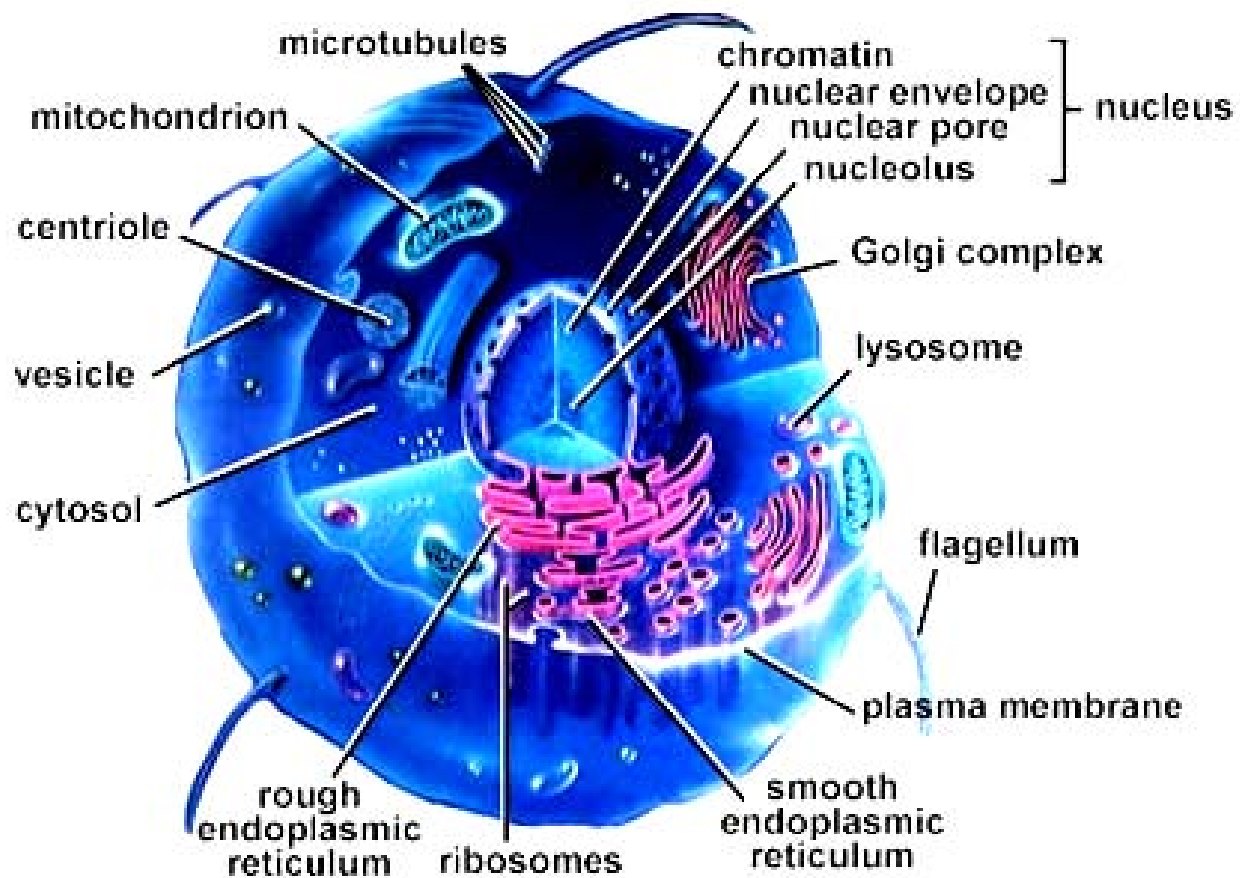


# DNA to RNA to Protein

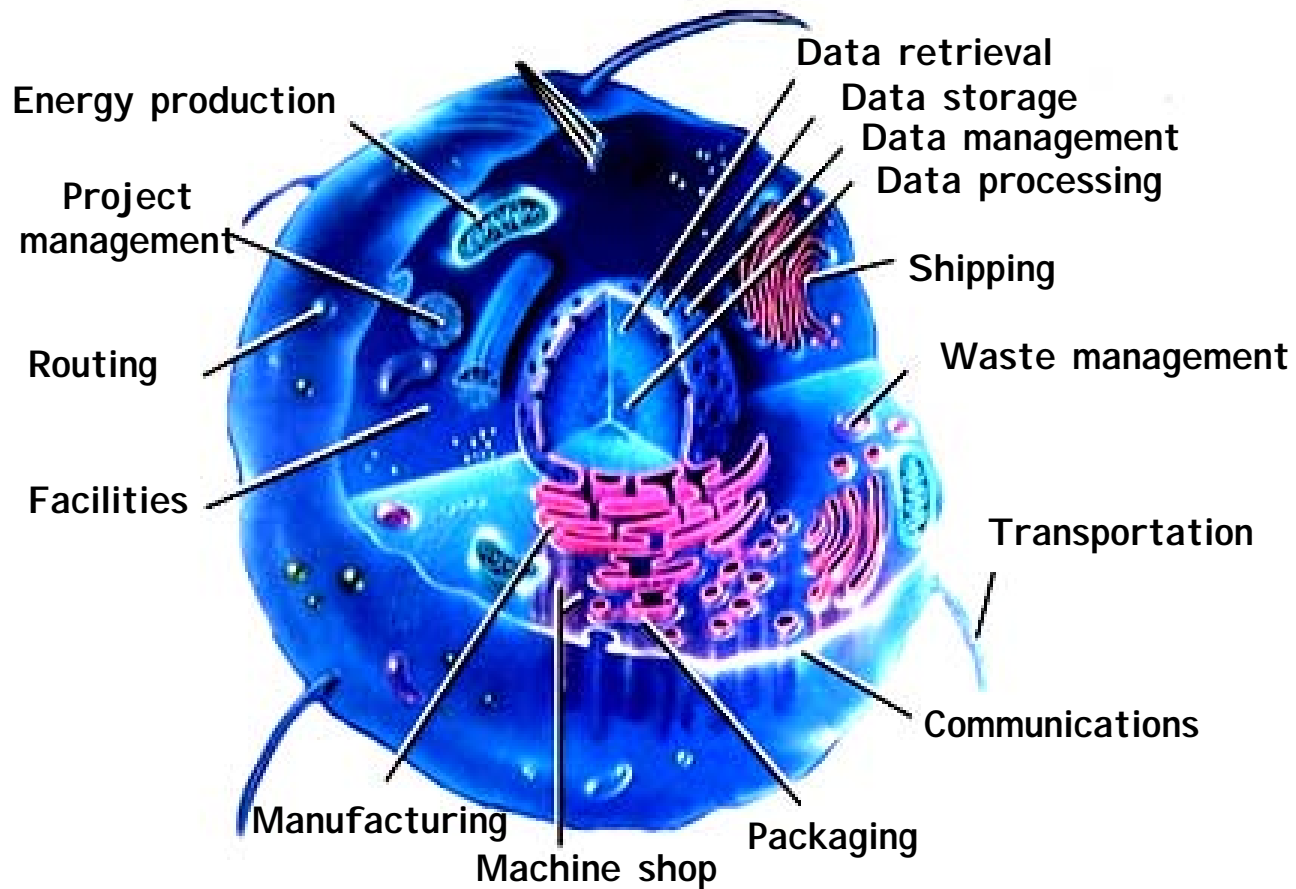
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Understanding the Central  
Dogma of Biology

