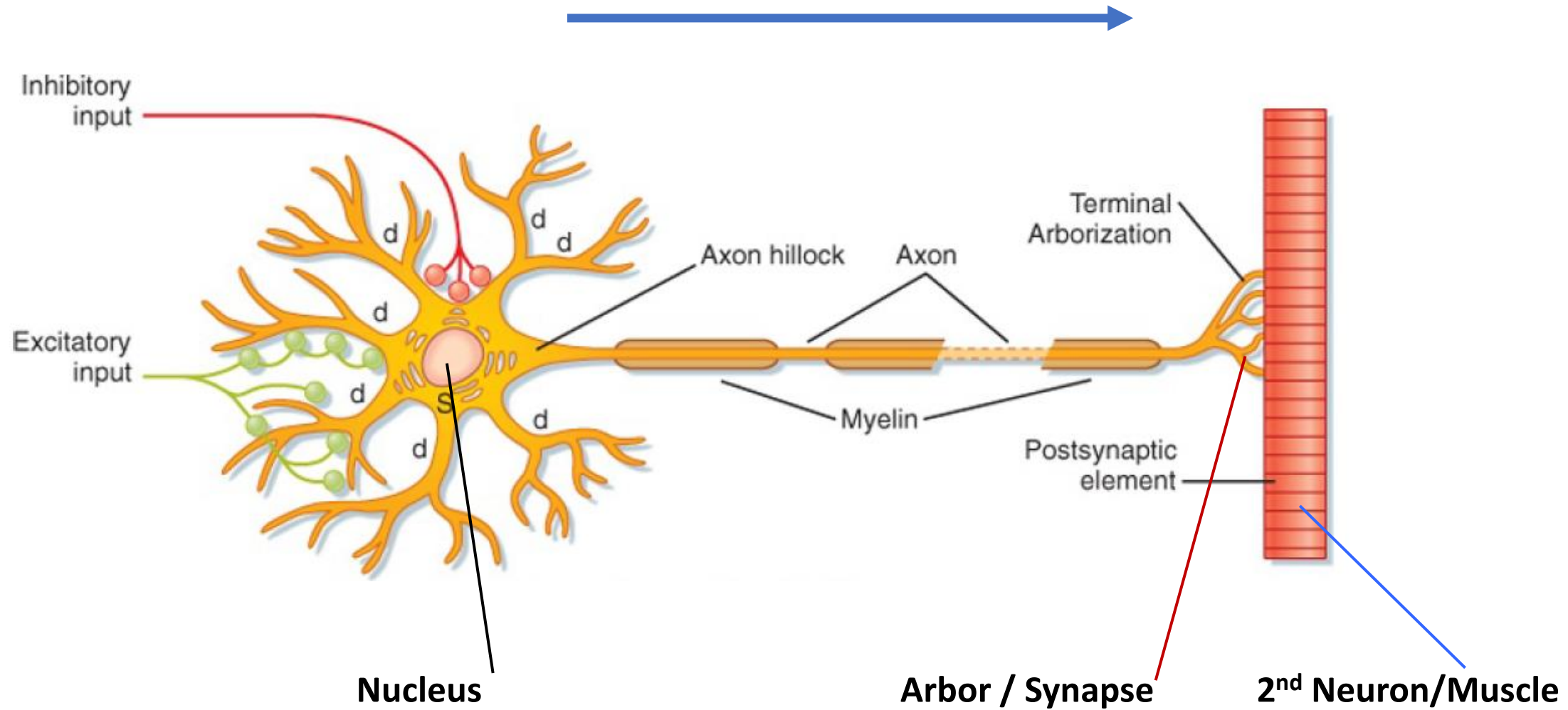


**Neuron:**

**Dynamics of Proteins & Enzymes**

# Neuron: Nucleus & Synapse



# **Stage-1:**

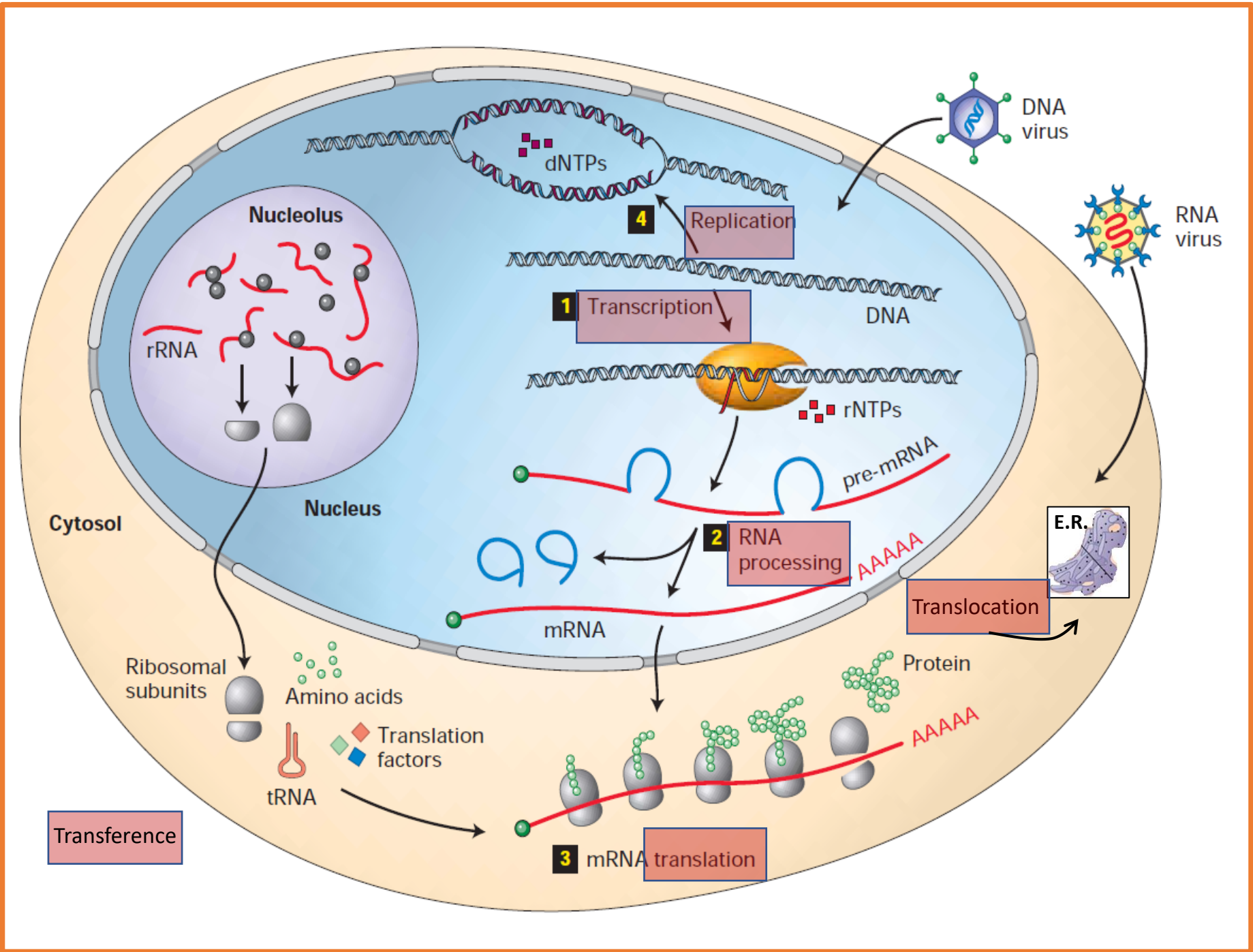
# **Protein Formation**

Basic Genetic Processes:  
 $R^2 T^5$

Replication of DNA  
(during Cell Division)

Protein Formation Steps:

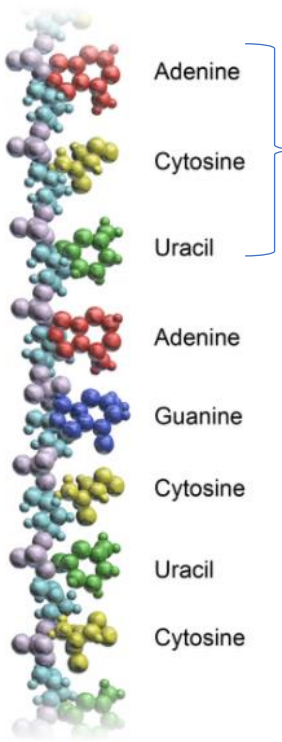
- Transcription,
- RNA processing,
- Transference,
- Translation
- Translocation



# Genetic Code (RNA to Amino Acids)\*

(Discovery of Har Govind Khorana)

