPEPTIDE CHAIN = PROTEIN

# GENETIC CODE



First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	HI U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA Leucine	CCA Proline	CAA Glutamine	CGA Arginine	A
	CUG Leucine	CCG Proline	CAG Glutamine	CGG Arginine	G
A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	<b>AUG</b> U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
<b>C</b>	CUU Leucine	CCU Proline	<b>CAU</b> Histidine	CGU Arginine	<b>U</b> C
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA Leucine	CCA Proline	CAA Glutamine	CGA Arginine	A
	CUG Leucine	CCG Proline	CAG Glutamine	CGG Arginine	G
A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G



# GENETIC CODE

M-RNA AUGCAUAACAAACUUCCCUAA

M-RNA AUG CAU AAC AAA CUU CCC UAA

CODON CODON CODON CODON CODON CODON CODON

MET \* HIS

HISTIDINE

\* = PEPTIDE BOND / POLYPEPTIDE CHAIN = PROTEIN

# GENETIC CODE

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	AS U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA Leucine	CCA Proline	CAA Glutamine	CGA Arginine	A
	CUG Leucine	CCG Proline	CAG Glutamine	CGG Arginine	G
A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	<b>AUG</b> U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA <i>STOP</i>	UGA <i>STOP</i>	A
	UUG Leucine	UCG Serine	UAG <i>STOP</i>	UGG Tryptophan	G
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA Leucine	CCA Proline	CAA Glutamine	CGA Arginine	A
	CUG Leucine	CCG Proline	CAG Glutamine	CGG Arginine	G
<b>A</b>	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	<b>AAC</b> Asparagine	AGC Serine	<b>C</b>
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG ( <i>START</i> ) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G



# GENETIC CODE

M-RNA AUGCAUAACAACUUCCCUAA

M-RNA AUG CAU AAC AAA CUU CCC UAA

CODON CODON CODON CODON CODON CODON CODON

MET \* HIS \* ASP

ASPARAGINE

\* = PEPTIDE BOND / POLYPEPTIDE CHAIN = PROTEIN

# GENETIC CODE

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	LY U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA Leucine	CCA Proline	CAA Glutamine	CGA Arginine	A
	CUG Leucine	CCG Proline	CAG Glutamine	CGG Arginine	G
A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	<b>AUG</b> U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA Leucine	CCA Proline	CAA Glutamine	CGA Arginine	A
	CUG Leucine	CCG Proline	CAG Glutamine	CGG Arginine	G
<b>A</b>	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	<b>AAA Lysine</b>	AGA Arginine	<b>A</b>
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G





# GENETIC CODE

M-RNA AUGCAUAACAAACUUCCCUAA

M-RNA AUG CAU AAC AAA CUU CCC UAA

CODON CODON CODON CODON CODON CODON CODON

MET \* HIS \* ASP \* LYS

LYSINE

\* = PEPTIDE BOND / POLYPEPTIDE CHAIN = PROTEIN

# GENETIC CODE

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	LE U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	
	CUA Leucine	CCA Proline	CAA Glutamine	CGA Arginine	
	CUG Leucine	CCG Proline	CAG Glutamine	CGG Arginine	
A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	AUG U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA Leucine	CCA Proline	CAA Glutamine	CGA Arginine	A
	CUG Leucine	CCG Proline	CAG Glutamine	CGG Arginine	G
A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G



# GENETIC CODE

M-RNA AUGCAUAACAAACUUCCCUAA

M-RNA AUG CAU AAC AAA CUU CCC UAA

CODON CODON CODON CODON CODON CODON CODON

MET \* HIS \* ASP \* LYS LEU

LEUCINE

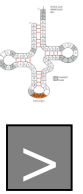
\* = PEPTIDE BOND / POLYPEPTIDE CHAIN = PROTEIN