# Structure of Cells



# The Cell as a Factory



# What are Cells Made of?

- Membranes (fats)
- Proteins
- Carbohydrates (sugars)
- Cofactors (vitamins)
- Nucleic acids

# How is a Cell Assembled?

- There must be “information” that specifies the assembly of cell parts
- DNA contains the information necessary to build a cell
- The mechanisms by which DNA gives rise to cells and organisms is at the heart of the “central dogma” of biology

# Central Dogma of Biology

**DNA** → **RNA** → **PROTEIN**

Data storage

Readout

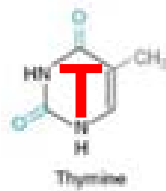
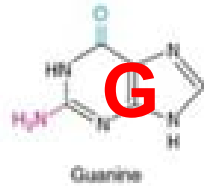
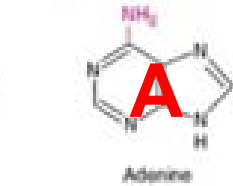
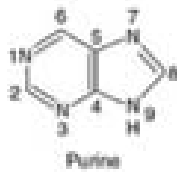
Execution

# What is DNA?

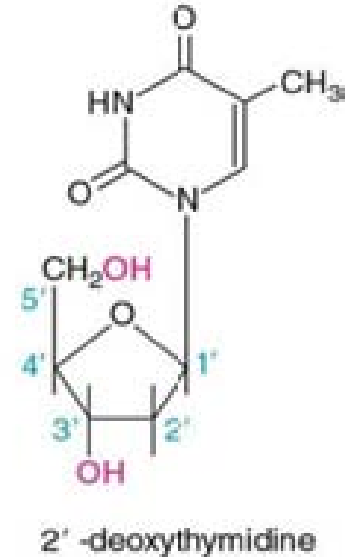
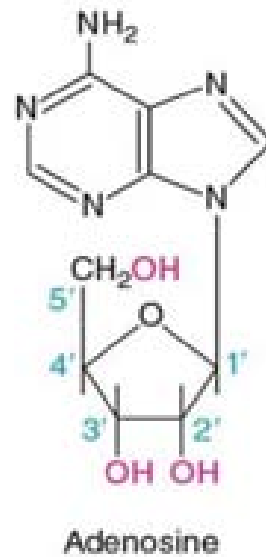
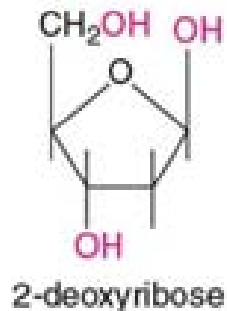
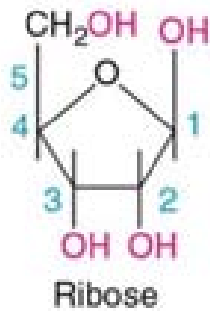
- DNA is deoxyribonucleic acid
- It is a polymer of nucleotides
- It encodes the information necessary to build a cell
- It allows the storage and replication and execution of cellular information

