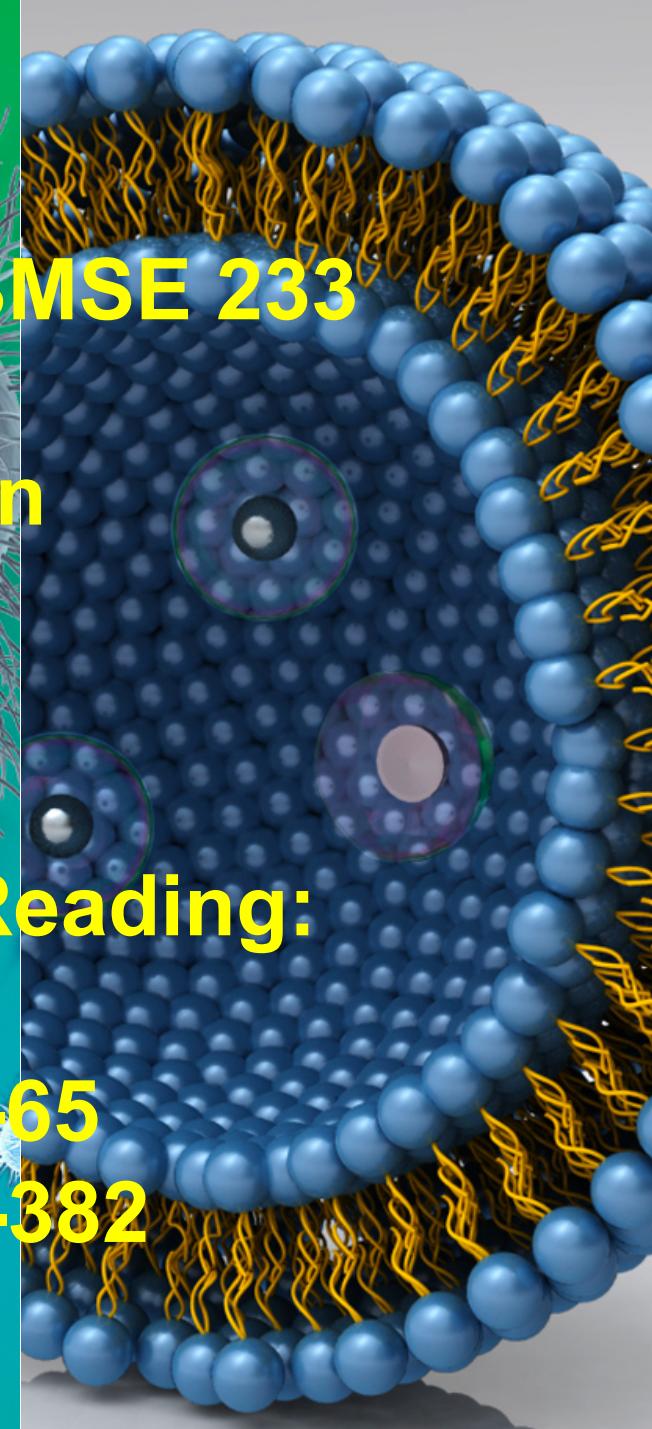
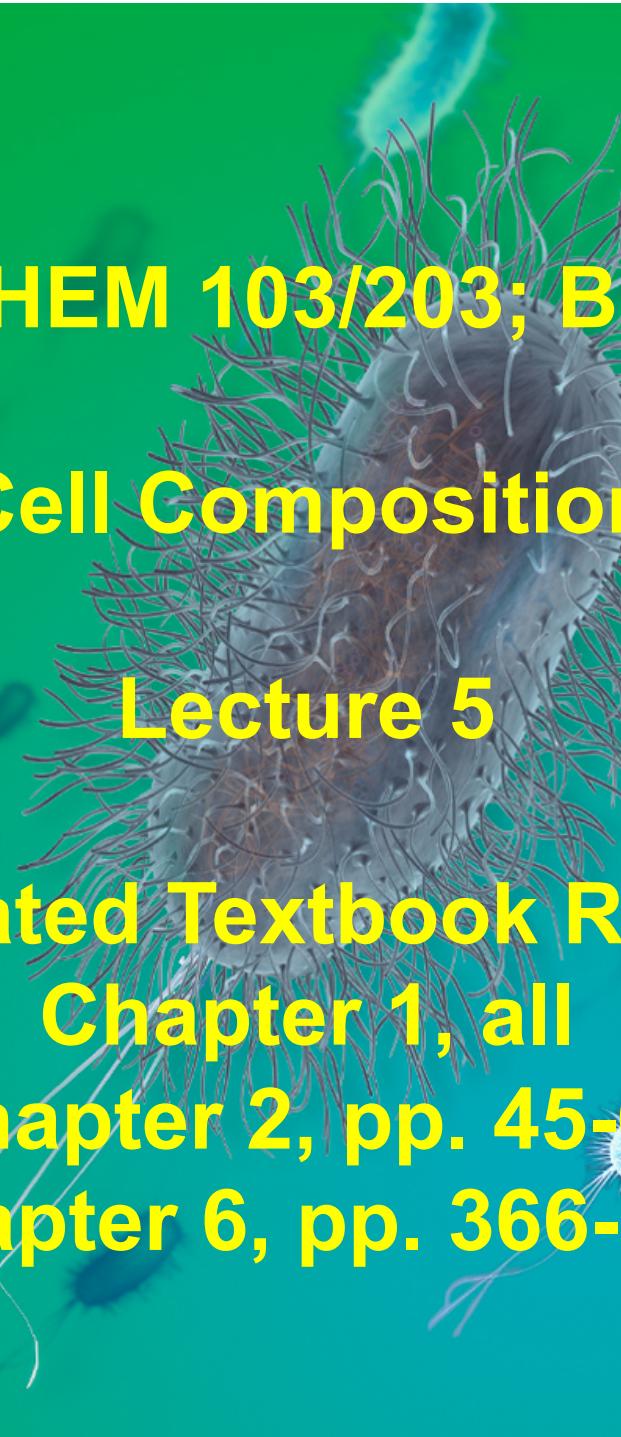


**MCDB/CHEM 103/203; BMSE 233**

## **Cell Composition**

**Lecture 5**

**Associated Textbook Reading:**  
**Chapter 1, all**  
**Chapter 2, pp. 45-65**  
**Chapter 6, pp. 366-382**



# From DNA to RNA to Protein

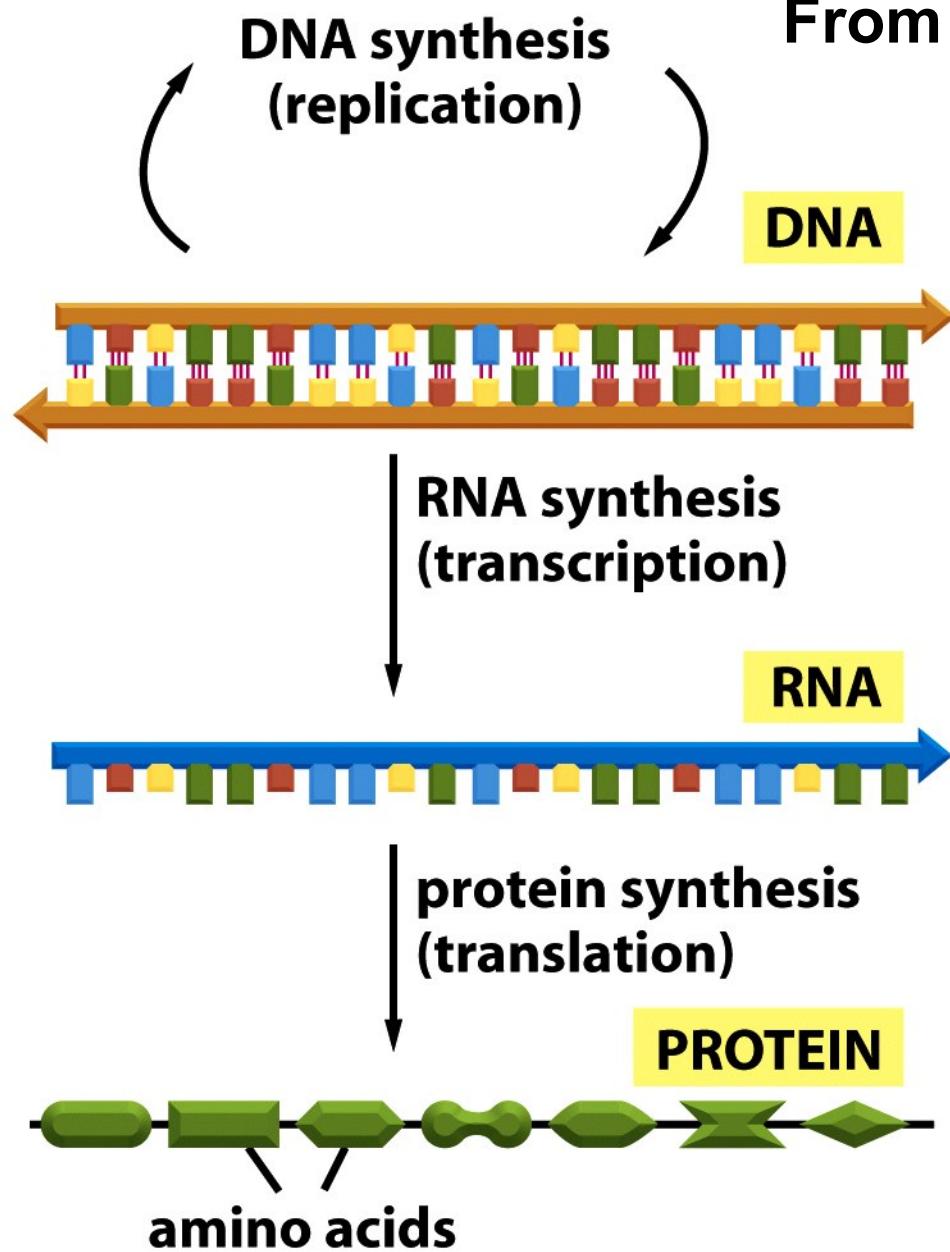
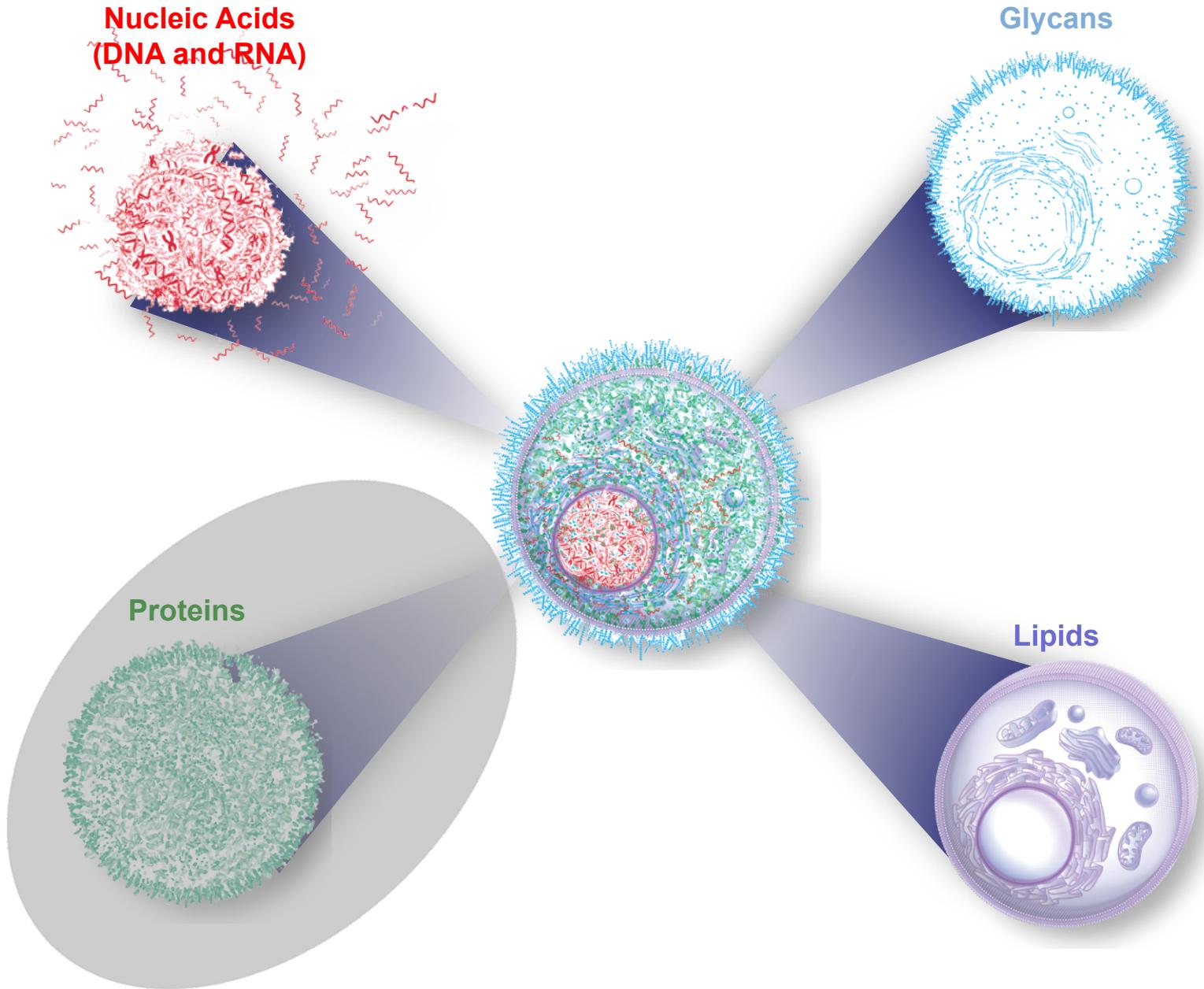


Figure 1-4 Molecular Biology of the Cell 5/e (© Garland Science 2008)

# The Genetic Code

	Second Position				
	U	C	A	G	
First Position (5' end)	U	C	A	G	D C A G
	UUU    UUC    UUA    UUG } Phe	UCU    UCC    UCA    UCG } Ser	UAU    UAC    UAA    UAG } Tyr Stop	UGU    UGC    UGA    UGG } Cys Stop Trp	
C	CUU    CUC    CUA    CUG } Leu	CCU    CCC    CCA    CCG } Pro	CAU    CAC    CAA    CAG } His Gln	CGU    CGC    CGA    CGG } Arg	D C A G
A	AUU    AUC    AUA    AUG } Ile Met	ACU    ACC    ACA    ACG } Thr	AAU    AAC    AAA    AAG } Asn Lys	AGU    AGC    AGA    AGG } Ser Arg	D C A G
G	GUU    GUC    GUA    GUG } Val	GCU    GCC    GCA    GCG } Ala	GAU    GAC    GAA    GAG } Asp Glu	GGU    GGC    GGA    GGG } Gly	D C A G
	<p>● = Chain-terminating codon  <span style="color: green;">●</span> = Initiation codon</p>				
Third Position (3' end)					