## RNA



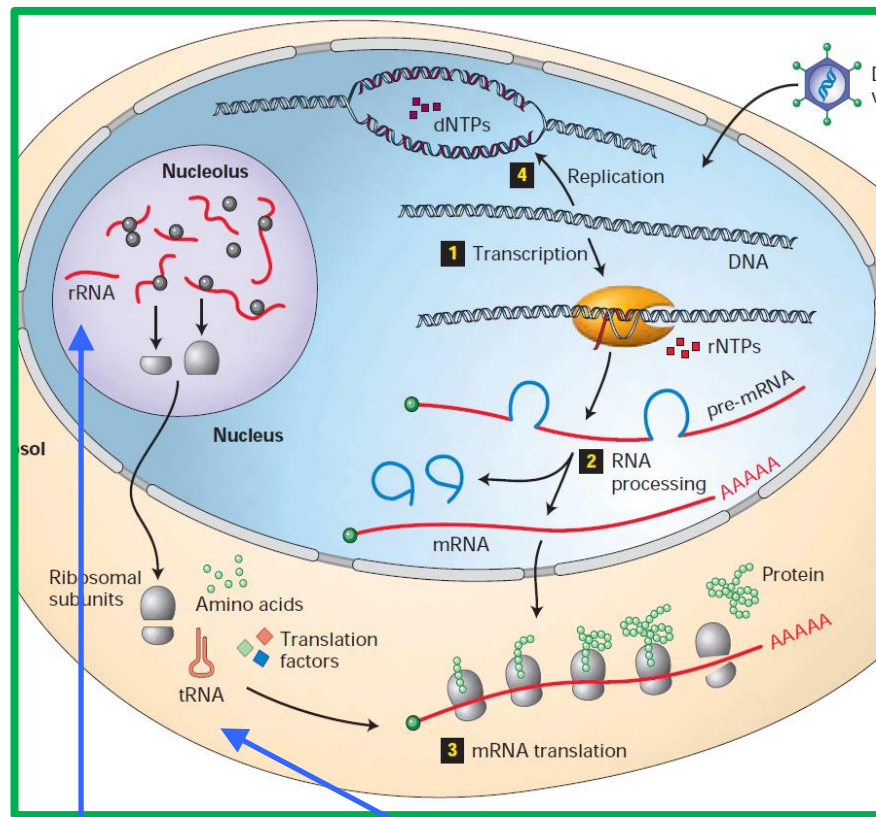
|                          |                             |                          |
|--------------------------|-----------------------------|--------------------------|
| Alanine<br>(Ala or A)    | Valine<br>(Val or V)        | Isoleucine<br>(Ile or I) |
| Methionine<br>(Met or M) | Phenylalanine<br>(Phe or F) | Tyrosine<br>(Tyr or Y)   |
| Lysine<br>(Lys or K)     | Arginine<br>(Arg or R)      | Histidine<br>(His or H)  |
| Glutamate<br>(Glu or E)  | Asparagine<br>(Asn or N)    | Glutamine<br>(Gln or Q)  |
| Aspartate<br>(Asp or D)  | Serine<br>(Ser or S)        | Threonine<br>(Thr or T)  |
| Cysteine<br>(Cys or C)   | Glycine<br>(Gly or G)       | Proline<br>(Pro or P)    |
| Leucine<br>(Leu or L)    | Tryptophan<br>(Trp or W)    |                          |

| First Position<br>(5' end) | Second Position    |            |              | Third Position<br>(3' end) |
|----------------------------|--------------------|------------|--------------|----------------------------|
| U                          | C                  | A          | G            |                            |
| U                          | Phe<br>Phe         | Ser<br>Ser | Tyr<br>Tyr   | Cys<br>Cys                 |
| U                          | Leu<br>Leu         | Ser<br>Ser | Stop<br>Stop | Stop<br>Trp                |
| C                          | Leu<br>Leu         | Pro<br>Pro | His<br>His   | Arg<br>Arg                 |
| C                          | Leu<br>Leu (Met)*  | Pro<br>Pro | Gln<br>Gln   | Arg<br>Arg                 |
| A                          | Ile<br>Ile         | Thr<br>Thr | Asn<br>Asn   | Ser<br>Ser                 |
| A                          | Ile<br>Met (start) | Thr<br>Thr | Lys<br>Lys   | Arg<br>Arg                 |
| G                          | Val<br>Val         | Ala<br>Ala | Asp<br>Asp   | Gly<br>Gly                 |
| G                          | Val<br>Val (Met)*  | Ala<br>Ala | Glu<br>Glu   | Gly<br>Gly                 |

\*AUG is the most common initiator codon; GUG usually codes for valine, and CUG for leucine, but, rarely, these codons can also code for methionine to initiate a protein chain.