# Structure of Nucleotides

## Bases

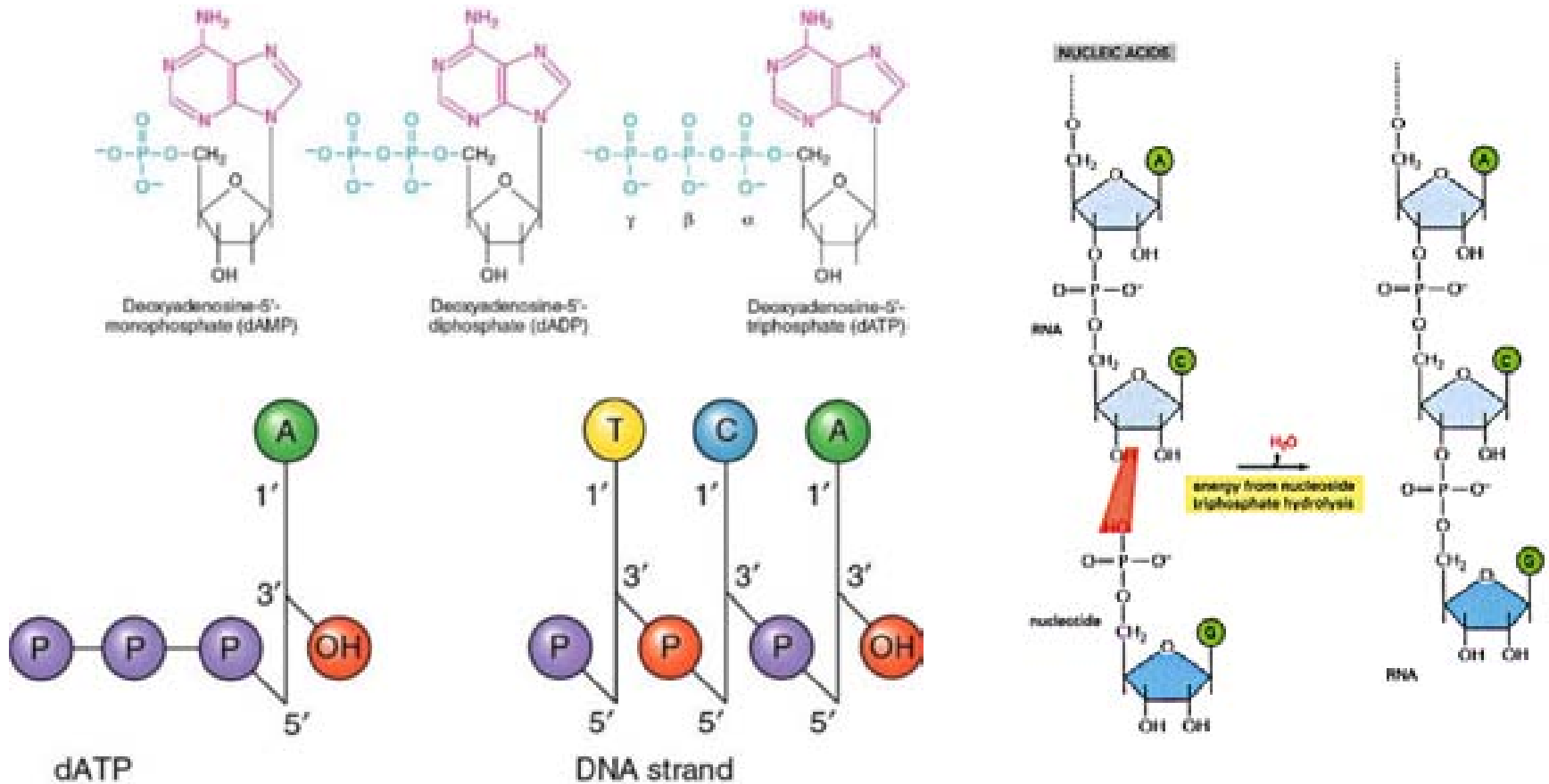


## Sugars

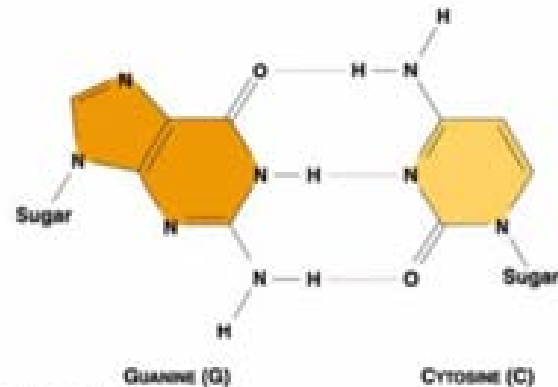
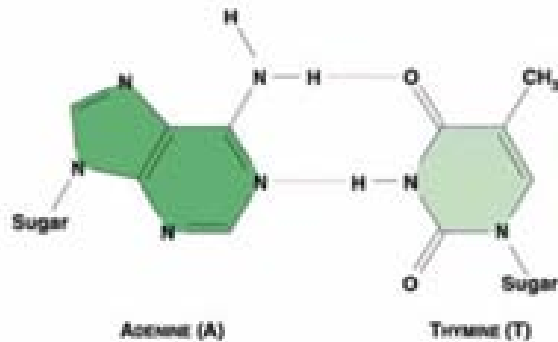




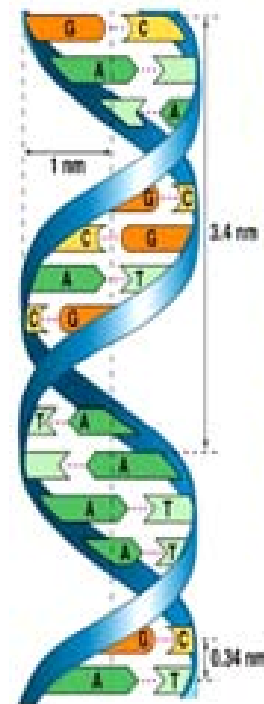
# Nucleotides Polymerize to Form Nucleic Acids



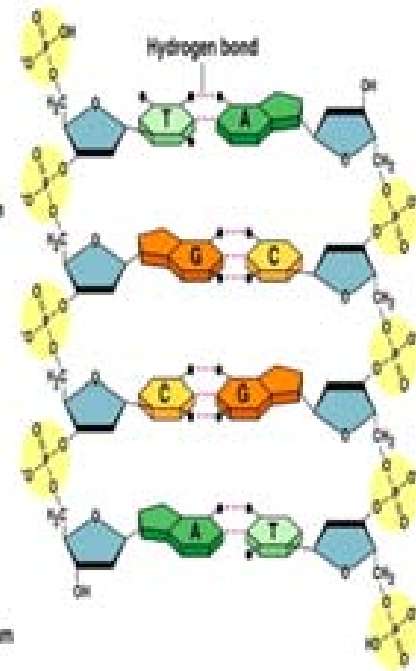
# Base-pairing Controls Formation of Second Polymer Chain



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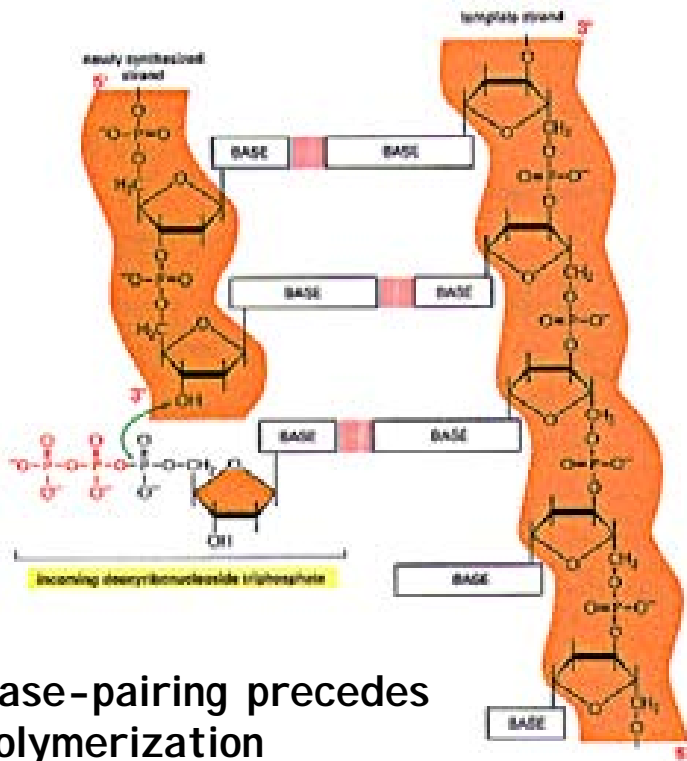