# Cells are Composed of Four Types of Molecular Components



# Proteins are Used to Make Up Many (But Not All) Structures of the Cell

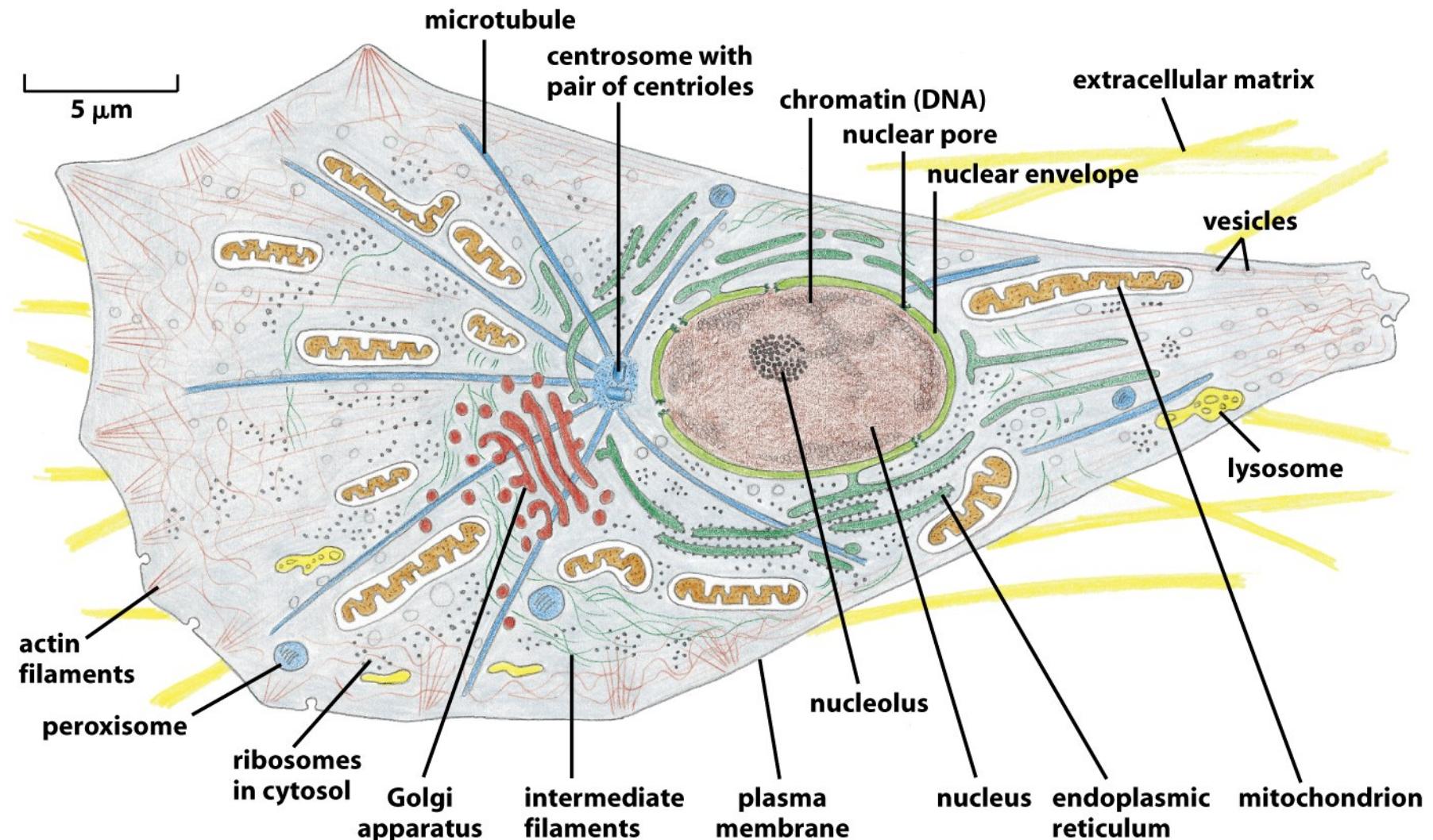
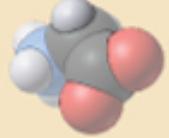
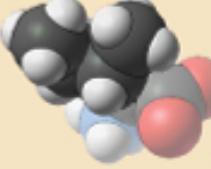
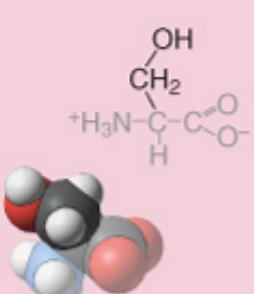
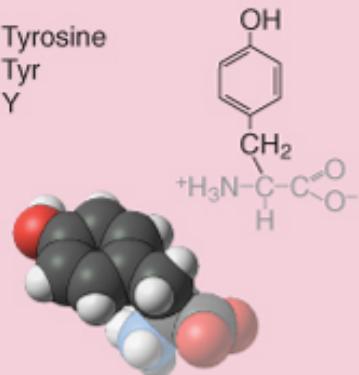
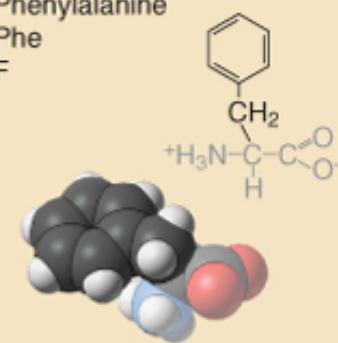
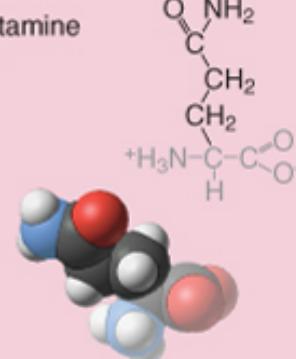
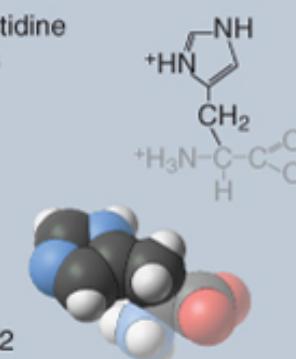
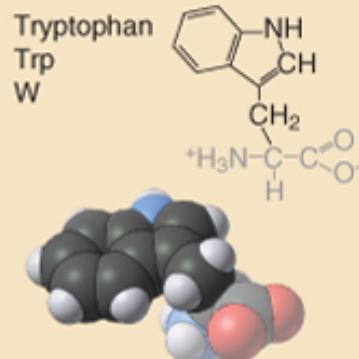
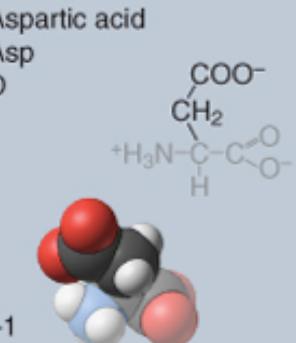
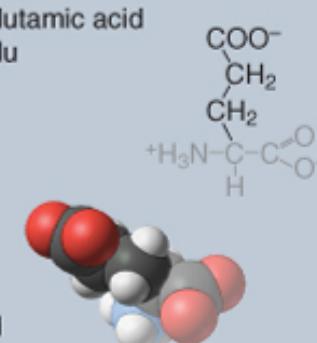
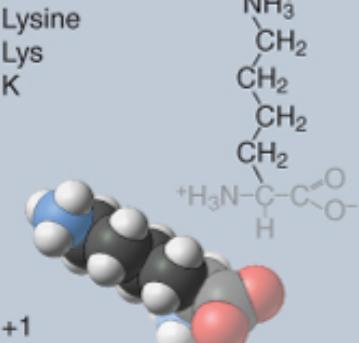
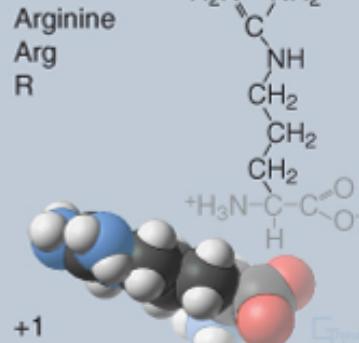


Figure 1-30 Molecular Biology of the Cell 5/e (© Garland Science 2008)

# AMINO ACIDS IN PROTEIN SYNTHESIS

UNCHARGED	Glycine Gly G	Alanine Ala A	Valine Val V	Leucine Leu L
 <chem>[NH3+][C@@H](C)C(=O)[O-]</chem>	 <chem>[NH3+][C@H](C)C(=O)[O-]</chem>	 <chem>[NH3+][C@H](C)C(C)C(=O)[O-]</chem>	 <chem>[NH3+][C@H](C)C(C)C(C)C(=O)[O-]</chem>	
 <chem>[NH3+][C@H](CS)C(=O)[O-]</chem>	 <chem>[NH3+][C@H](CS(C)C)C(=O)[O-]</chem>	 <chem>[NH2+]C1CCC1C(=O)[O-]</chem>	 <chem>[NH3+][C@H](C)C(C)C(C)C(=O)[O-]</chem>	

# AMINO ACIDS IN PROTEIN SYNTHESIS

<p><b>POLAR UNCHARGED</b></p> <p>Serine Ser S</p>  <p><chem>NC(C(=O)O)C(O)C</chem></p>	<p>Threonine Thr T</p>  <p><chem>NC(C(=O)O)C(O)C(C)C</chem></p>	<p>Tyrosine Tyr Y</p>  <p><chem>NC(C(=O)O)C(O)C(Cc1ccc(O)cc1)C</chem></p>	<p>Phenylalanine Phe F</p>  <p><chem>NC(C(=O)O)C(O)C(Cc1ccccc1)C</chem></p>
<p>Asparagine Asn N</p>  <p><chem>NC(C(=O)O)C(O)C(=O)N</chem></p>	<p>Glutamine Gln Q</p>  <p><chem>NC(C(=O)O)C(O)C(=O)NCC</chem></p>	<p>Histidine His H</p>  <p><chem>NC(C(=O)O)C(O)C(=O)Nc1cc[nH]cn1</chem></p> <p>+1/2</p>	<p>Tryptophan Trp W</p>  <p><chem>NC(C(=O)O)C(O)C(=O)c1cc[nH]c2ccccc12</chem></p>
<p><b>CHARGED</b></p> <p>Aspartic acid Asp D</p>  <p><chem>NC(C(=O)O)C(O)C(=O)[O-]</chem></p> <p>-1</p>	<p>Glutamic acid Glu E</p>  <p><chem>NC(C(=O)O)C(O)C(=O)[O-]</chem></p> <p>-1</p>	<p>Lysine Lys K</p>  <p><chem>NC(C(=O)O)C(O)C(CCCCC(N)+)C</chem></p> <p>+1</p>	<p>Arginine Arg R</p>  <p><chem>NC(C(=O)O)C(O)C(CCCC(N)N)C</chem></p> <p>+1</p>

# Why are Some Amino Acids Electrochemically Charged in the Cell?

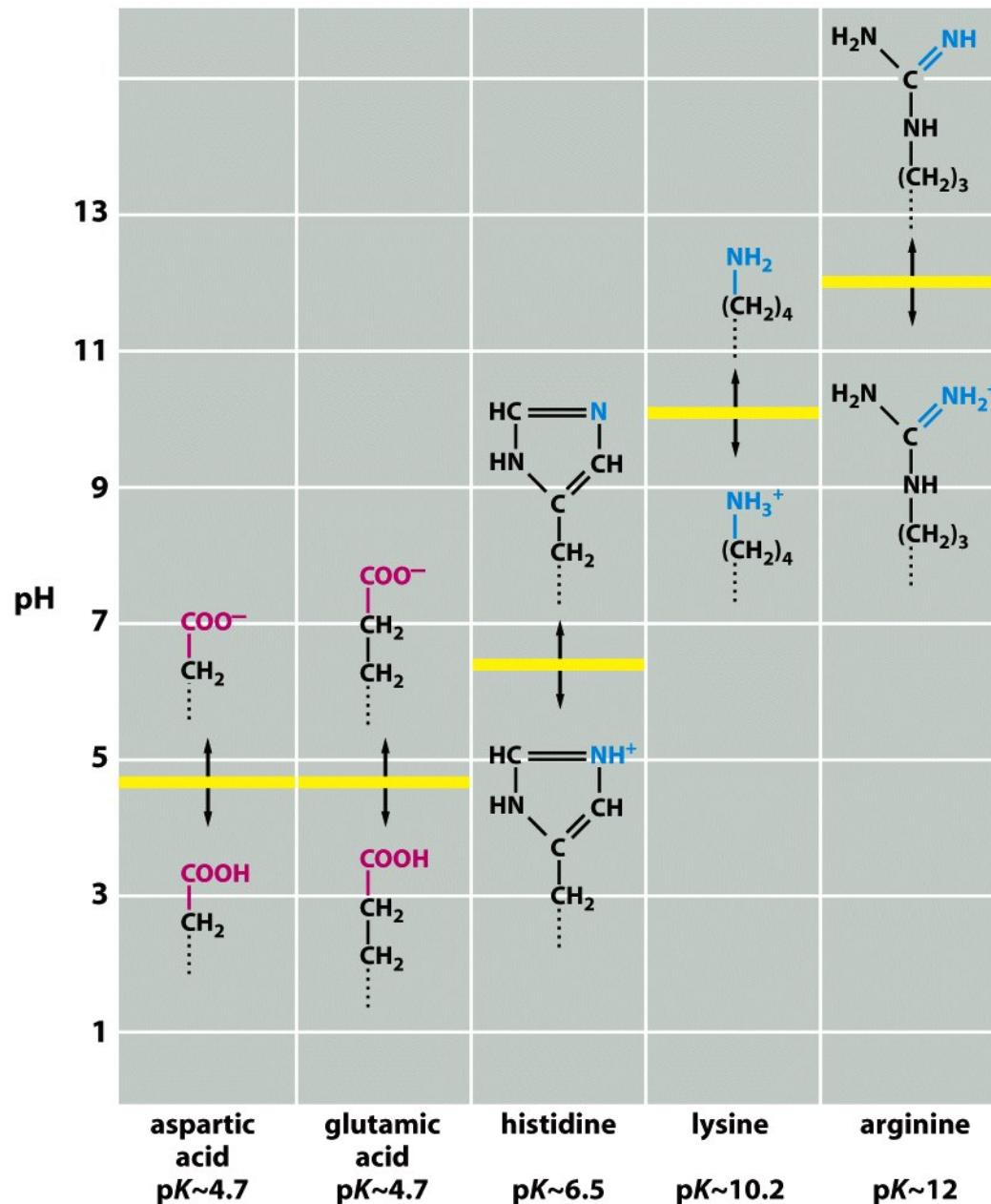
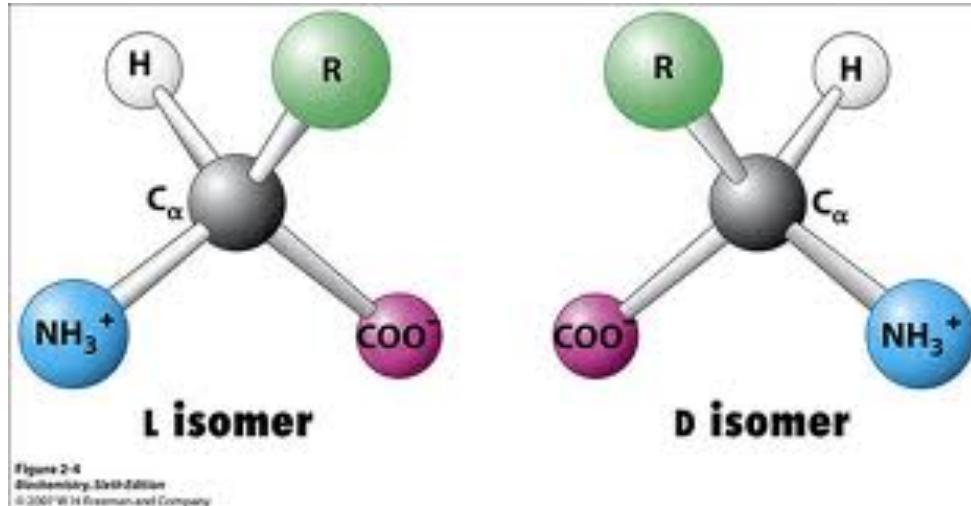