## Translation: Protein Synthesis by “3” RNAs

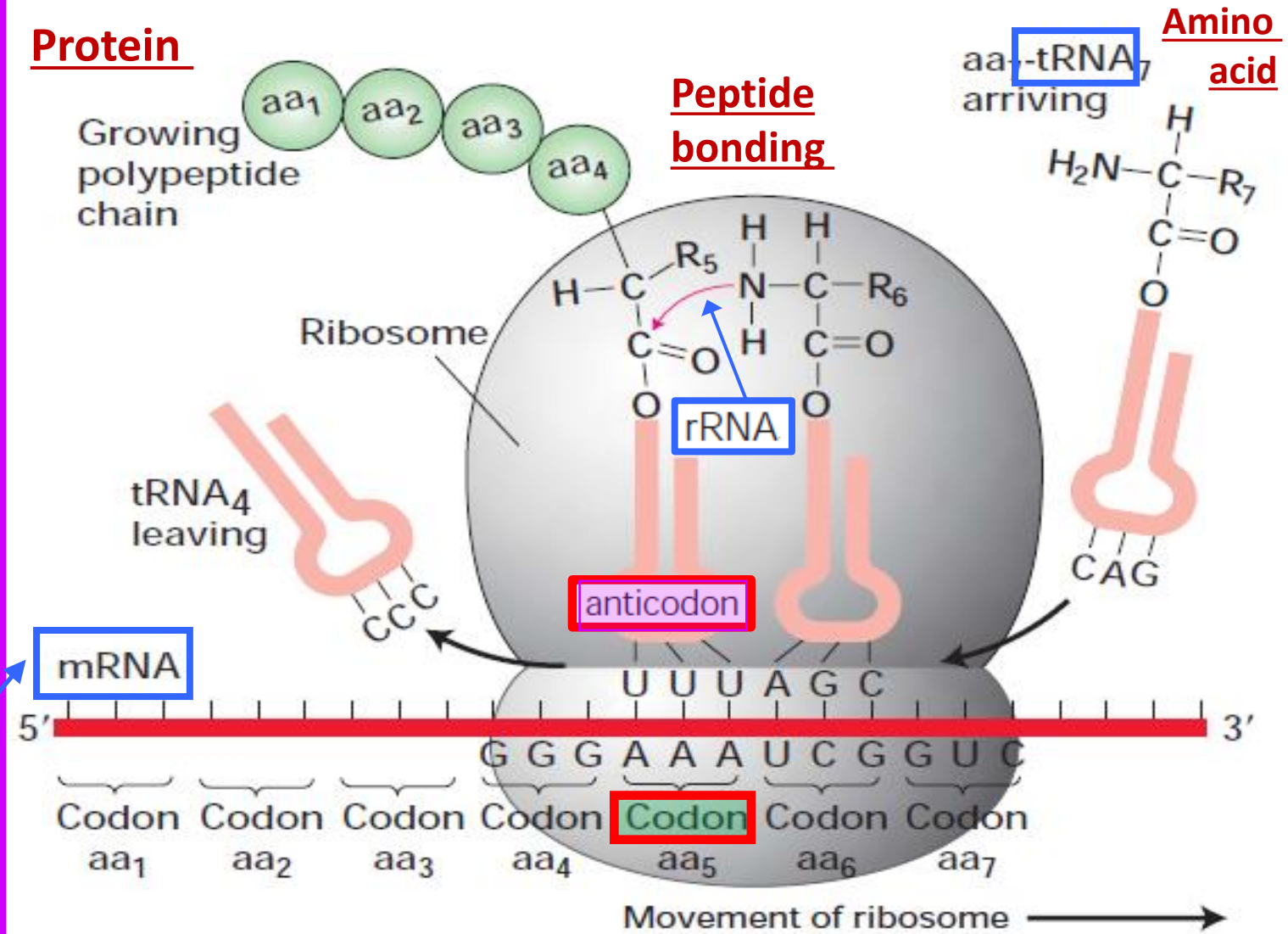


Ribosoma RNA (rRNA)

Transfer RNA (tRNA)

Messenger RNA (mRNA)