(a) Key features of DNA structure

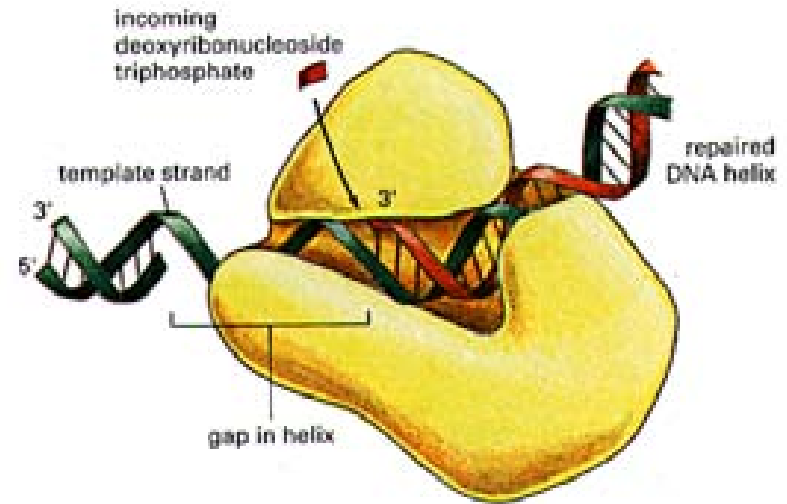


(b) Partial chemical structure

# Base-complementation Allows DNA Replication

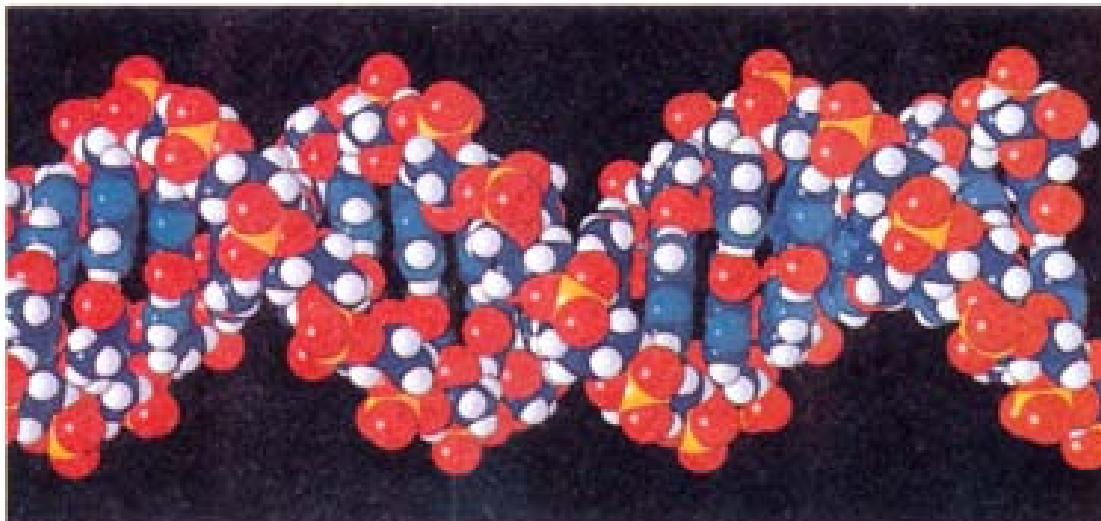
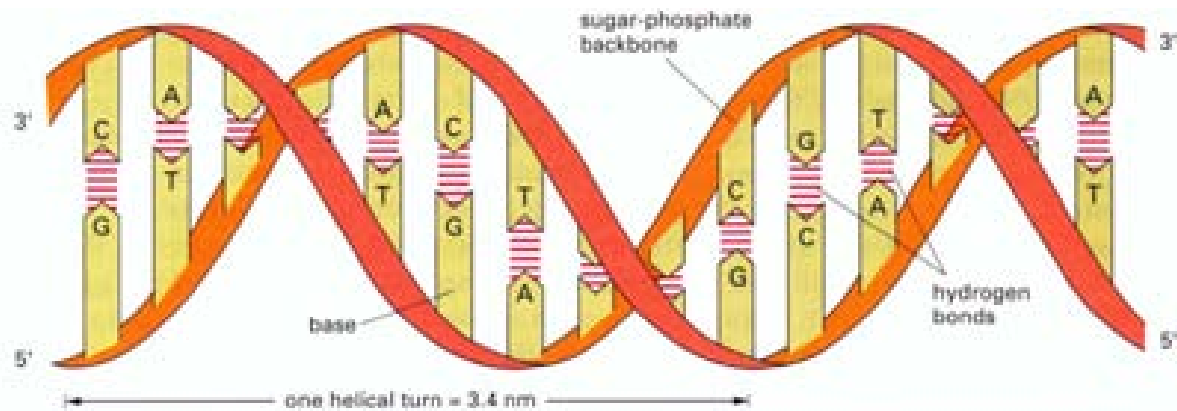


Base-pairing precedes polymerization



DNA polymerase makes DNA

# The Two Strands of DNA are Complementary



# Central Dogma of Biology

**DNA** → **RNA** → **PROTEIN**

Data storage

Readout

Execution

# What are Proteins?

- Proteins are polymers of amino acids
- Each protein has a unique sequence of amino acids
- The sequence of amino acids specifies protein shape and function

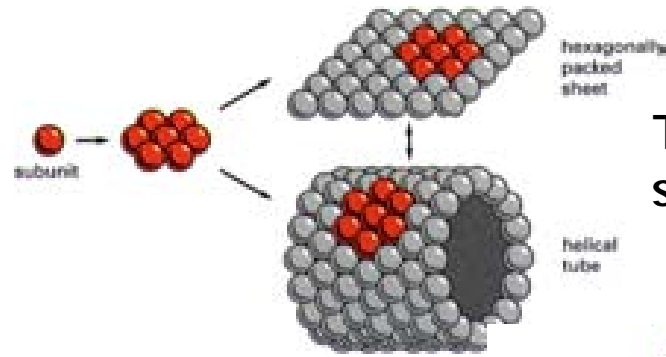
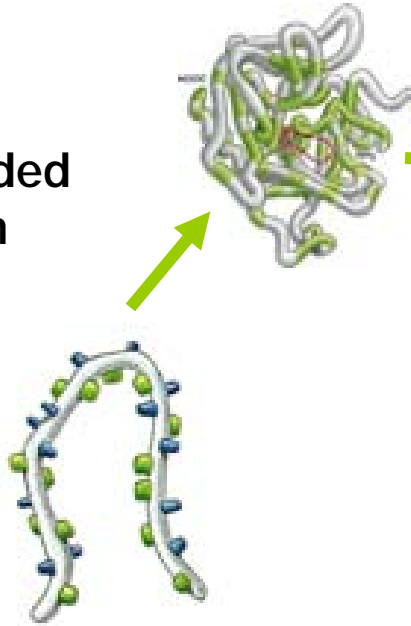
# Proteins Have Many Functions in Cells

- They make most of the structures in cells
- They are the enzymes that break down food
- They are responsible for building new parts
- They act as the eyes and ears of cells