Figure 2-25 *Molecular Biology of the Cell* (© Garland Science 2008)

## D versus L amino acids



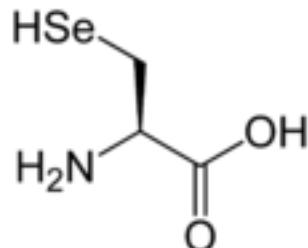
Of the standard amino acids, all but glycine can exist in either of two optical isomers, called L or D amino acids, which are mirror images of each other

While L-amino acids represent all of the amino acids found in proteins during translation in the ribosome, D-amino acids are found in some proteins produced by enzyme posttranslational modifications. D- alanine and D-glutamic acid are structural components of certain bacterial walls.

Amino Acids are Chiral

# UNUSUAL AMINO ACIDS IN PROTEIN SYNTHESIS

## Selenocysteine (Se-Cys)



Considered the 21<sup>st</sup> protogenic amino acid

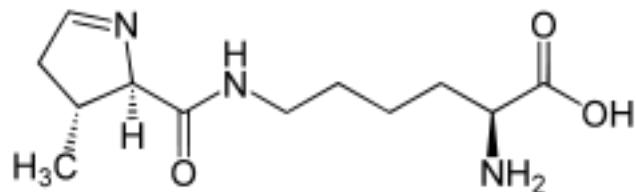
Selenocysteine is present in several enzymes in eukaryotes.

Encoded in mRNA by the UAG codon, which in most organisms is the 'amber' stop codon.

The UGA codon is made to encode selenocysteine by the presence of a SECIS element (SElenoCysteine Insertion Sequence) in the mRNA. The SECIS element is defined by characteristic nucleotide sequences and secondary structure base-pairing patterns.

# UNUSUAL AMINO ACIDS IN PROTEIN SYNTHESIS

## Pyrrolysine



Encoded in mRNA by the UAG codon, which in most organisms is the 'amber' stop codon.

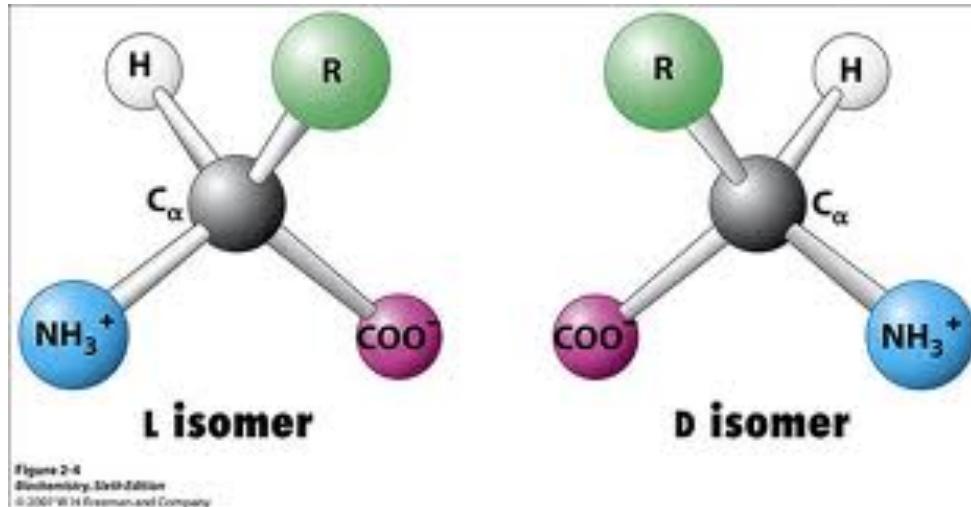
Considered the 22<sup>nd</sup> protogenic amino acid

Used by some methanogenic archaea and one known bacterium in enzymes that are part of their methane-producing metabolism.

# Essential and Non-Essential Amino Acids

Essential	Nonessential	
<u>Isoleucine</u>	<u>Alanine</u>	
<u>Leucine</u>	<u>Arginine*</u>	
<u>Lysine</u>	<u>Aspartate</u>	
<u>Methionine</u>	<u>Cysteine*</u>	
<u>Phenylalanine</u>	<u>Glutamate</u>	
<u>Threonine</u>	<u>Glutamine*</u>	
<u>Tryptophan</u>	<u>Glycine*</u>	
<u>Valine</u>	<u>Proline*</u>	
<u>Histidine</u>	<u>Serine</u>	<b>*essential in some cases</b>
<u>Asparagine*</u>	<u>Tyrosine*</u>	
<u>Selenocysteine**</u>	<u>Pyrrolysine**</u>	<b>**not known</b>

## D versus L amino acids



Of the standard amino acids, all but glycine can exist in either of two optical isomers, called L or D amino acids, which are mirror images of each other

While L-amino acids represent all of the amino acids found in proteins during translation in the ribosome, D-amino acids are found in some proteins produced by enzyme posttranslational modifications. D- alanine and D-glutamic acid are structural components of certain bacterial walls.

Amino Acids are Chiral

**Proteins are Amino Acids  
Linked Together by  
the Peptide Bond**

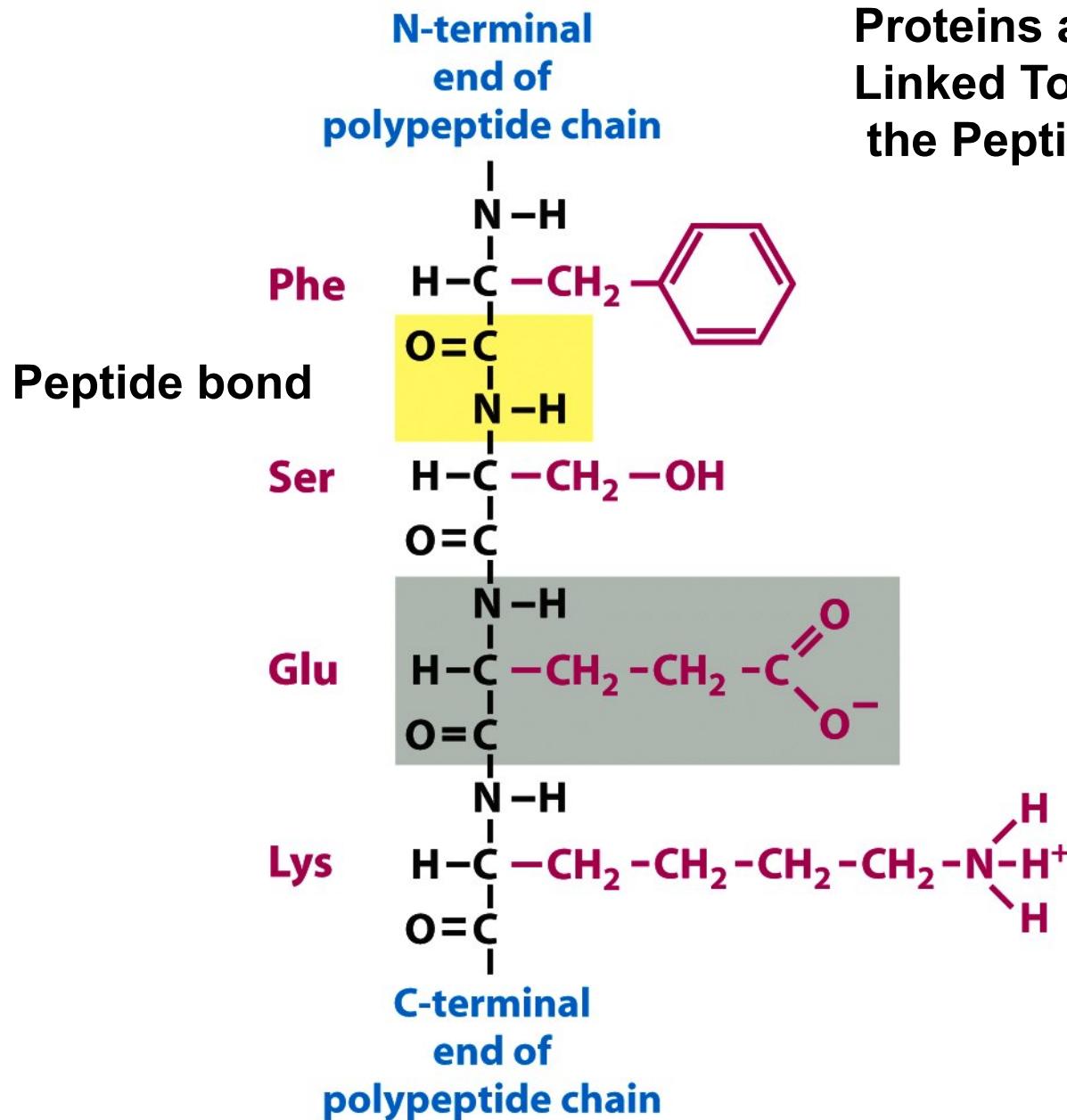
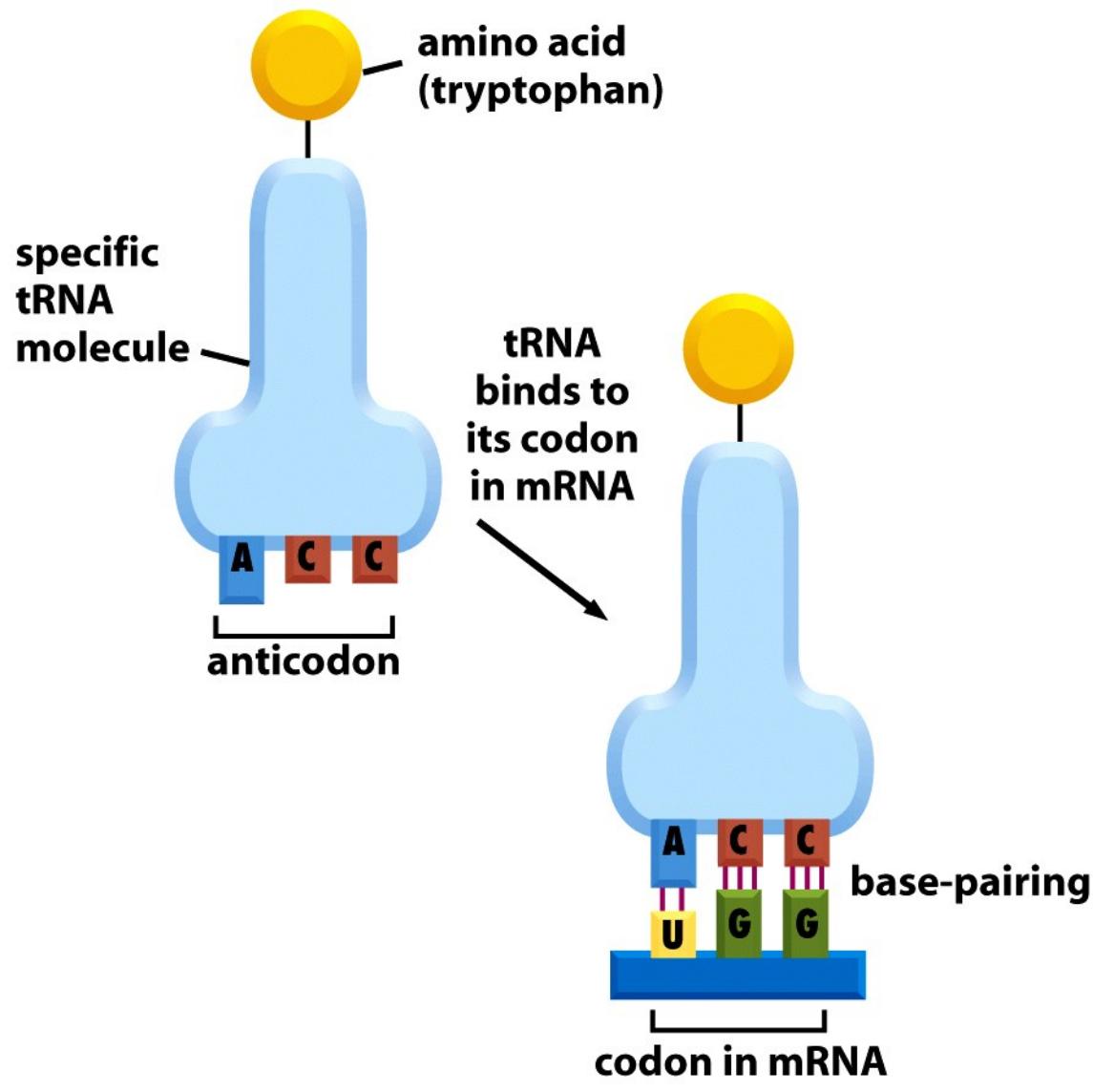