### Protein



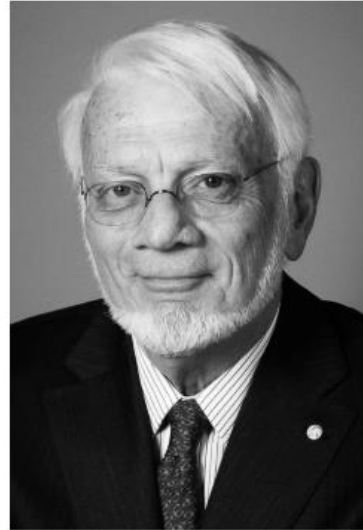
# The Nobel Prize in Chemistry 2009



© The Nobel Foundation. Photo: U. Montan

Venkatraman  
Ramakrishnan

Prize share: 1/3



© The Nobel Foundation. Photo: U. Montan

Thomas A. Steitz

Prize share: 1/3



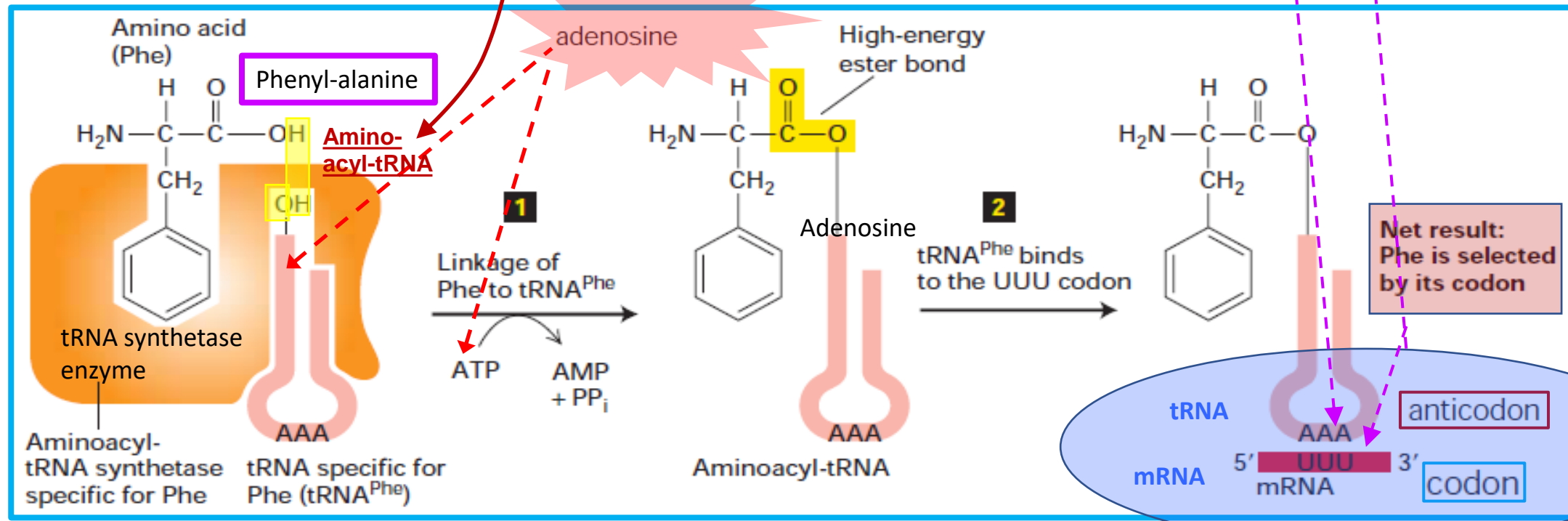
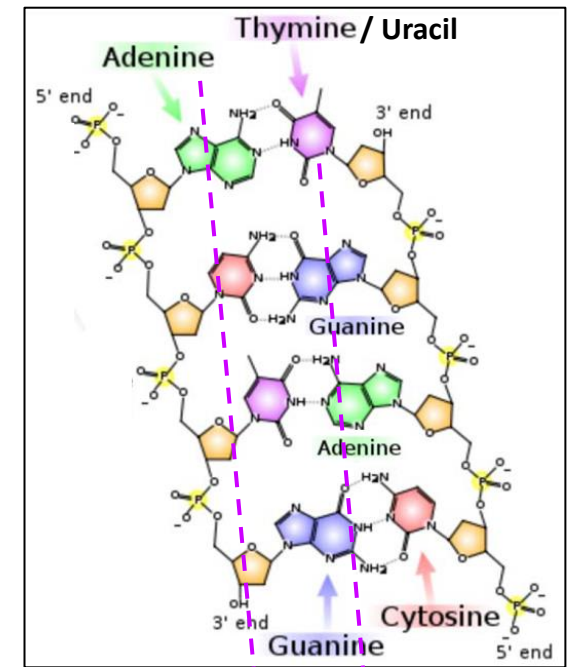
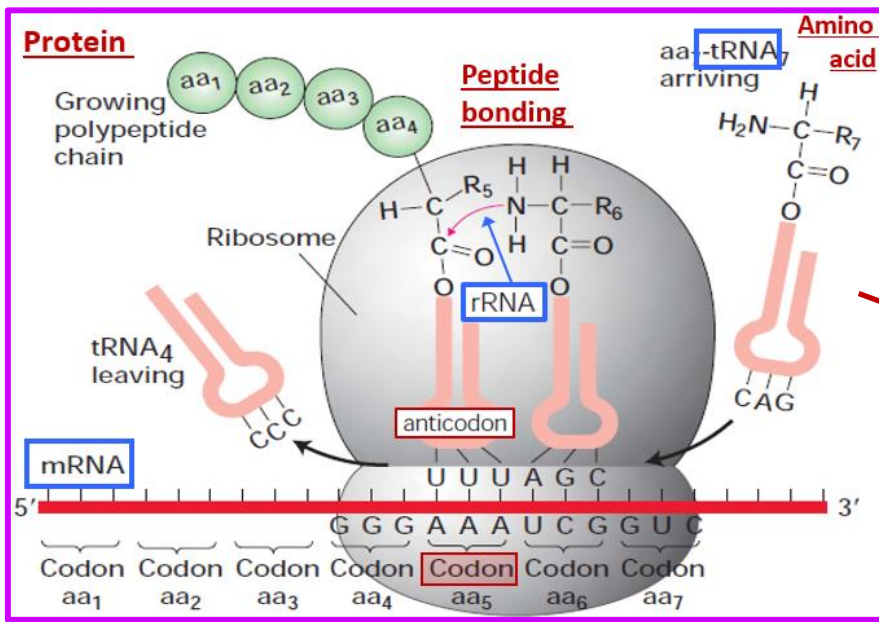
© The Nobel Foundation. Photo: U. Montan

Ada E. Yonath

Prize share: 1/3

The Nobel Prize in Chemistry 2009 was awarded jointly to Venkatraman Ramakrishnan, Thomas A. Steitz and Ada E. Yonath "for studies of the structure and function of the ribosome."

# Protein Synthesis





# Genetic Code (RNA to Amino Acids)\*

|                                 |                                    |                                 |
|---------------------------------|------------------------------------|---------------------------------|
| <b>Alanine</b><br>(Ala or A)    | <b>Valine</b><br>(Val or V)        | <b>Isoleucine</b><br>(Ile or I) |
| <b>Methionine</b><br>(Met or M) | <b>Phenylalanine</b><br>(Phe or F) | <b>Tyrosine</b><br>(Tyr or Y)   |
| <b>Lysine</b><br>(Lys or K)     | <b>Arginine</b><br>(Arg or R)      | <b>Histidine</b><br>(His or H)  |
| <b>Glutamate</b><br>(Glu or E)  | <b>Asparagine</b><br>(Asn or N)    | <b>Glutamine</b><br>(Gln or Q)  |
| <b>Aspartate</b><br>(Asp or D)  | <b>Serine</b><br>(Ser or S)        | <b>Threonine</b><br>(Thr or T)  |
| <b>Cysteine</b><br>(Cys or C)   | <b>Glycine</b><br>(Gly or G)       | <b>Proline</b><br>(Pro or P)    |
| <b>Leucine</b><br>(Leu or L)    | <b>Tryptophan</b><br>(Trp or W)    |                                 |