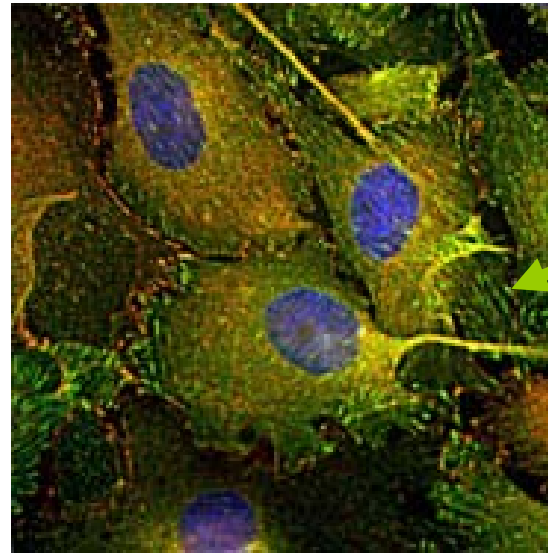
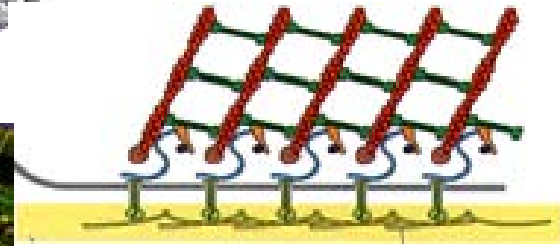
**Most cell functions are  
carried out by proteins**

# Proteins Make Cellular Structures

To folded protein



To assembled structure



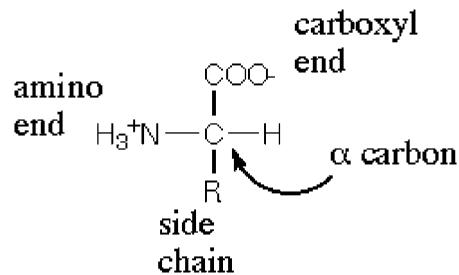
Cells are built from proteins (and some other stuff)

LLCDGGALPTYSLQTTIAALMRRTLGGDEHICVLISTH

From primary transcript

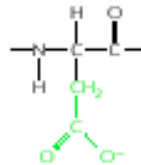


# What are Amino Acids?

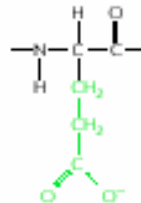


## ACIDIC SIDE CHAINS

aspartic acid  
(Asp, or D)

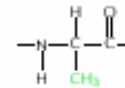


glutamic acid  
(Glu, or E)

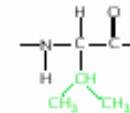


## NONPOLAR SIDE CHAINS

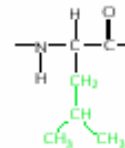
alanine  
(Ala, or A)



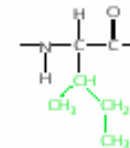
valine  
(Val, or V)



leucine  
(Leu, or L)

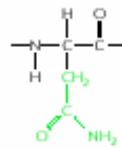


isoleucine  
(Ile, or I)

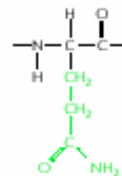


## UNCHARGED POLAR SIDE CHAINS

asparagine  
(Asn, or N)

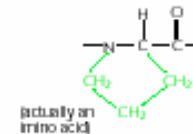


glutamine  
(Gln, or Q)

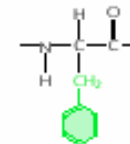


Although the amide N is not charged at neutral pH, it is polar.

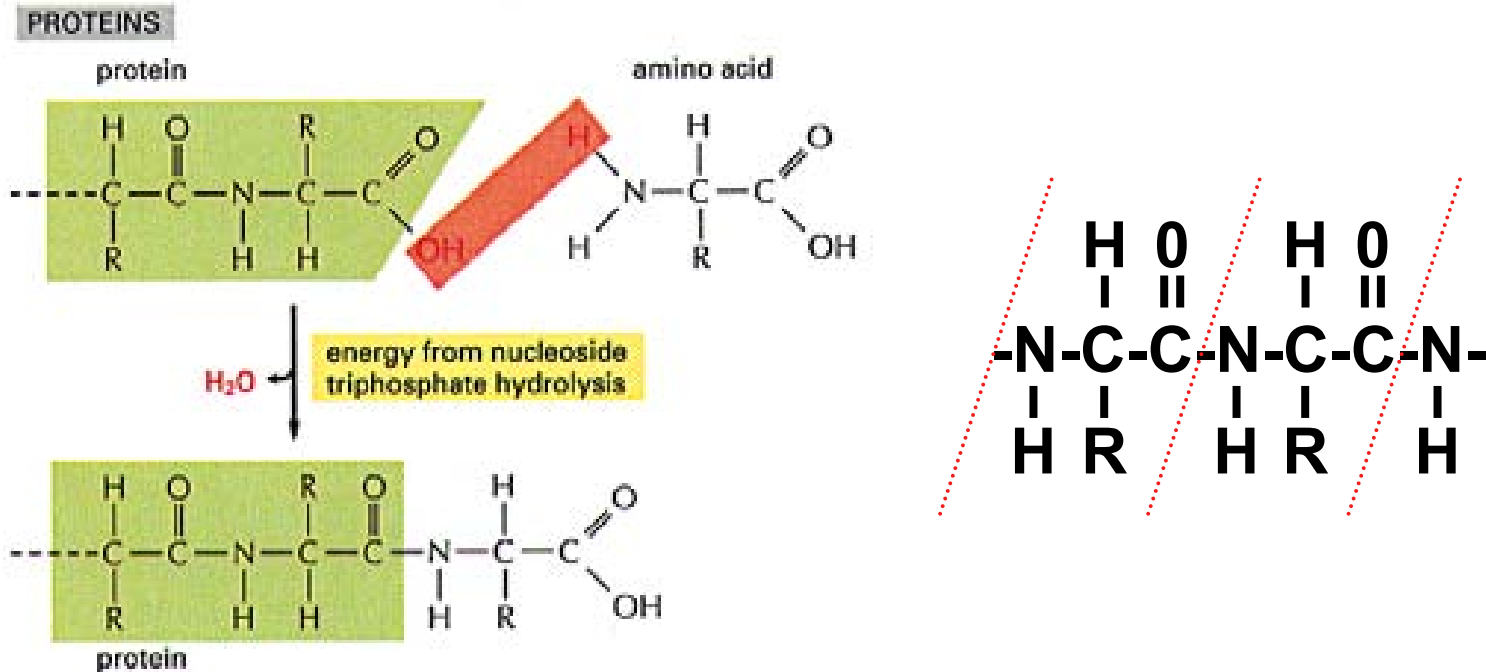
proline  
(Pro, or P)