Figure 2-24 *Molecular Biology of the Cell* (© Garland Science 2008)



**NET RESULT: AMINO ACID IS  
SELECTED BY ITS CODON**

Figure 1-9a Molecular Biology of the Cell 5/e (© Garland Science 2008)

## Charging the tRNA with an Amino Acid

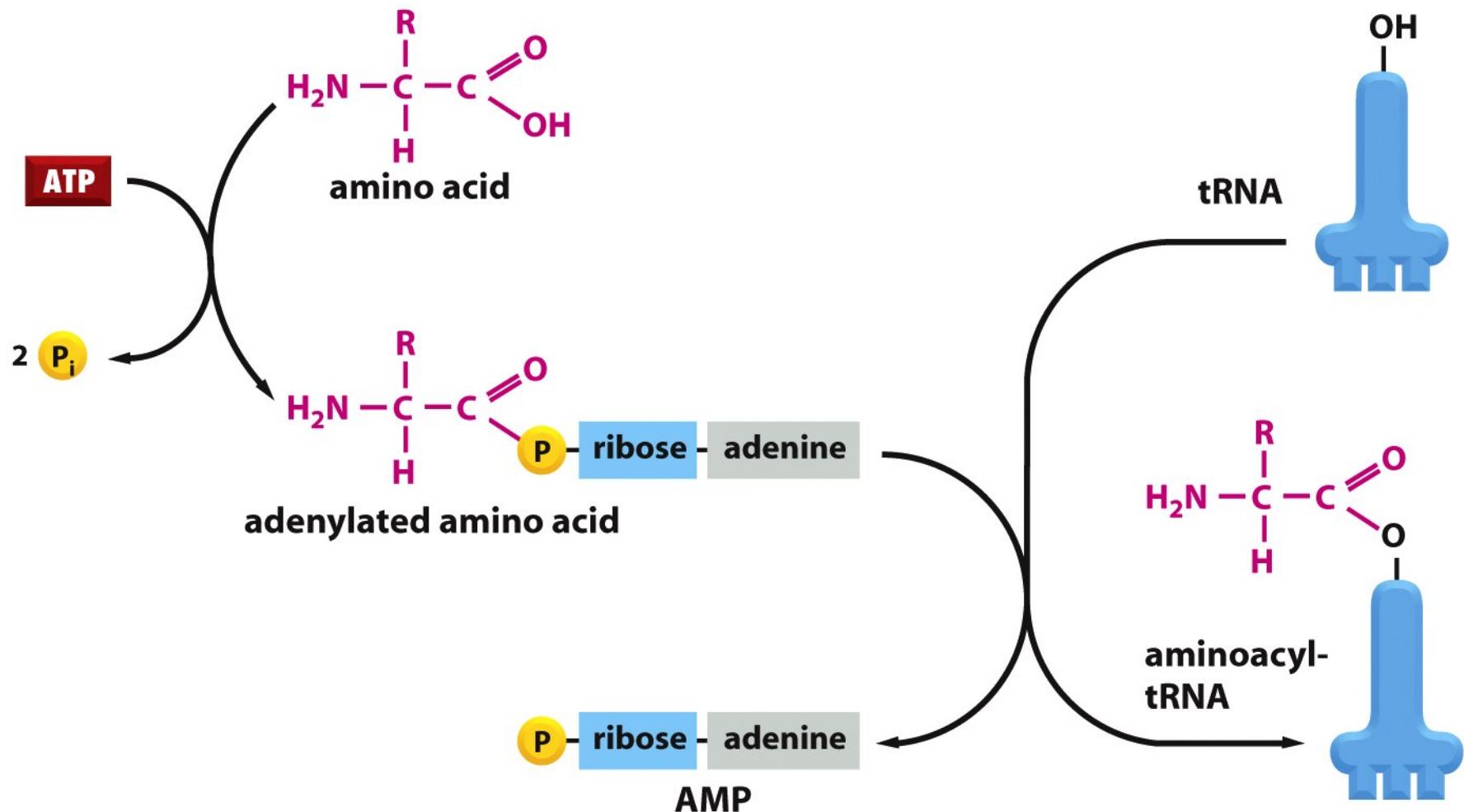
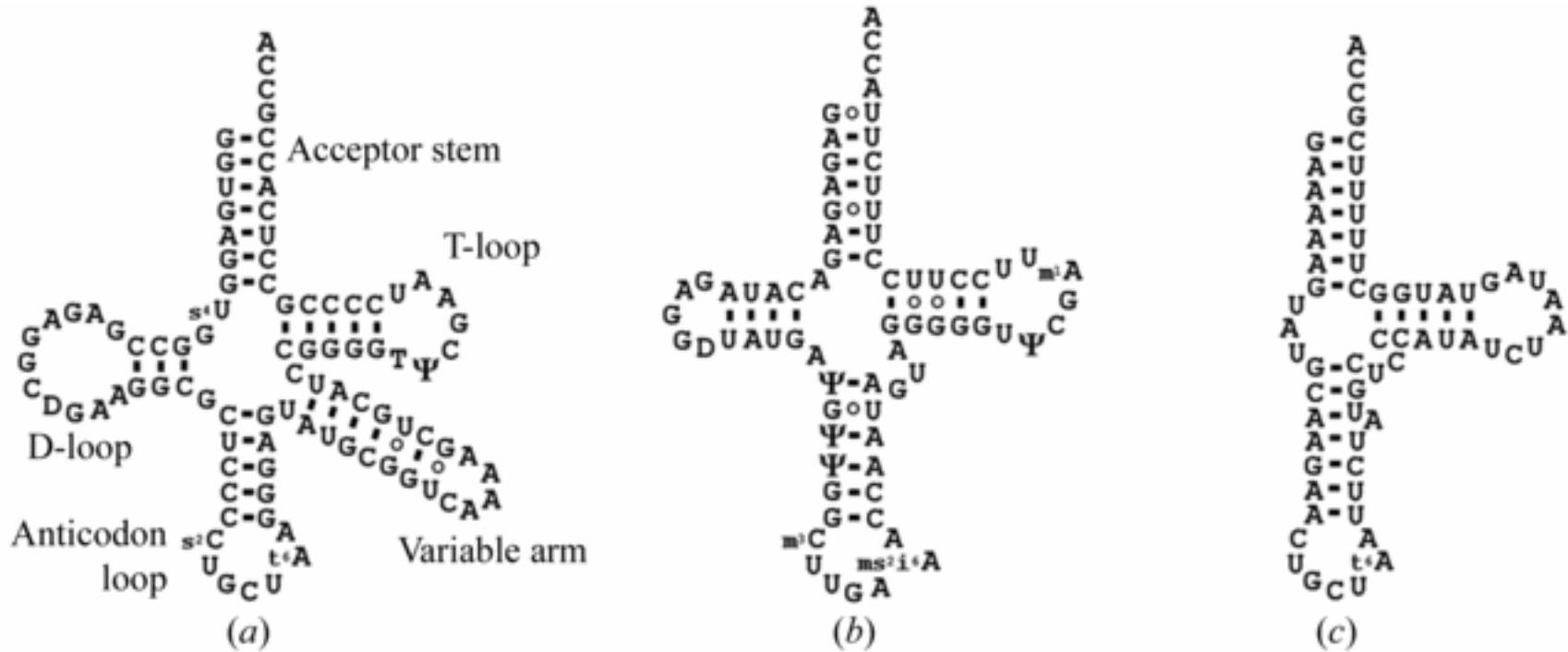


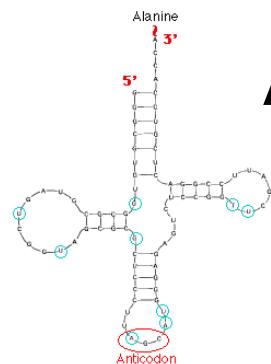
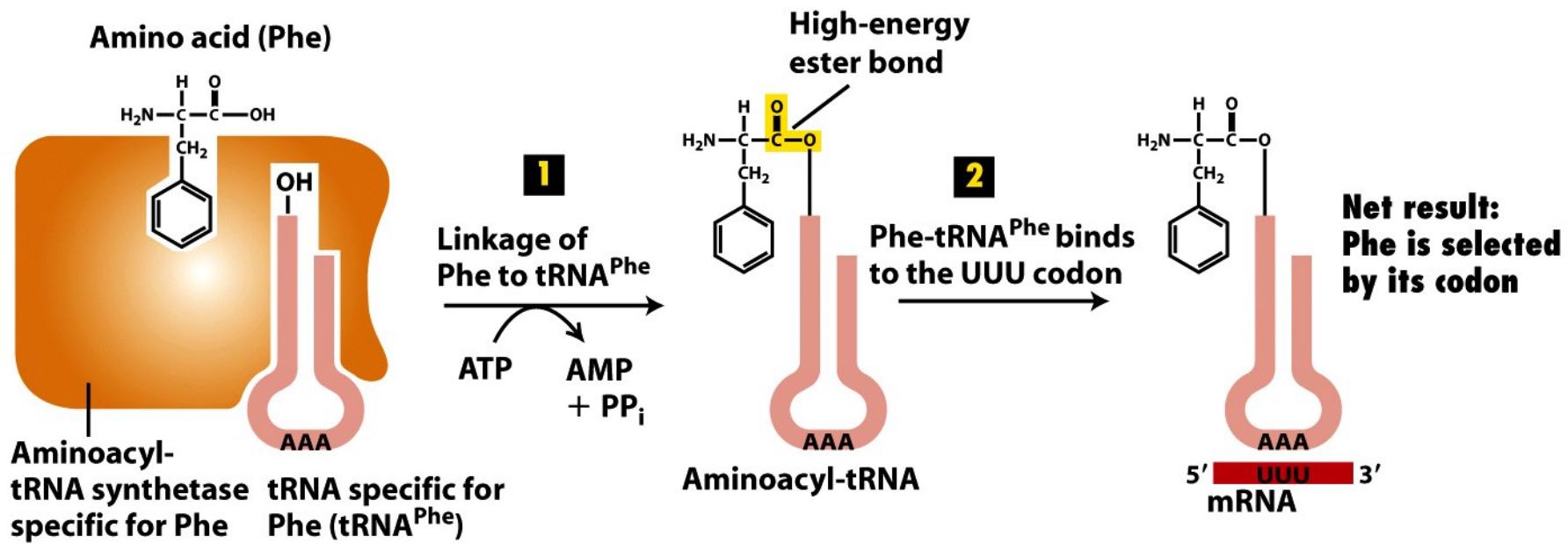
Figure 6-56 Molecular Biology of the Cell 5/e (© Garland Science 2008)