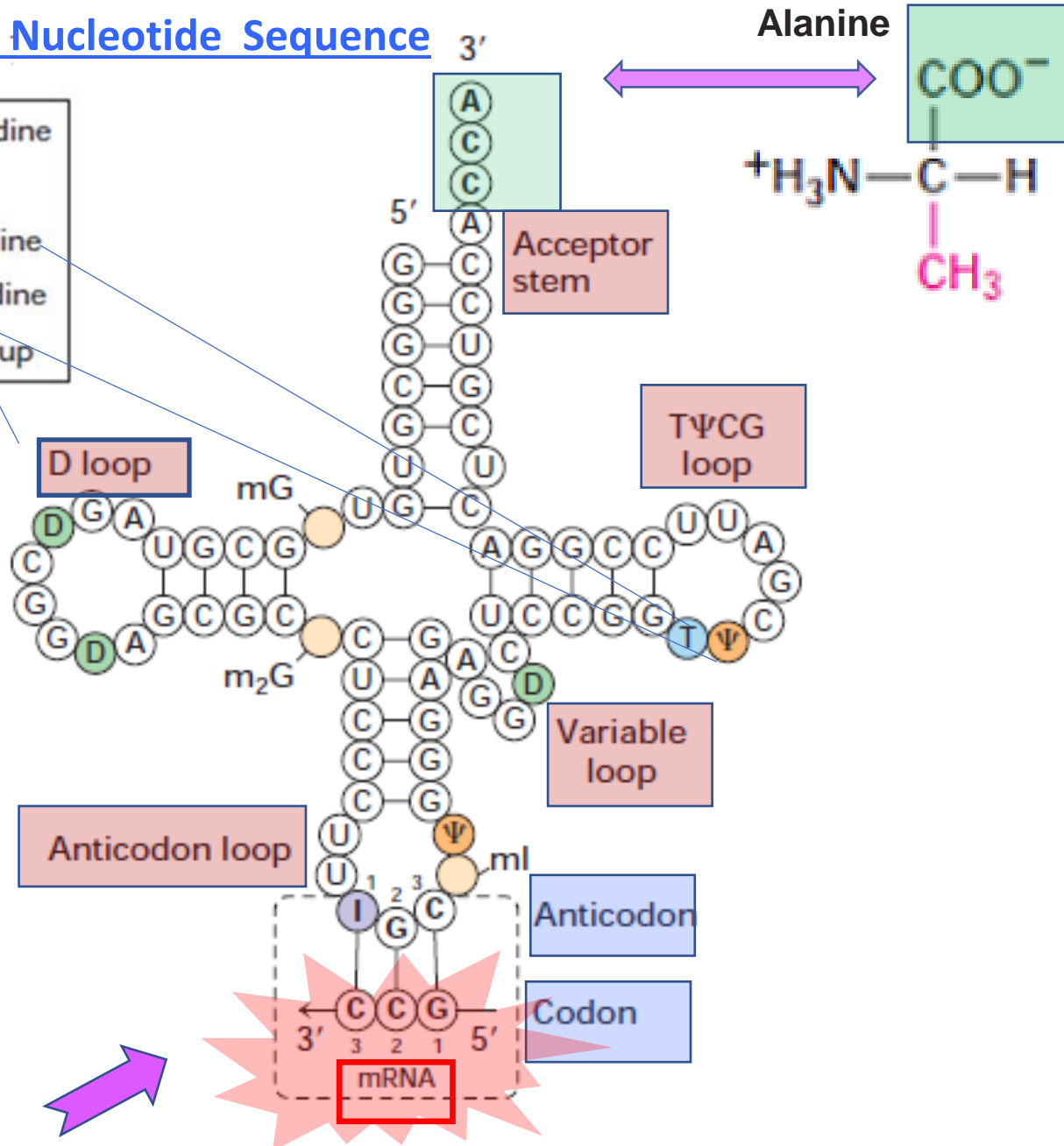
| First Position<br>(5' end) | Second Position    |            |              |             | Third Position<br>(3' end) |
|----------------------------|--------------------|------------|--------------|-------------|----------------------------|
|                            | U                  | C          | A            | G           |                            |
| U                          | Phe<br>Phe         | Ser<br>Ser | Tyr<br>Tyr   | Cys<br>Cys  | U<br>C                     |
|                            | Leu<br>Leu         | Ser<br>Ser | Stop<br>Stop | Stop<br>Trp | A<br>G                     |
| C                          | Leu<br>Leu         | Pro<br>Pro | His<br>His   | Arg<br>Arg  | U<br>C                     |
|                            | Leu<br>Leu (Met)*  | Pro<br>Pro | Gln<br>Gln   | Arg<br>Arg  | A<br>G                     |
| A                          | Ile<br>Ile         | Thr<br>Thr | Asn<br>Asn   | Ser<br>Ser  | U<br>C                     |
|                            | Ile<br>Met (start) | Thr<br>Thr | Lys<br>Lys   | Arg<br>Arg  | A<br>G                     |
| G                          | Val<br>Val         | Ala<br>Ala | Asp<br>Asp   | Gly<br>Gly  | U<br>C                     |
|                            | Val<br>Val (Met)*  | Ala<br>Ala | Glu<br>Glu   | Gly<br>Gly  | A<br>G                     |

\*AUG is the most common initiator codon; GUG usually codes for valine, and CUG for leucine, but, rarely, these codons can also code for methionine to initiate a protein chain.