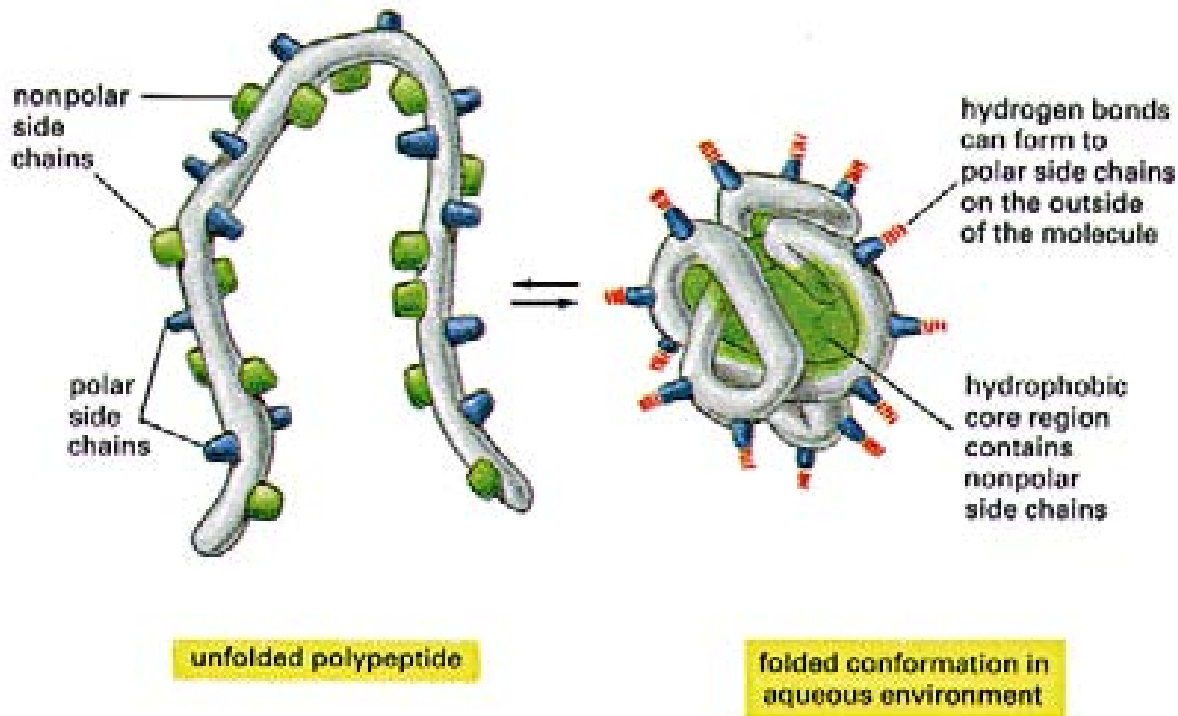
phenylalanine  
(Phe, or F)



# Amino Acids Polymerize to Form Proteins



# Sequence of Protein Dictates its Folding Pattern



# How Does DNA Specify the Sequence of a Protein?

- A DNA sequence must be “decoded” to make a protein
- This decoding requires creation of an RNA template
- Creation of “messenger RNA” is called *transcription*
- Creation of protein from the mRNA is called *translation*

# Central Dogma of Biology

**DNA**  **RNA**  **PROTEIN**

Data storage

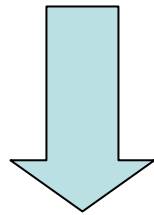
Readout

Execution

# Two Types of RNA

DNA

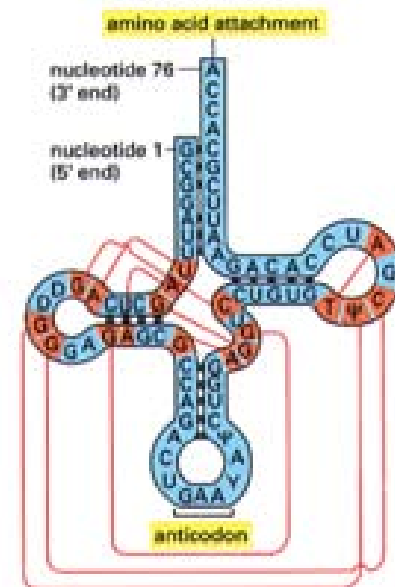
**ATGGCCTAAGCTCTGA**



mRNA

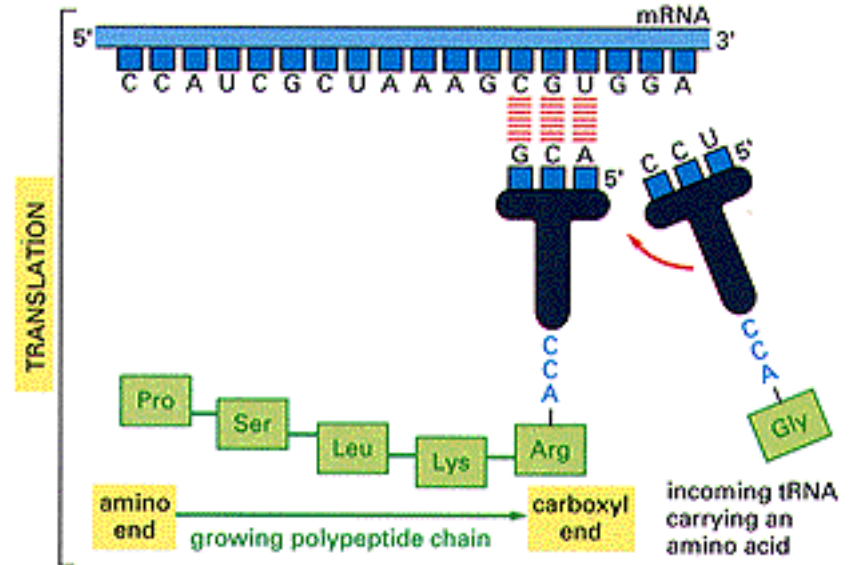
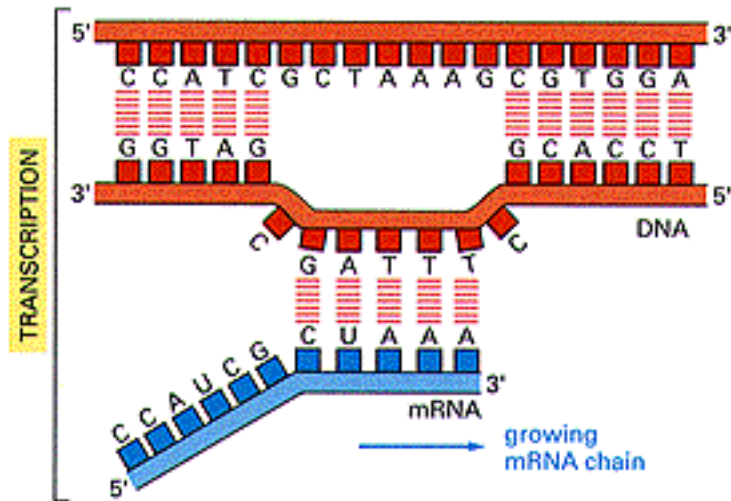
**UACCGGAUUCGAGACU**