# tRNA Structure Contributors to tRNA Function



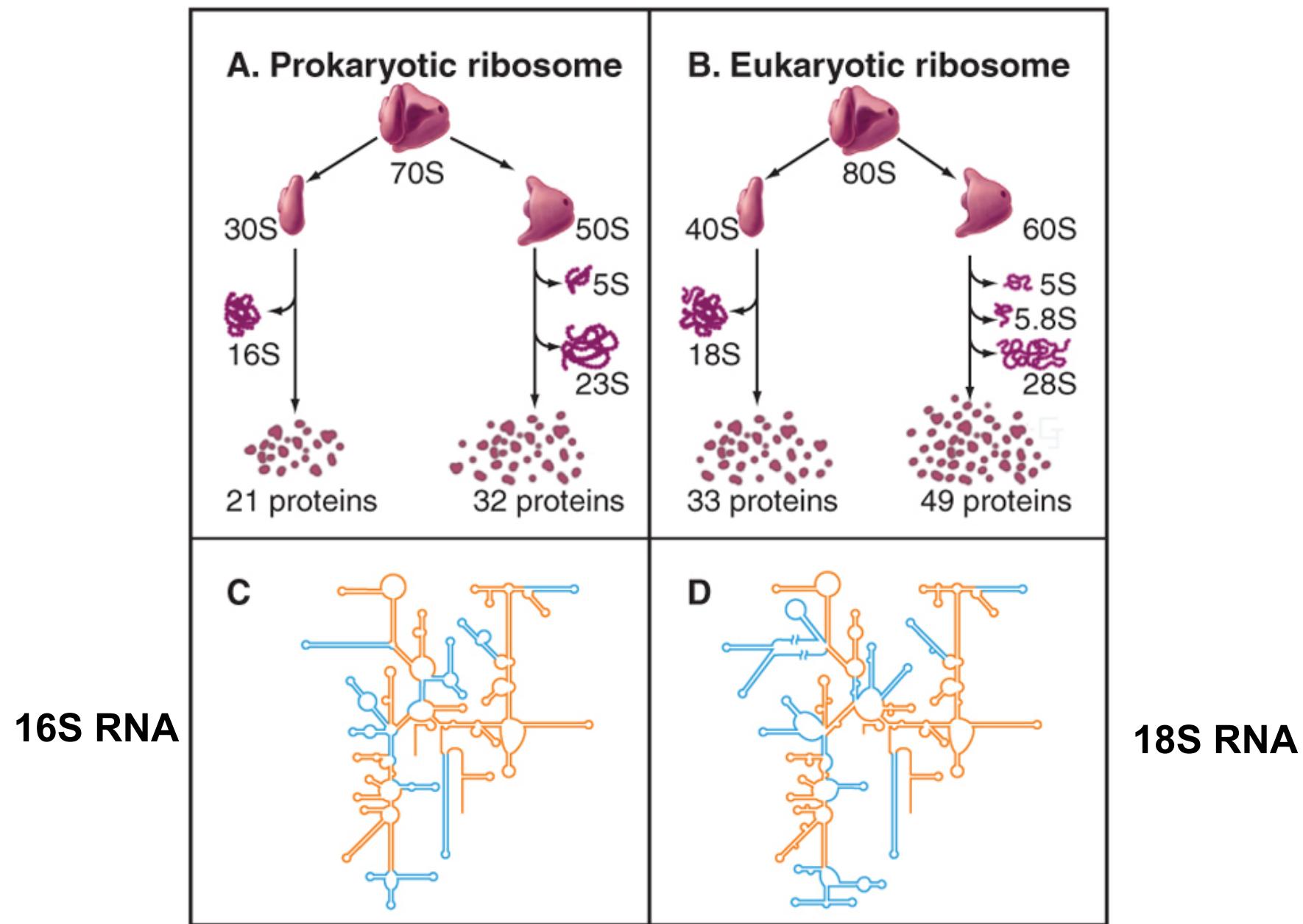
## Serine tRNAs

# Determining tRNA Identity and Function



Alanine t-RNA structure

# The Composition of Ribosomes



# Translation of the mRNA into Protein

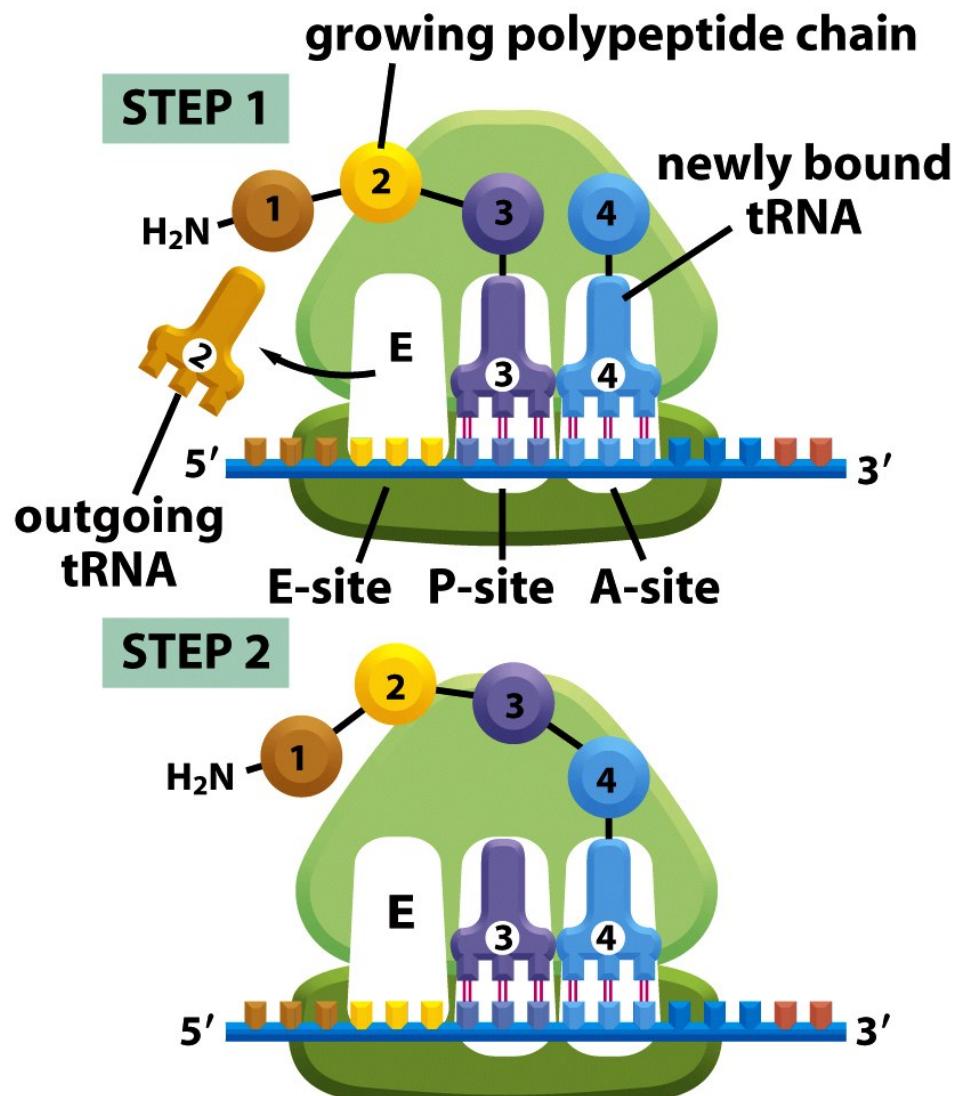


Figure 6-66 part 1 of 7 Molecular Biology of the Cell 5/e (© Garland Science 2008)

# Translation of the mRNA into Protein

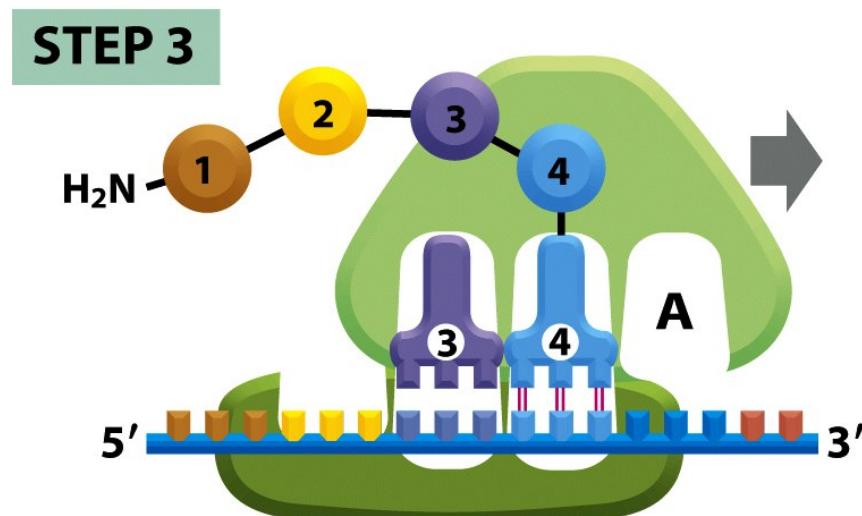
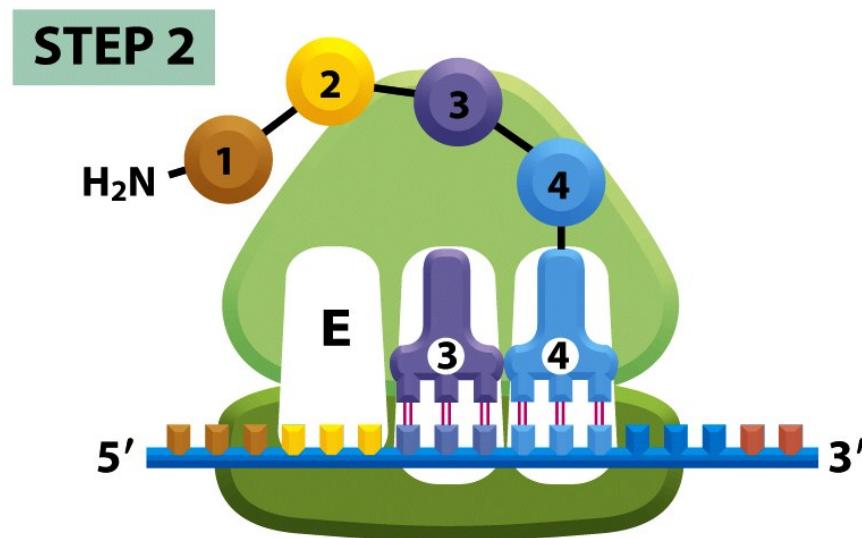


Figure 6-66 part 2 of 7 Molecular Biology of the Cell 5/e (© Garland Science 2008)

# Translation of the mRNA into Protein

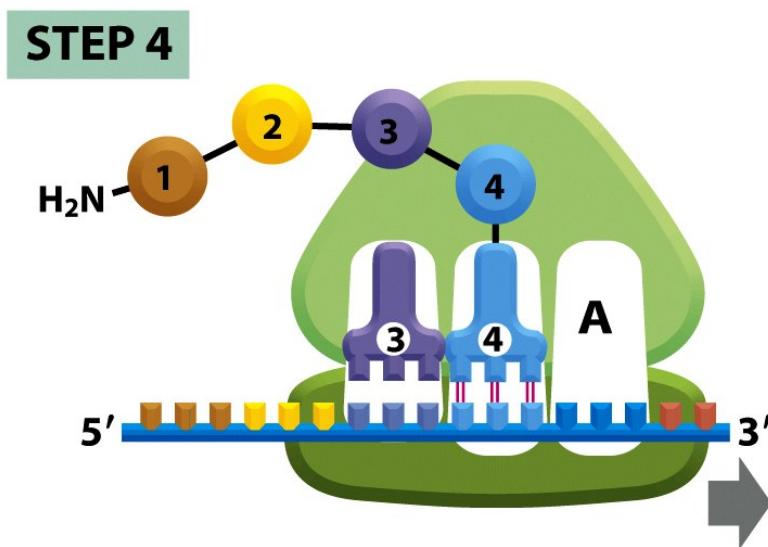
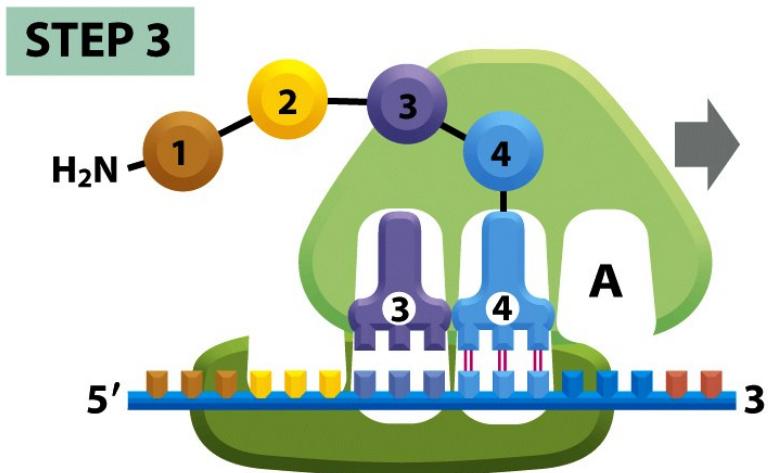


Figure 6-66 part 3 of 7 Molecular Biology of the Cell 5/e (© Garland Science 2008)

# Translation of the mRNA into Protein

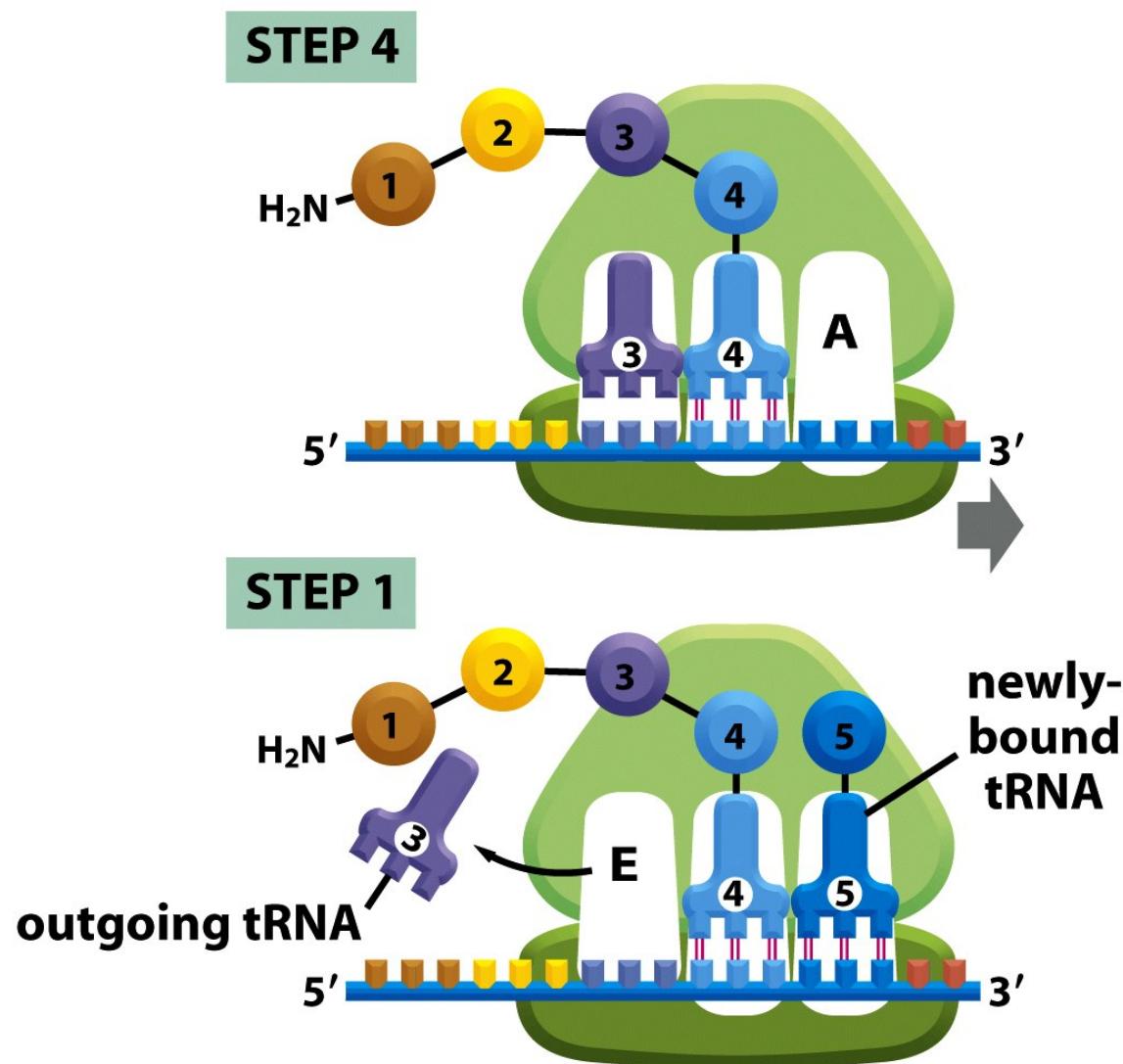


Figure 6-66 part 4 of 7 Molecular Biology of the Cell 5/e (© Garland Science 2008)