# GENETIC CODE

# TRANSFER RNA

# **TRANSFER RNA**

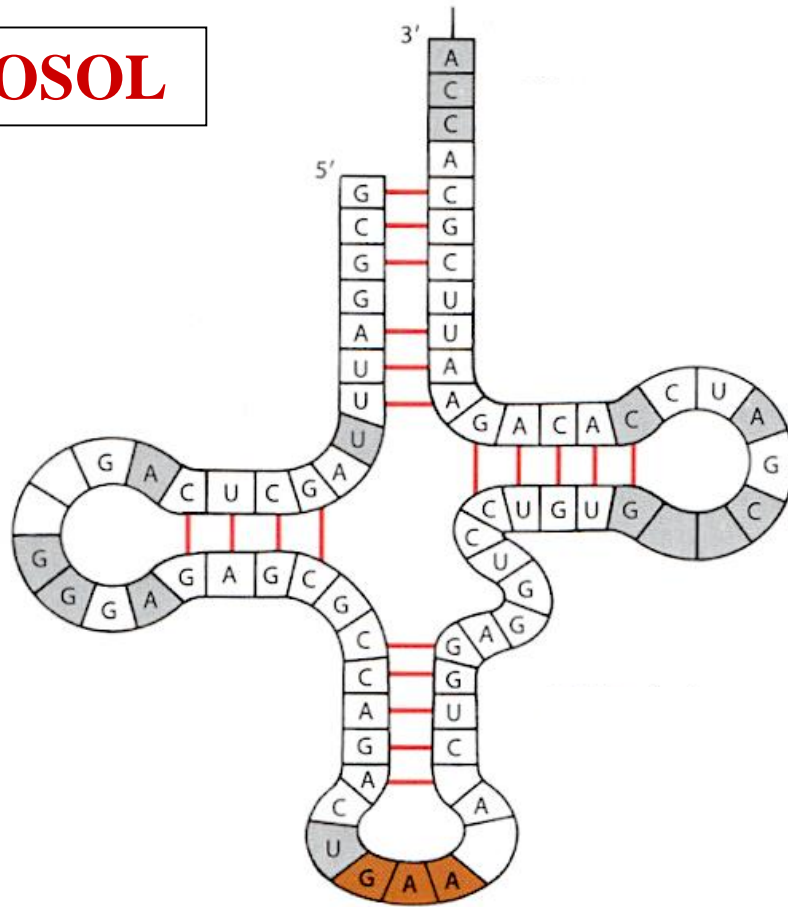
# TRANSFER RNA



TRANSPORTS CYTOSOL  
AMINO ACIDS TO  
RIBOSOME

TRANSFER RNA

**CELL CYTOSOL**



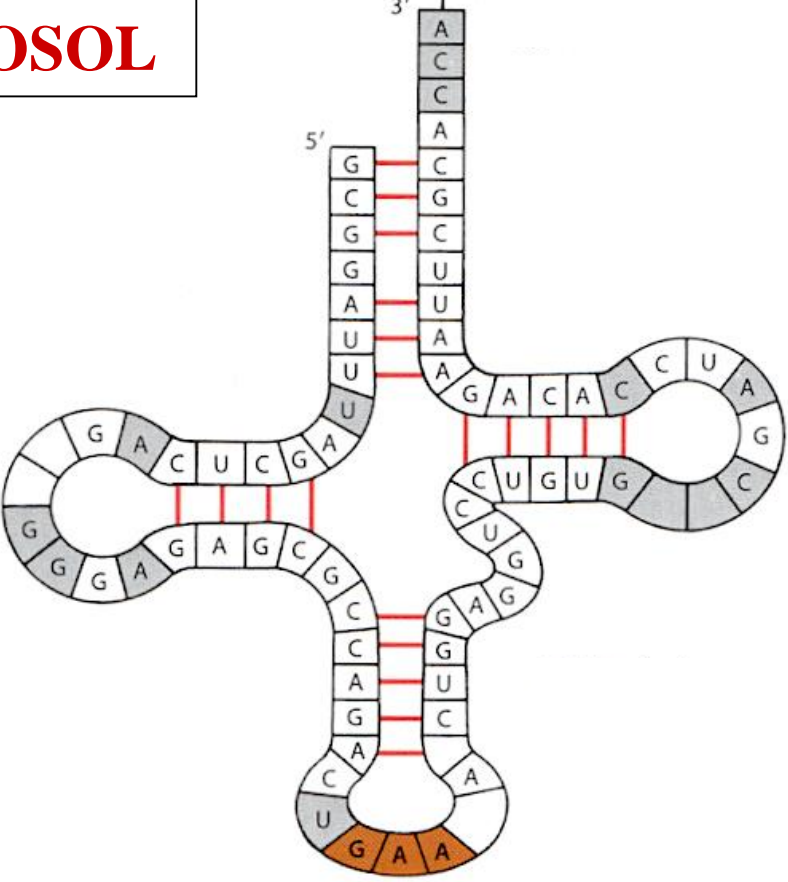
**T-RNA**





AMINO ACID

CELL CYTOSOL



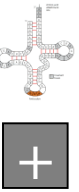
T-RNA



# TRANSFER RNA ANTICODON

**ANTICODON**

**ANTICODON**



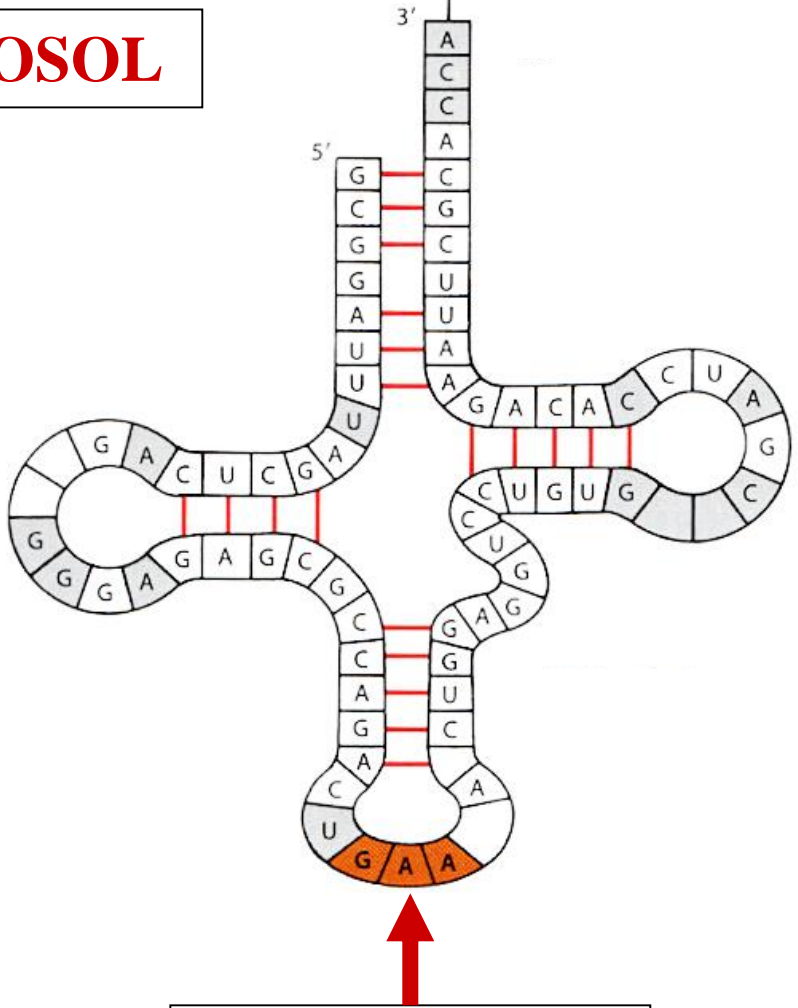
**3 NUCLEOTIDE BASES  
ALONG T-RNA**

**ANTICODON**



AMINO ACID

CELL CYTOSOL



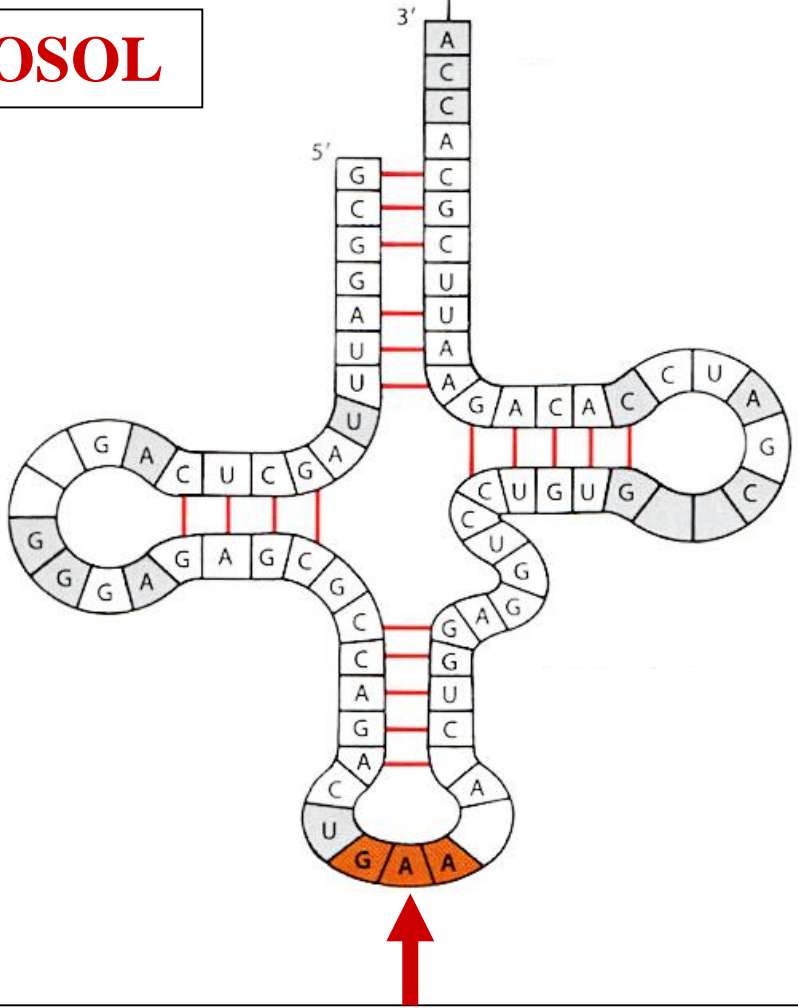
T-RNA

ANTICODON



AMINO ACID

CELL CYTOSOL



T-RNA

ANTICODON: 3 NUCLEOTIDE BASES ALONG T-RNA





First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	<b>64</b> U C A G U C
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	
	UUA Leucine	UCA Serine	UAA <i>STOP</i>	UGA <i>STOP</i>	
	UUG Leucine	UCG Serine	UAG <i>STOP</i>	UGG Tryptophan	
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C

# GENETIC CODE

A	Isoleucine	Threonine	Asparagine	Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG ( <i>START</i> ) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	3 U C A G
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	
	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC	CCC	CAC	CGC	

# GENETIC CODE

## 64 DIFFERENT CODONS

A	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	61 U C A G
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	
	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U

**3 STOP CODONS CODE FOR  
NO  
AMINO ACIDS**

	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	?
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA STOP	UGA STOP	A
	UUG Leucine	UCG Serine	UAG STOP	UGG Tryptophan	G
	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC	CCC	CAC	CGC	C