mRNA looks like DNA and is essentially a copy of a gene



“transfer” RNA (tRNA) is an adaptor used in protein synthesis

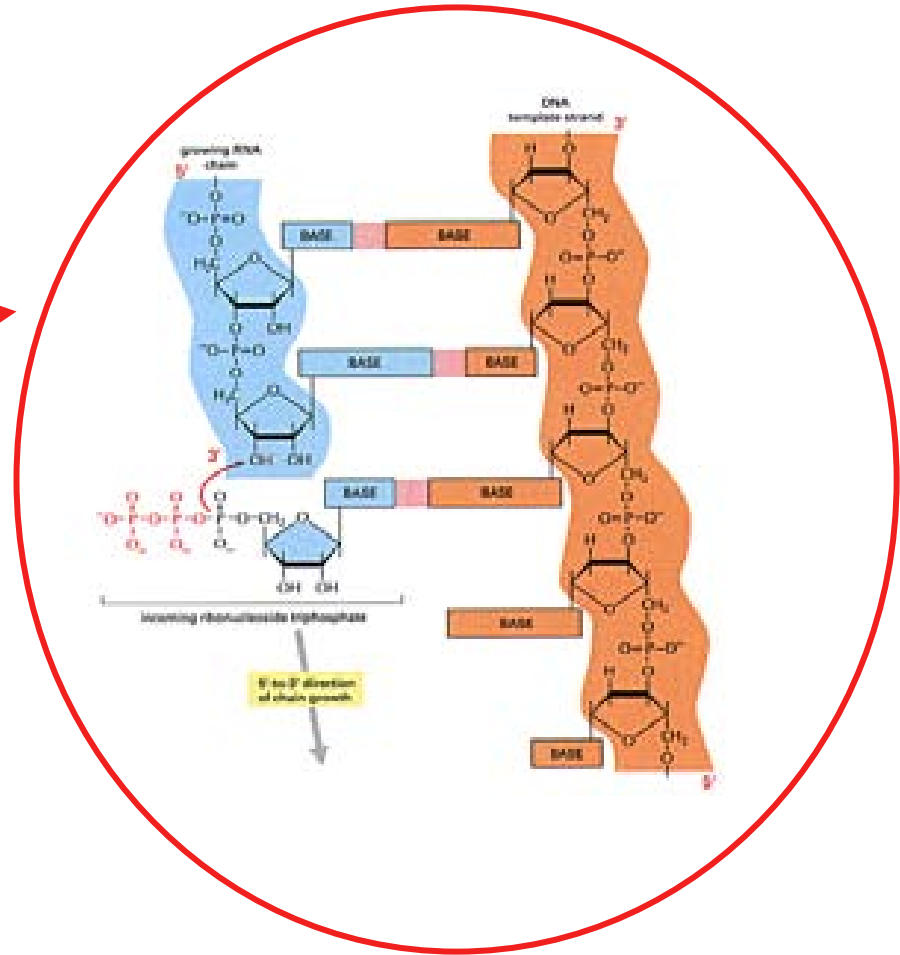
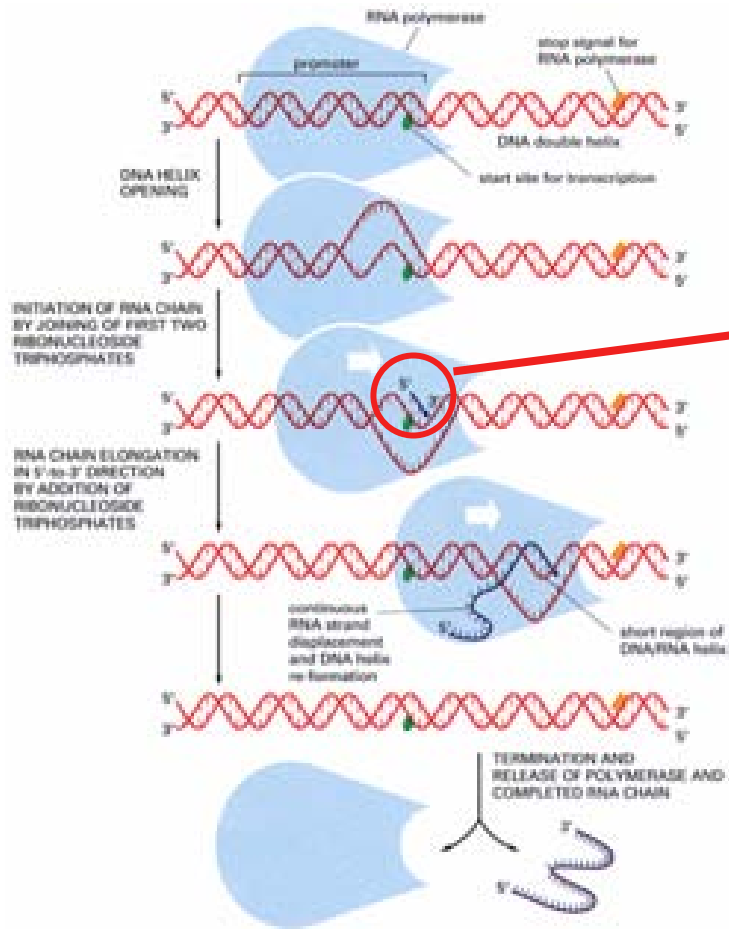
# Information Flow in Protein Synthesis