# Translation of the mRNA into Protein

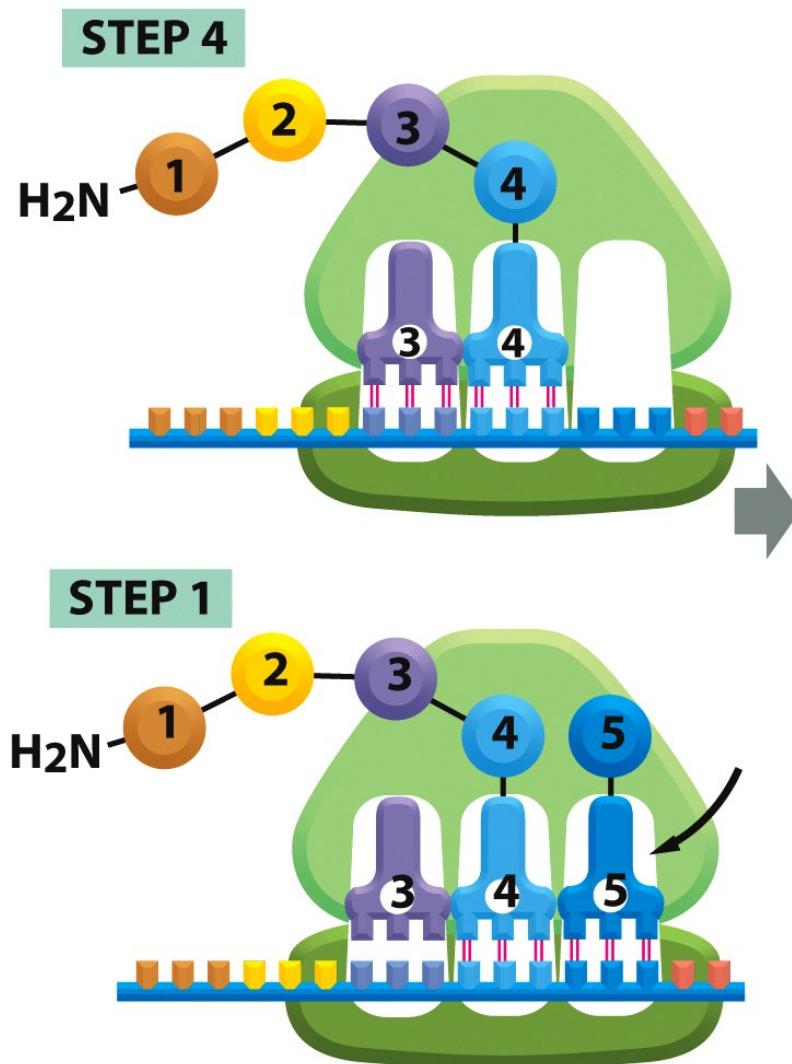


Figure 6-66 part 5 of 7 Molecular Biology of the Cell 5/e (© Garland Science 2008)

## Trans~~STEP 1~~<sup>ATION</sup> of the mRNA into Protein

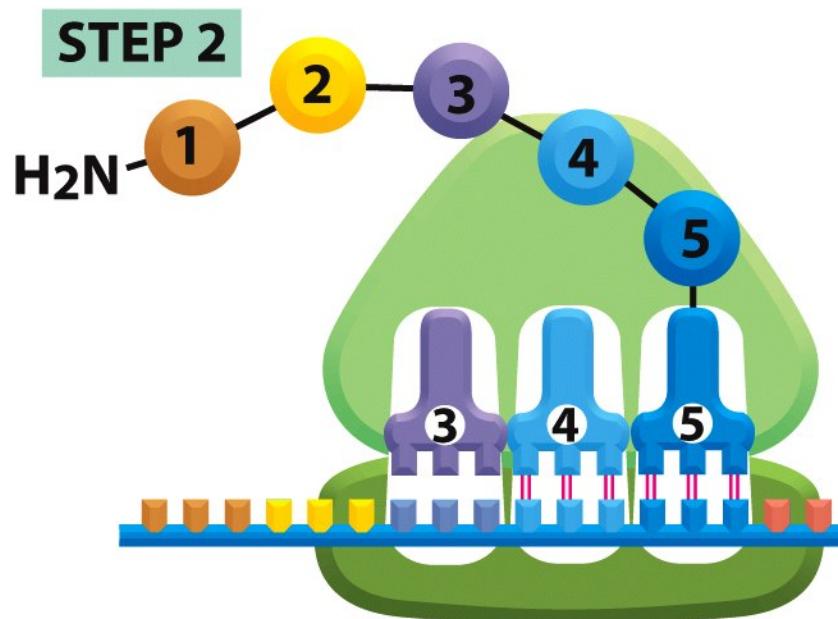
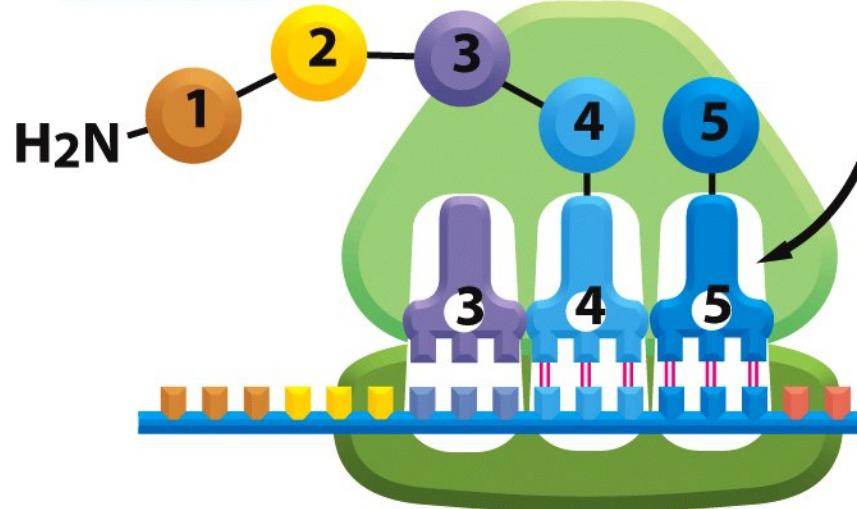


Figure 6-66 part 6 of 7 Molecular Biology of the Cell 5/e (© Garland Science 2008)

# Translation of the mRNA into Protein

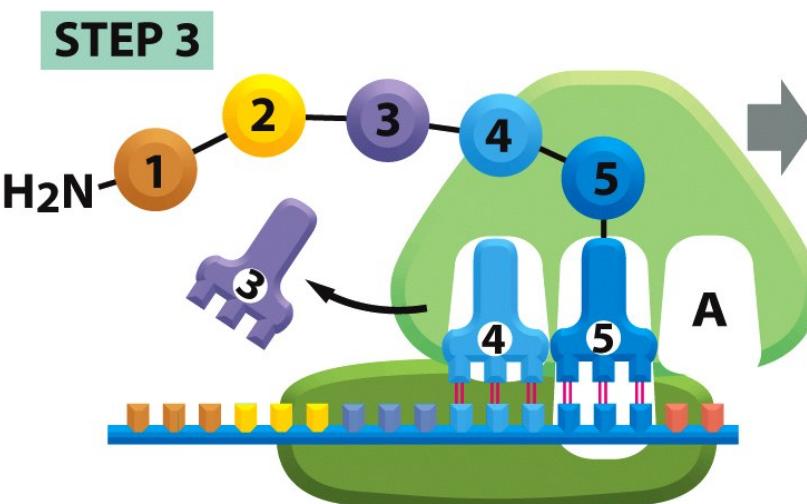
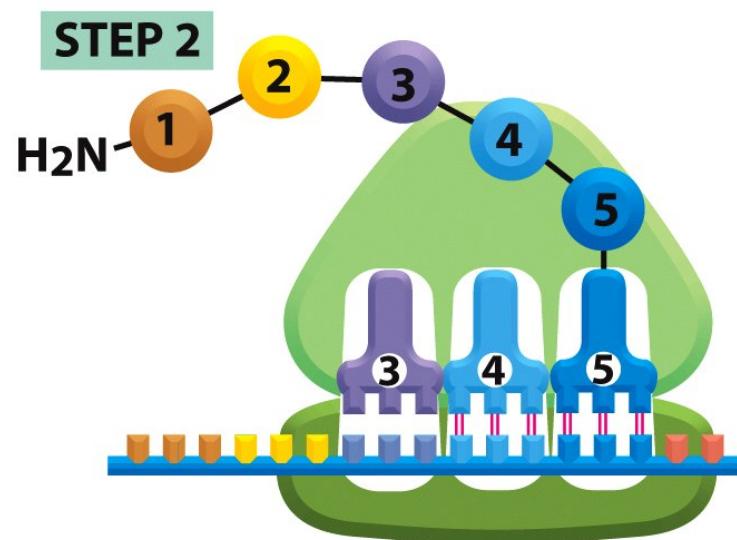
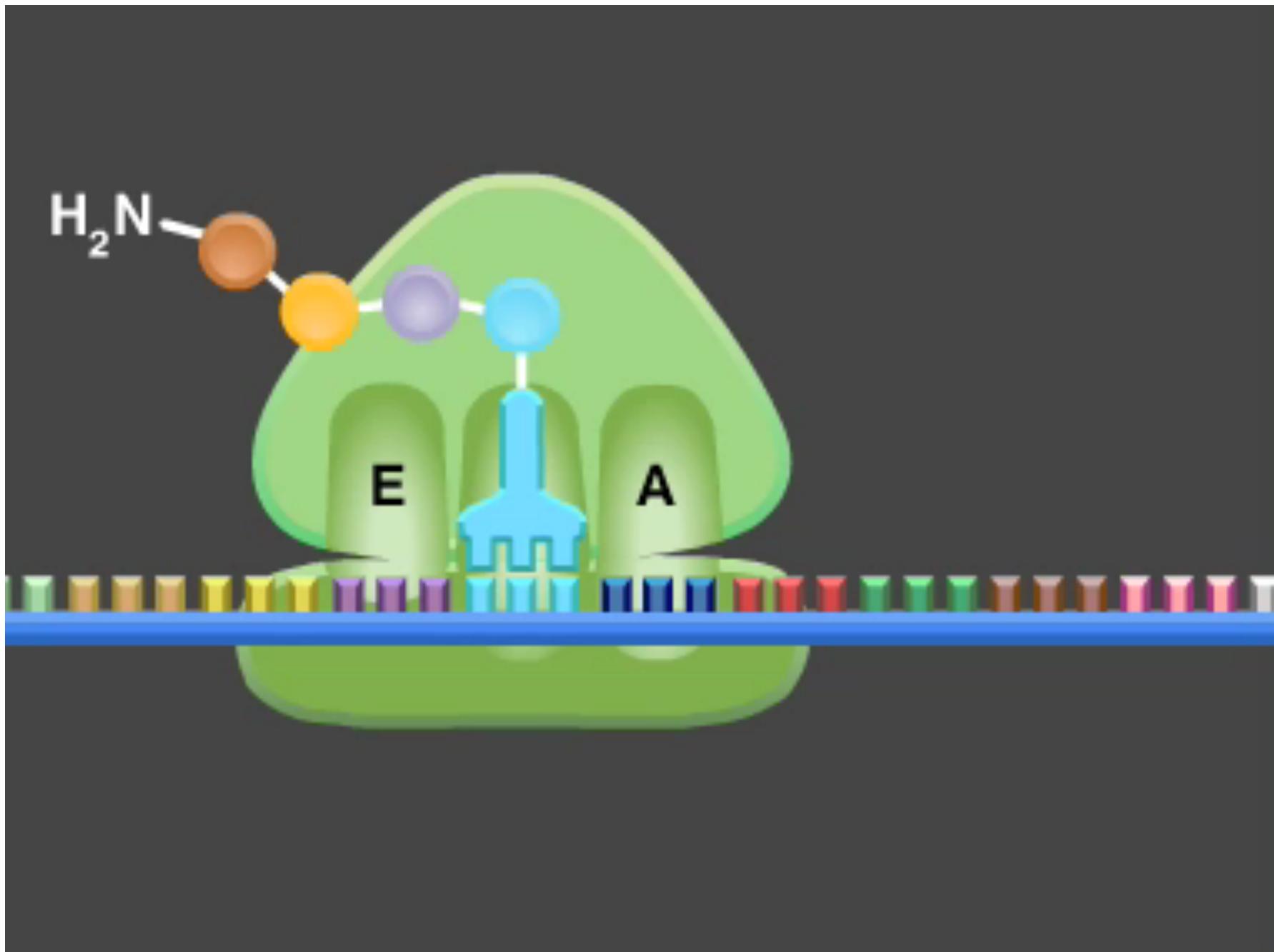
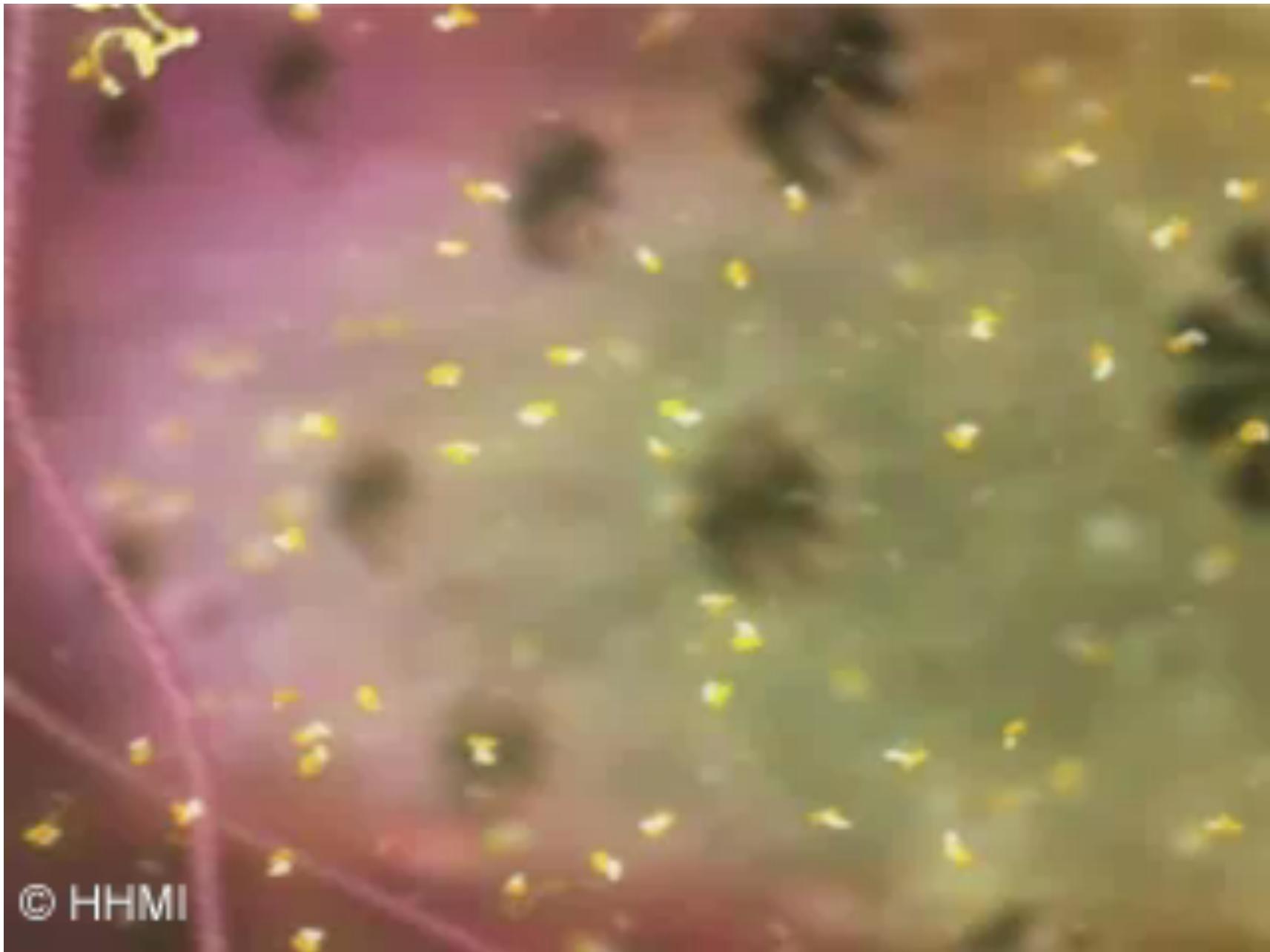