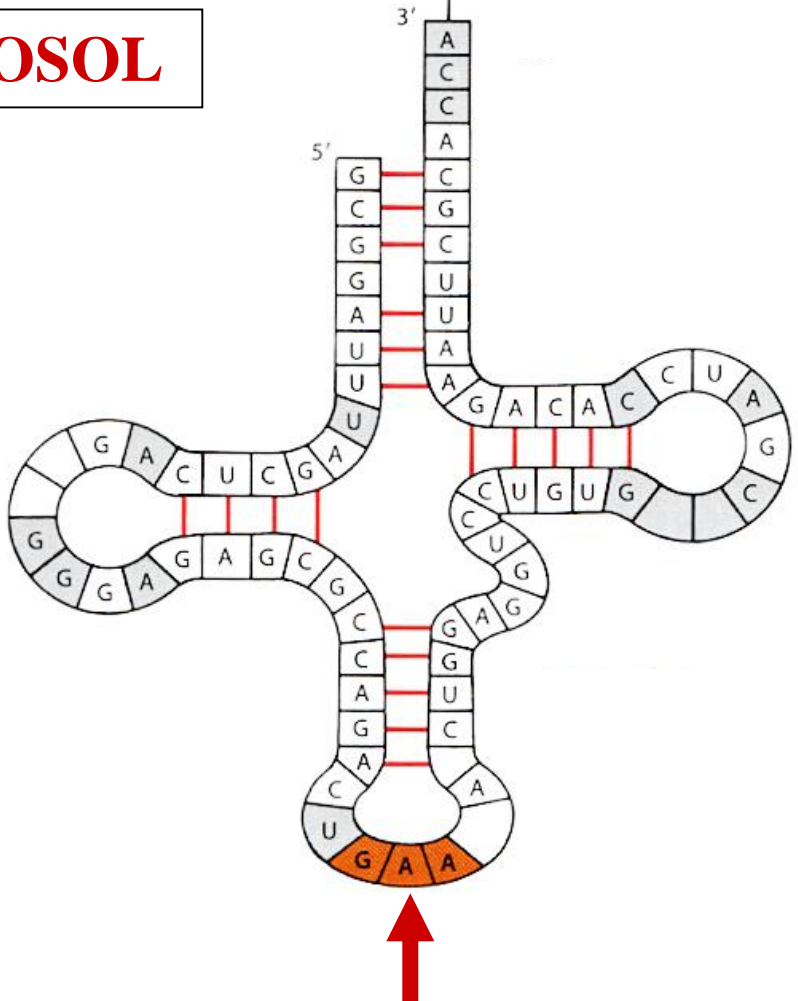
# 61 CODONS CODE FOR AMINO ACIDS

A	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG (START) Methionine	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic acid	GGG Glycine	G