# Structure of tRNA

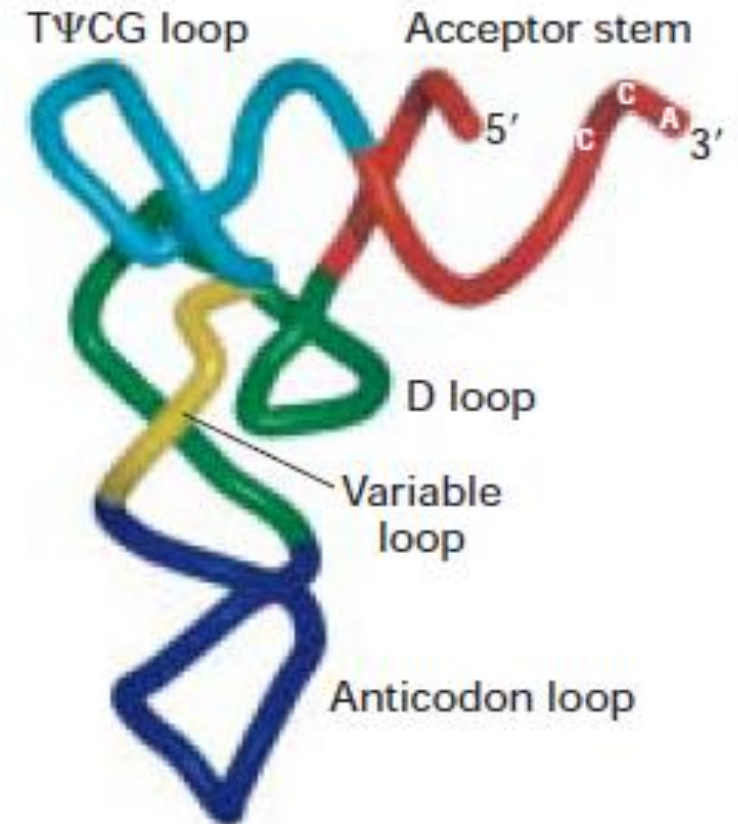
## "Substituted" Nucleotide Sequence

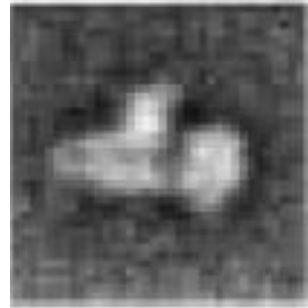
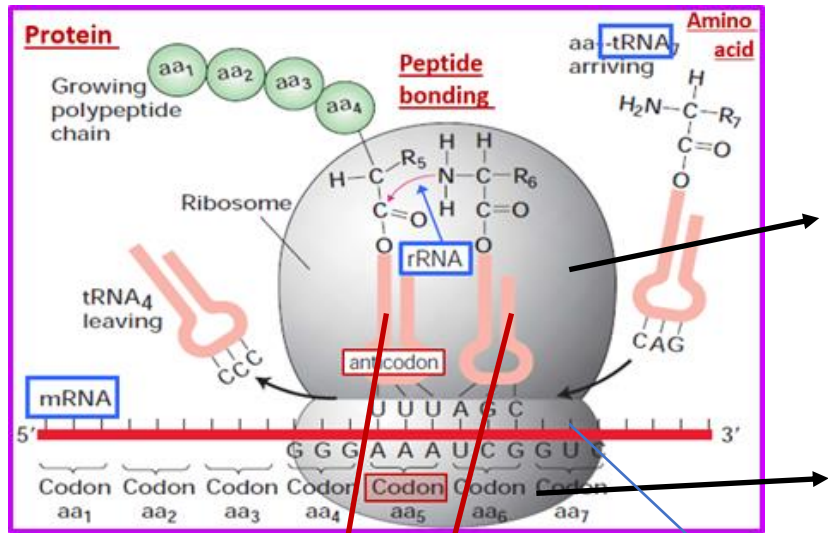
- D = dihydrouridine
- I = inosine
- T = ribothymidine
- Ψ = pseudouridine
- m = methyl group