Figure 6-66 part 7 of 7 Molecular Biology of the Cell 5/e (© Garland Science 2008)

# Model of Stepwise Process of Translation (Movie)

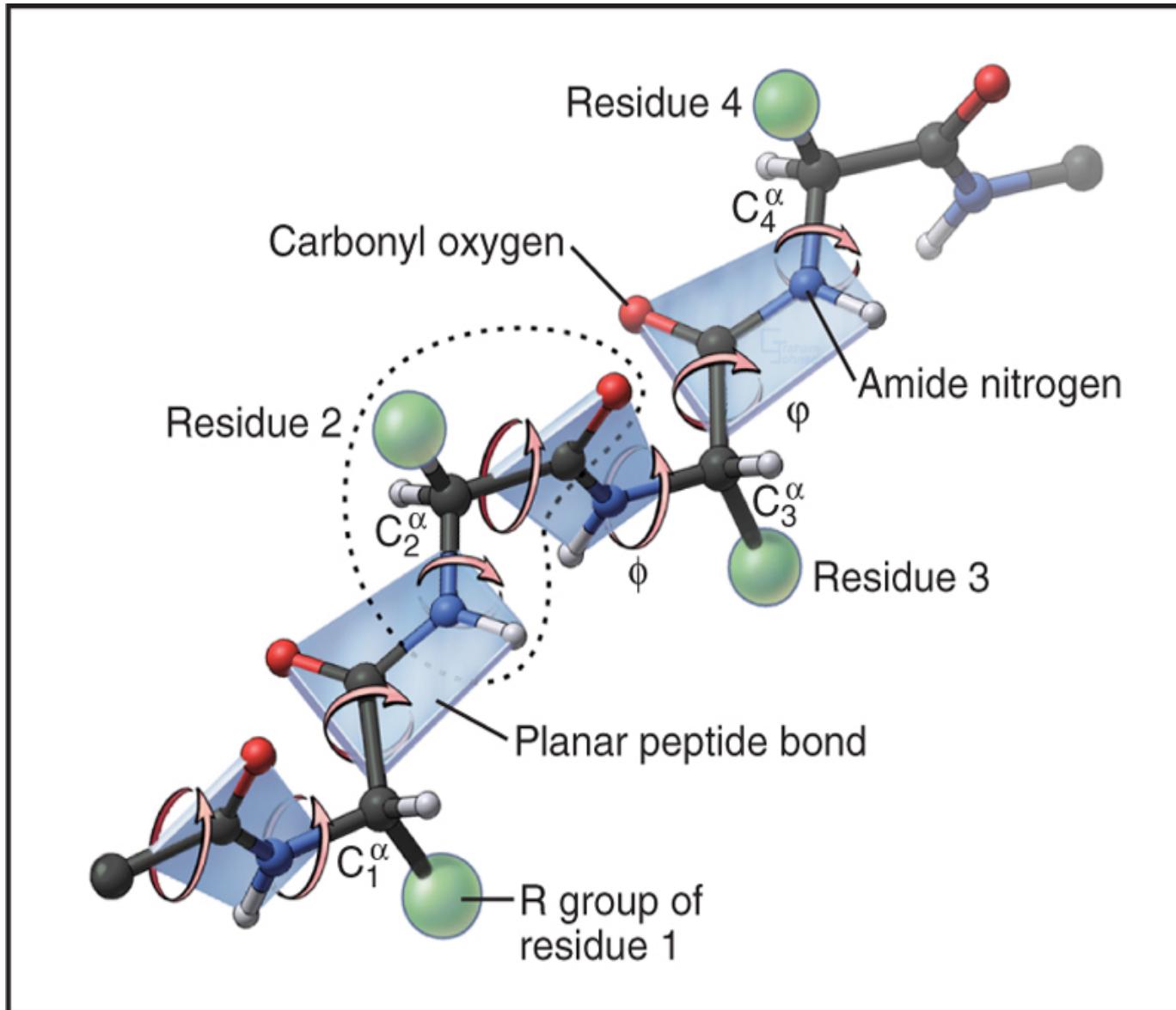


## Translation (Movie)

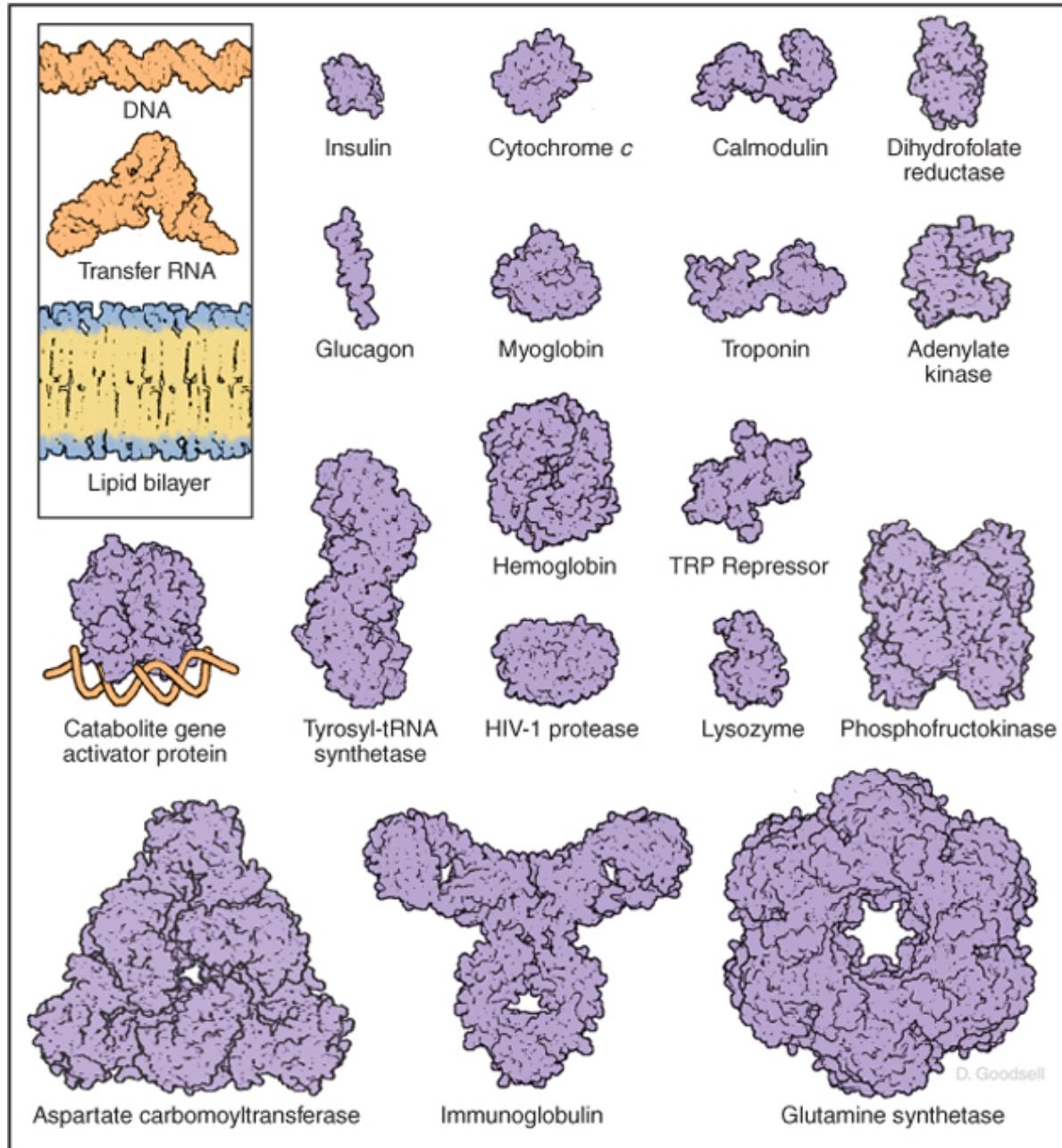


© HHMI

## Geometry and Flexibility of Amino Acids in Proteins



# Proteins Exist as a Diverse Repertoire of Biological Structures



## **Protein Domains**

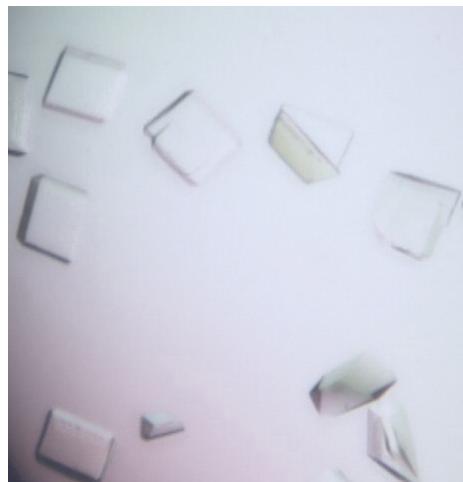
**A protein domain is a structurally independent unit that has a characteristic of a small globular protein. Thus, a domain is often stable when present alone**

**A protein domain often has a specific function  
(e.g. DNA-binding domain, Ca<sup>2+</sup> binding domain, etc)**

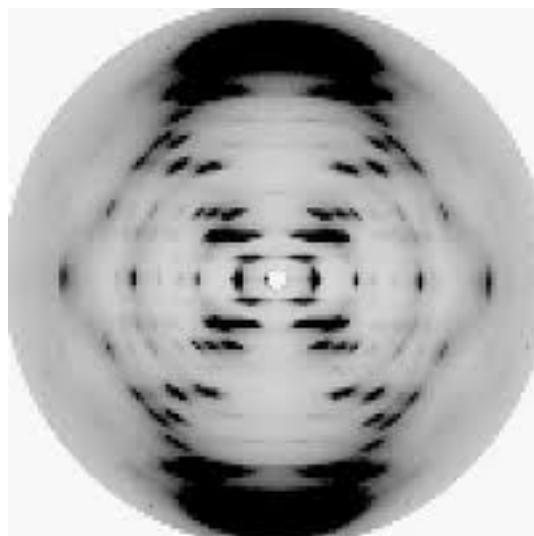
**A protein domain usually consist of 100 to 200 amino acid residues**

**A protein may have more than one domain**

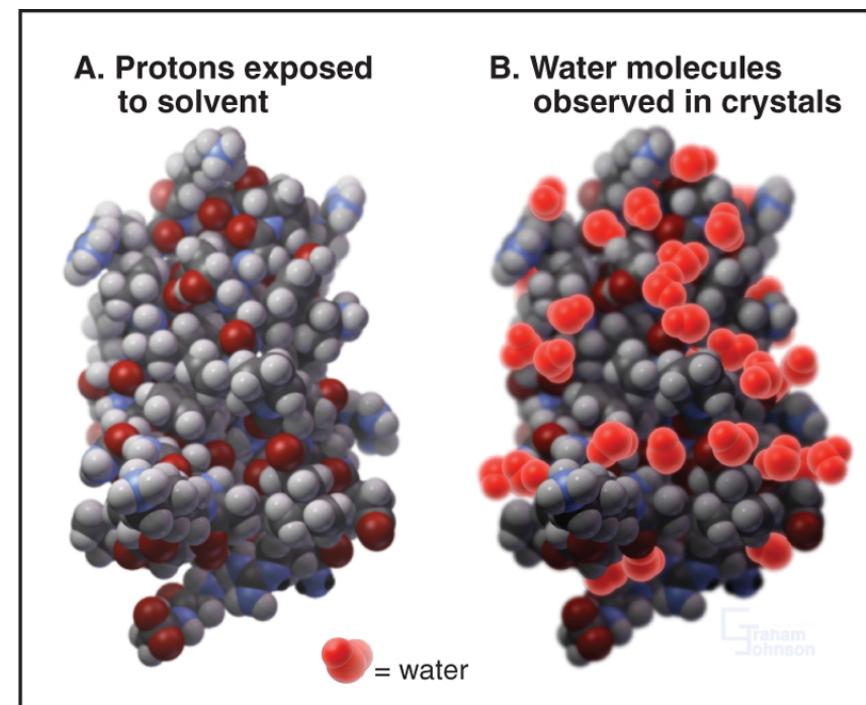
# X-Ray Crystallography Has Provided the Most Information on Biological Molecular Structure