LEU

AMINO ACID

CELL CYTOSOL



? T-RNA

1 T-RNA ANTICODON / AMINO ACID CODON





# PROTEIN SYNTHESIS

**DURING TRANSLATION:**

TRANSLATION

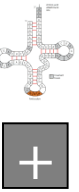


# PROTEIN SYNTHESIS

**T-RNA ANTICODON  
MUST COMPLEMENT  
M-RNA CODON**

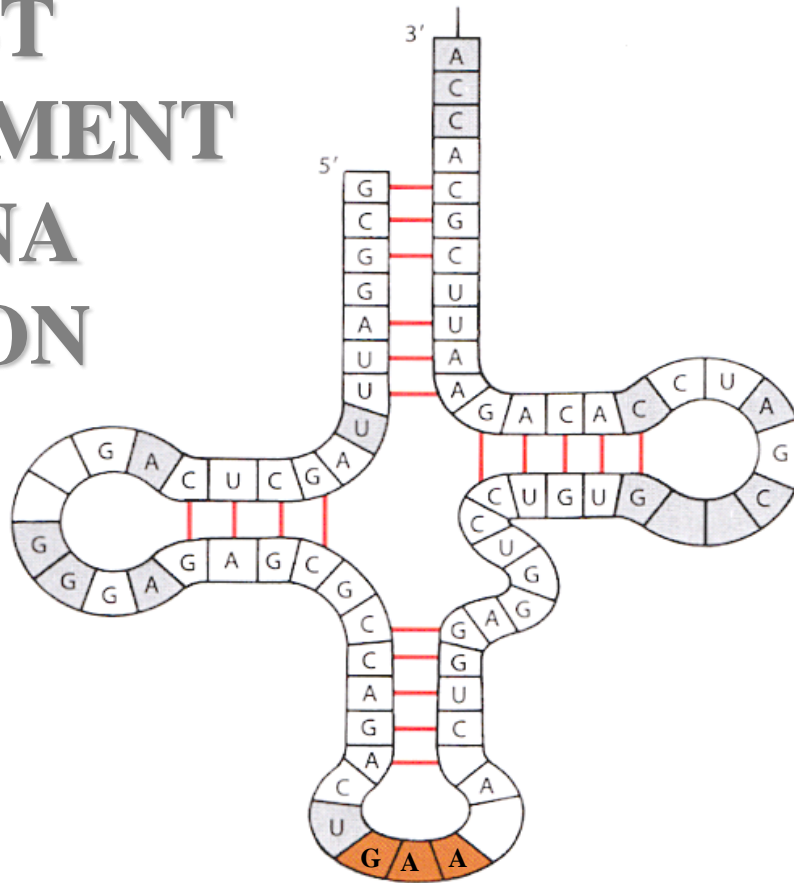
# TRANSLATION





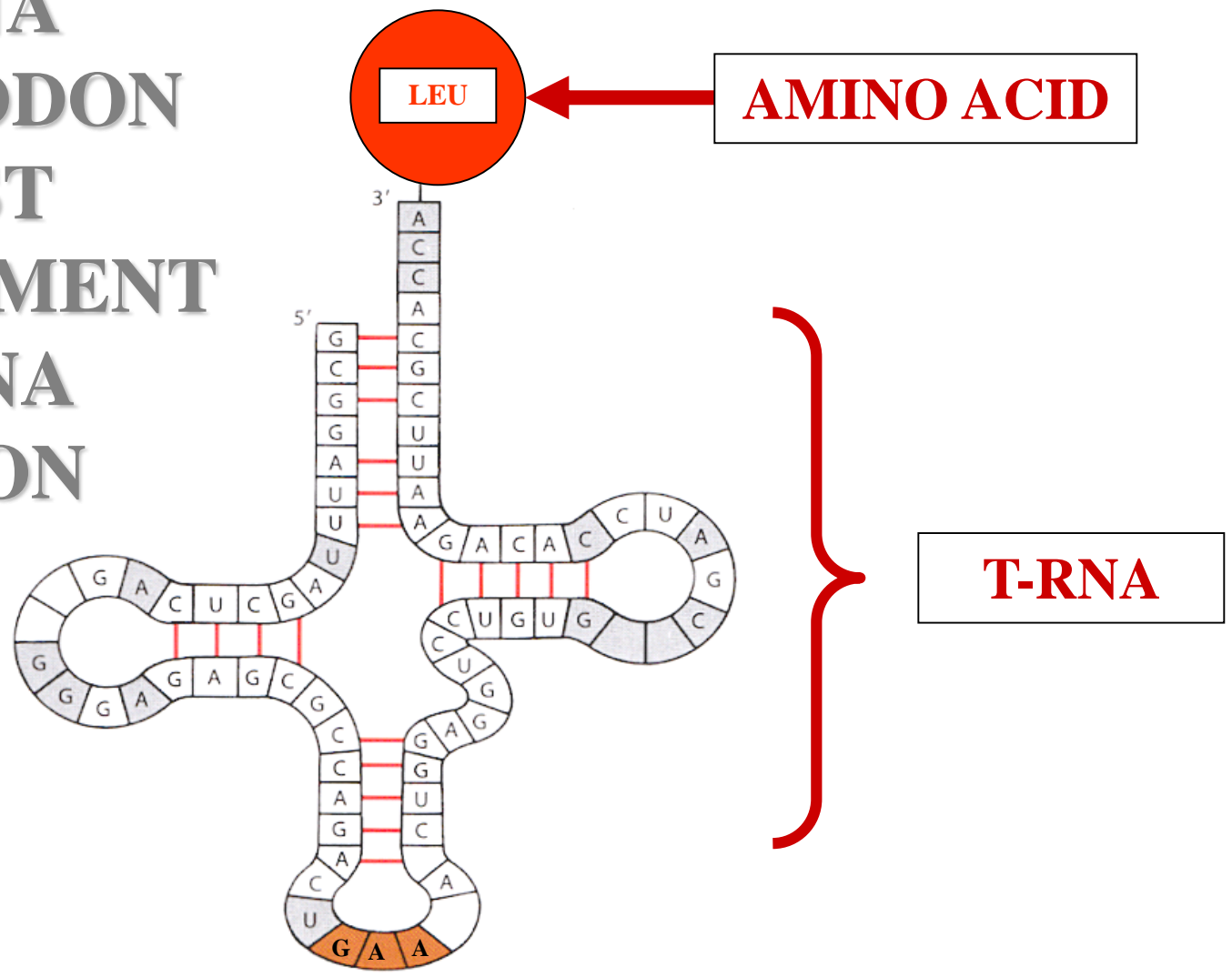
**CODON  
&  
ANTICODON  
APPLIED**

**T-RNA  
ANTICODON  
MUST  
COMPLIMENT  
M-RNA  
CODON**



**T-RNA**

**T-RNA  
ANTICODON  
MUST  
COMPLIMENT  
M-RNA  
CODON**



T-RNA  
ANTICODON  
MUST  
COMPLIMENT  
M-RNA  
CODON