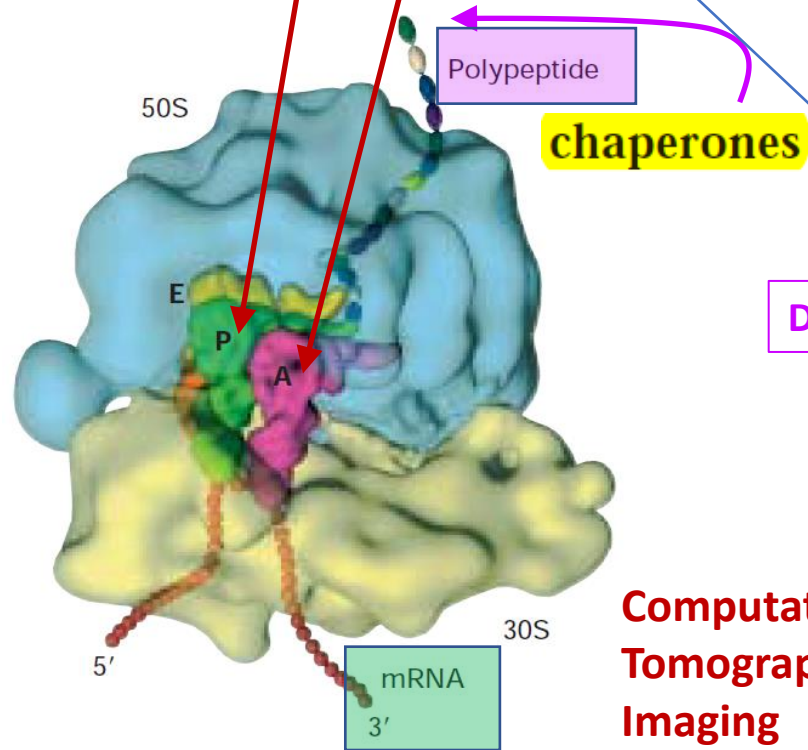
## 3-D Representation

### Yeast's Alanine tRNA





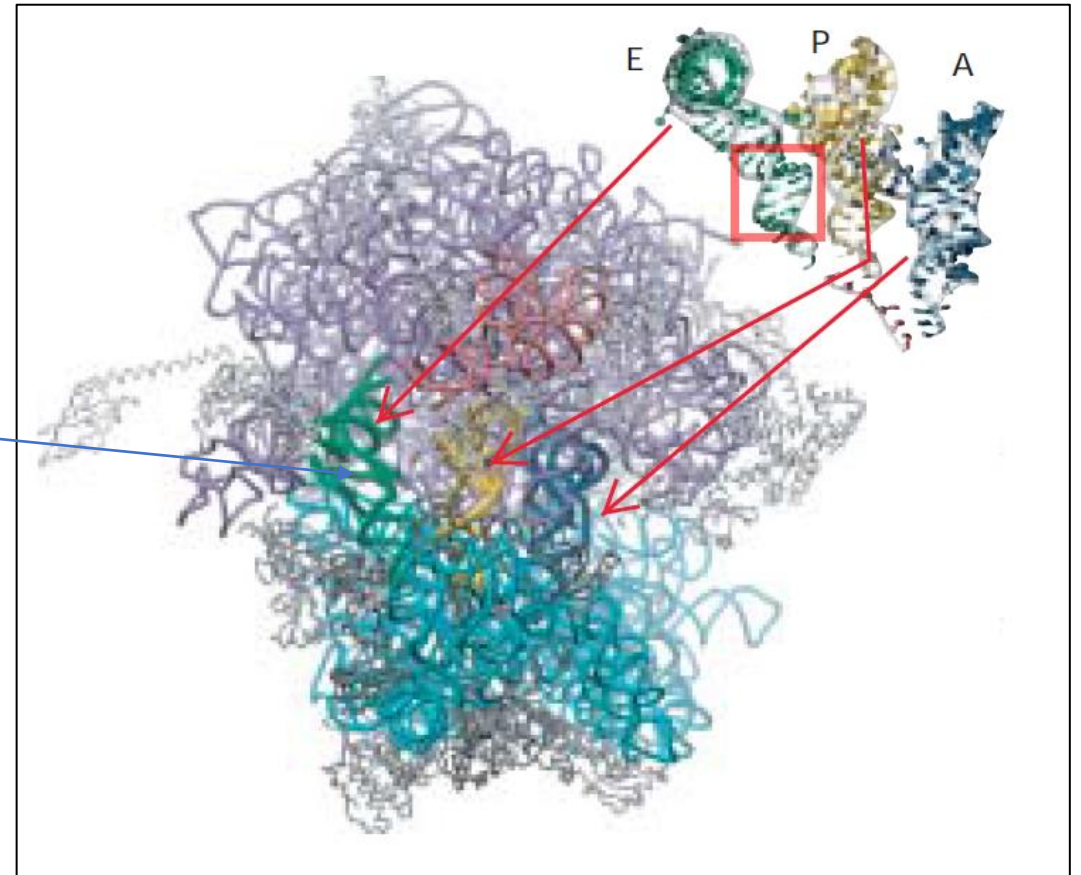
**Electron Microscopy**



**Computational Tomographic Imaging**

## Ribosome Structure

**X-Ray Crystallography**



**Double-Stranded RNA**



# Poly-ribosome (“Poly-some”): Recycled Ribosome

“Circular” mRNA used

Electron Microscopy

poly(A)-binding protein I (PABPI)

Ribosome  
Re-assembling