Protein crystals

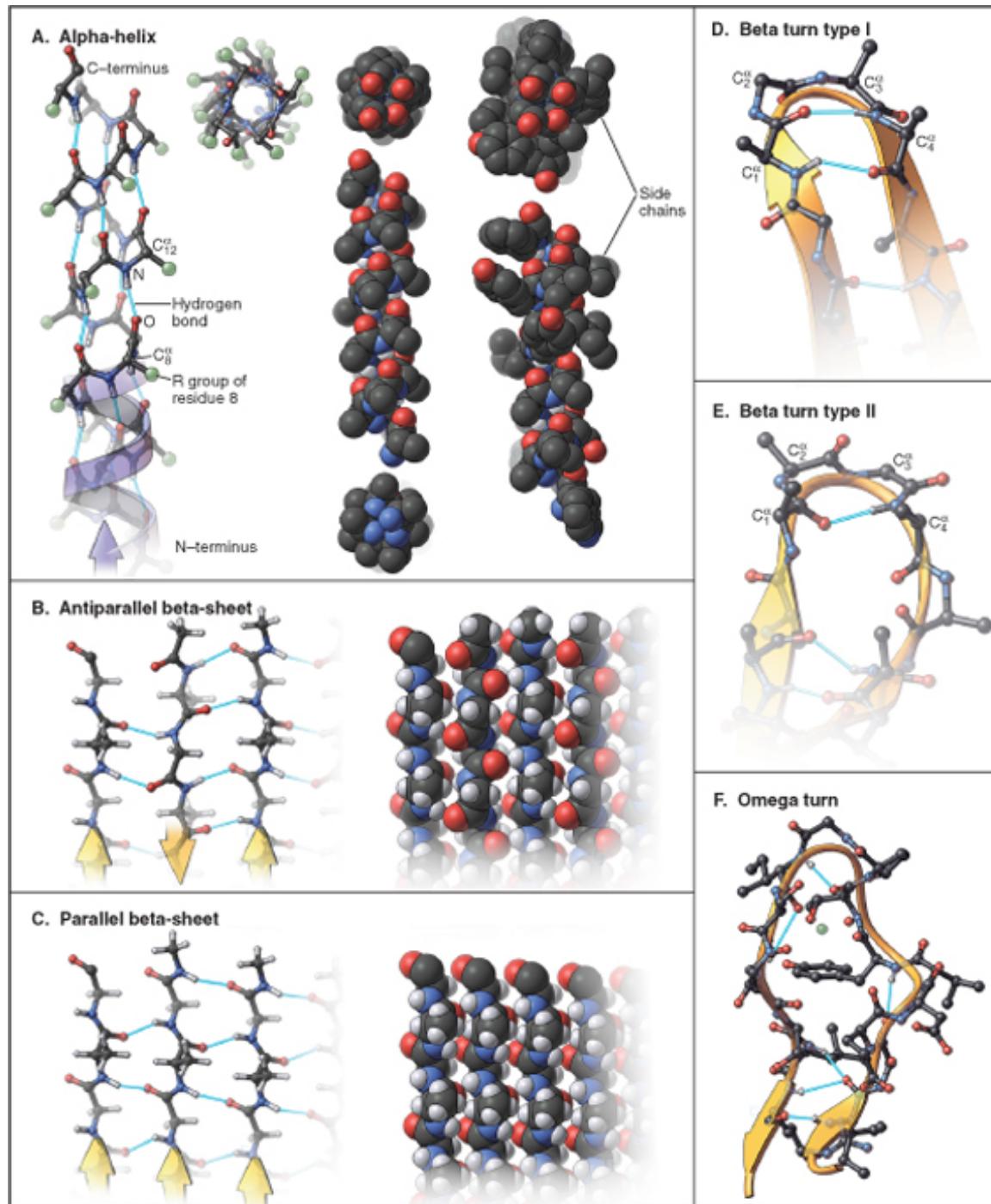


Diffraction pattern



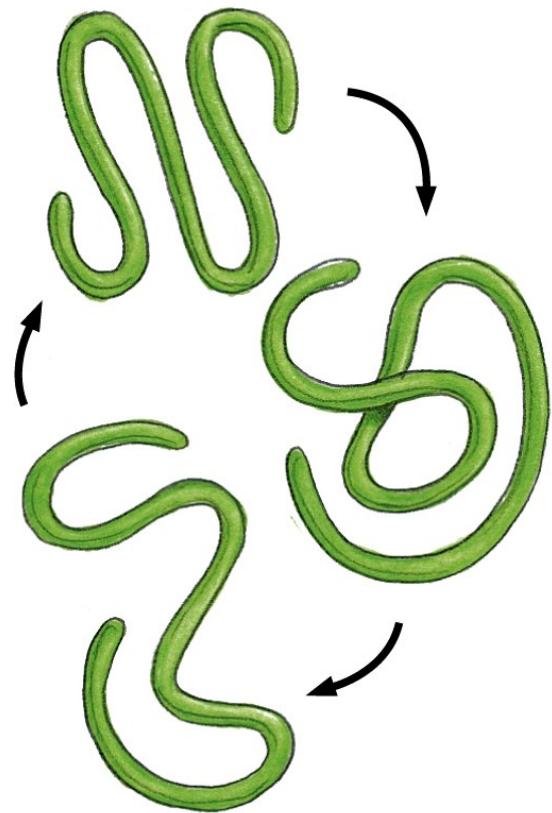
Protein structures in angstroms

# Types of Protein Structures and Folds



What factors cause this?

# Proteins Fold into a Conformation



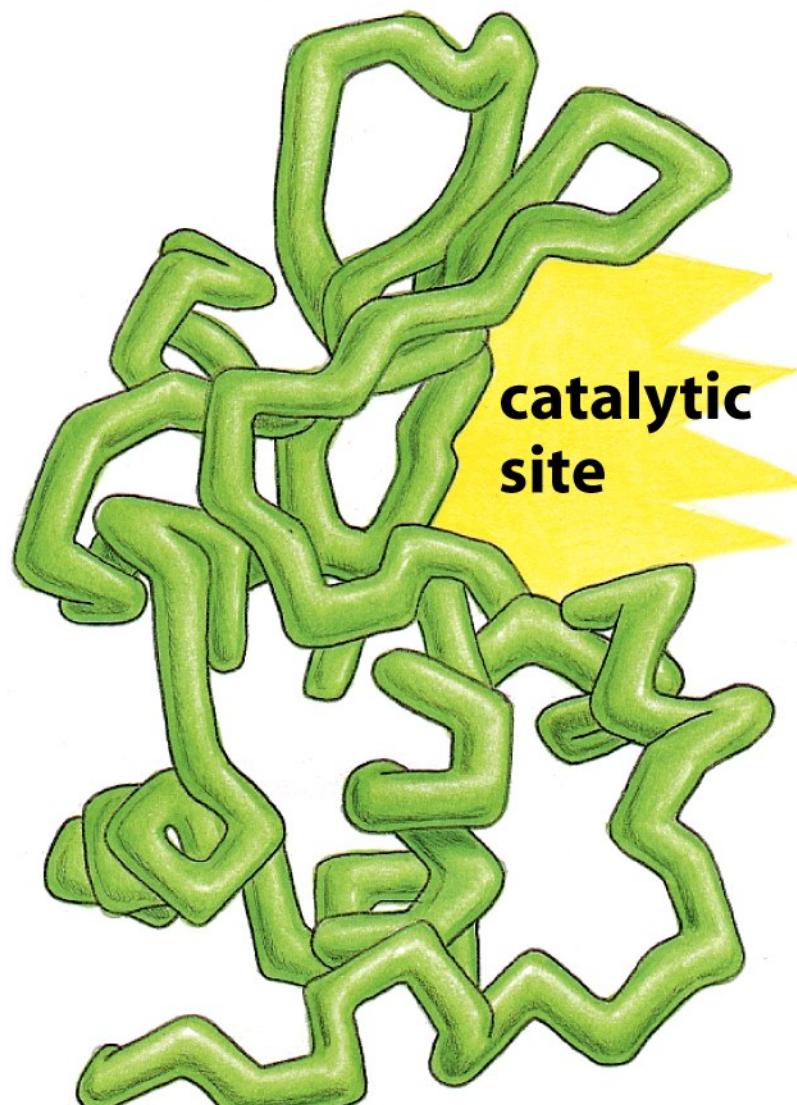
**many unstable  
conformations**



**one stable folded  
conformation**

Figure 2-31 Molecular Biology of the Cell 5/e (© Garland Science 2008)

## Proteins can be Enzymes



**lysozyme**

Figure 1-7a Molecular Biology of the Cell 5/e (© Garland Science 2008)

# Enzymes Catalyze Reactions

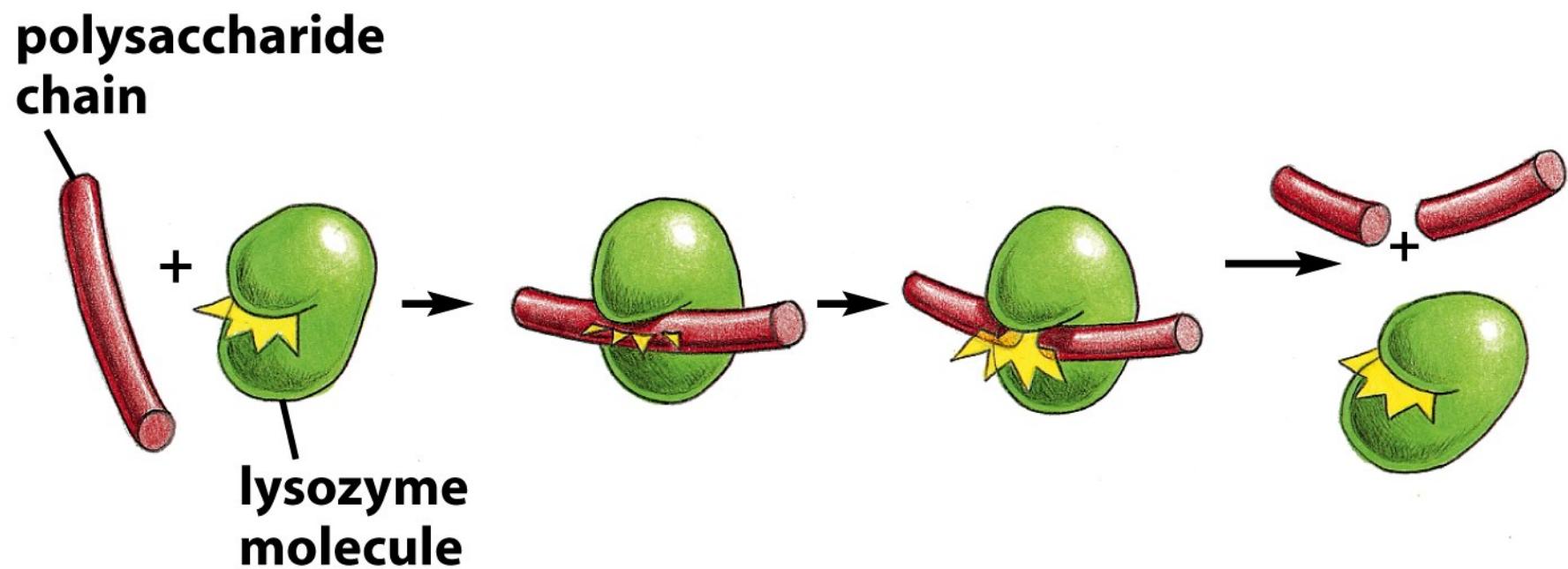


Figure 1-7b Molecular Biology of the Cell 5/e (© Garland Science 2008)

# Proteins also Regulate Gene Expression

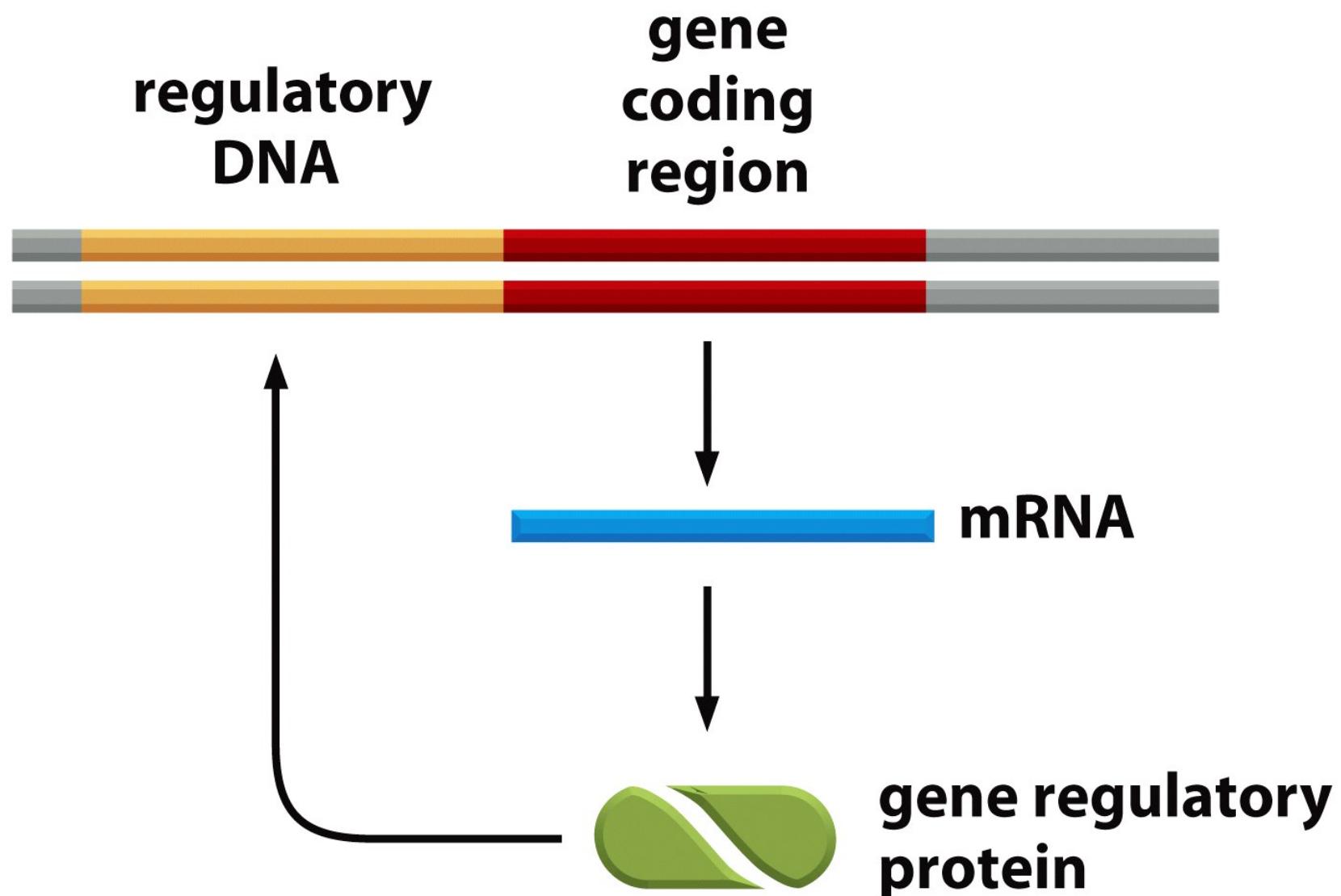


Figure 1-45 Molecular Biology of the Cell 5/e (© Garland Science 2008)

# Sequential Events by Proteins and Enzymes Are the Basis of Many Biological Signals