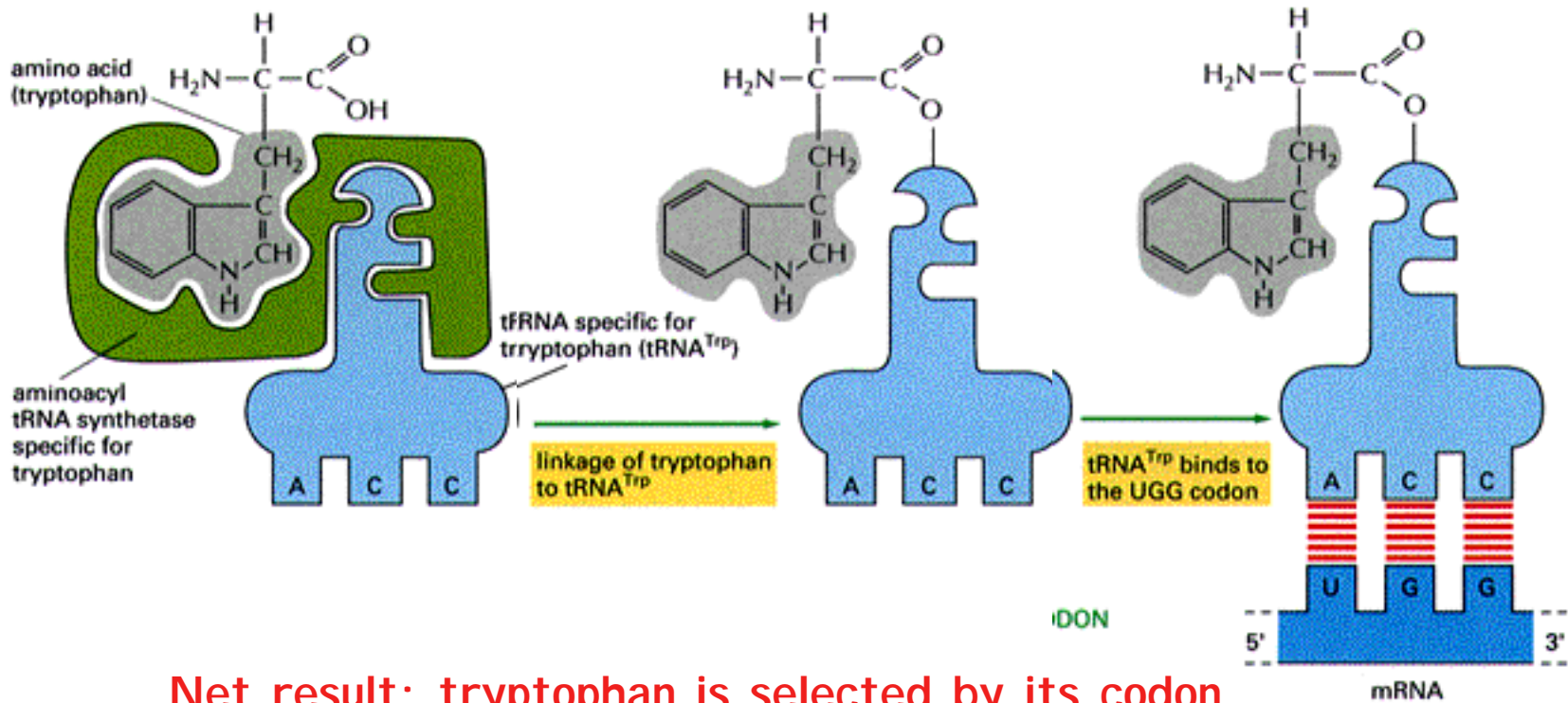


# Synthesis of RNA

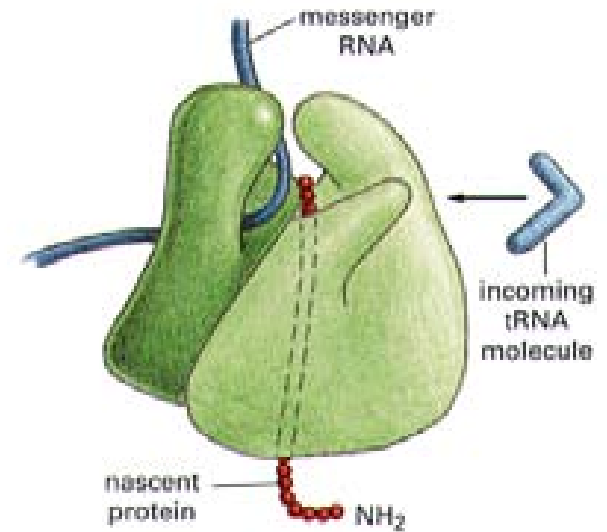
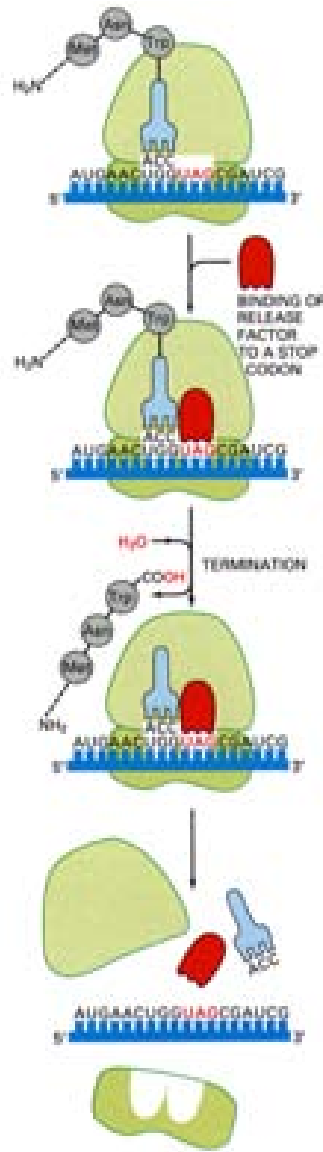
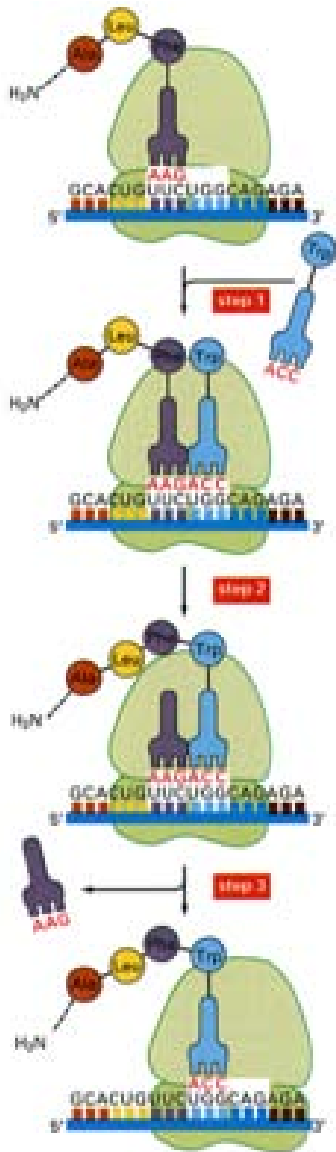




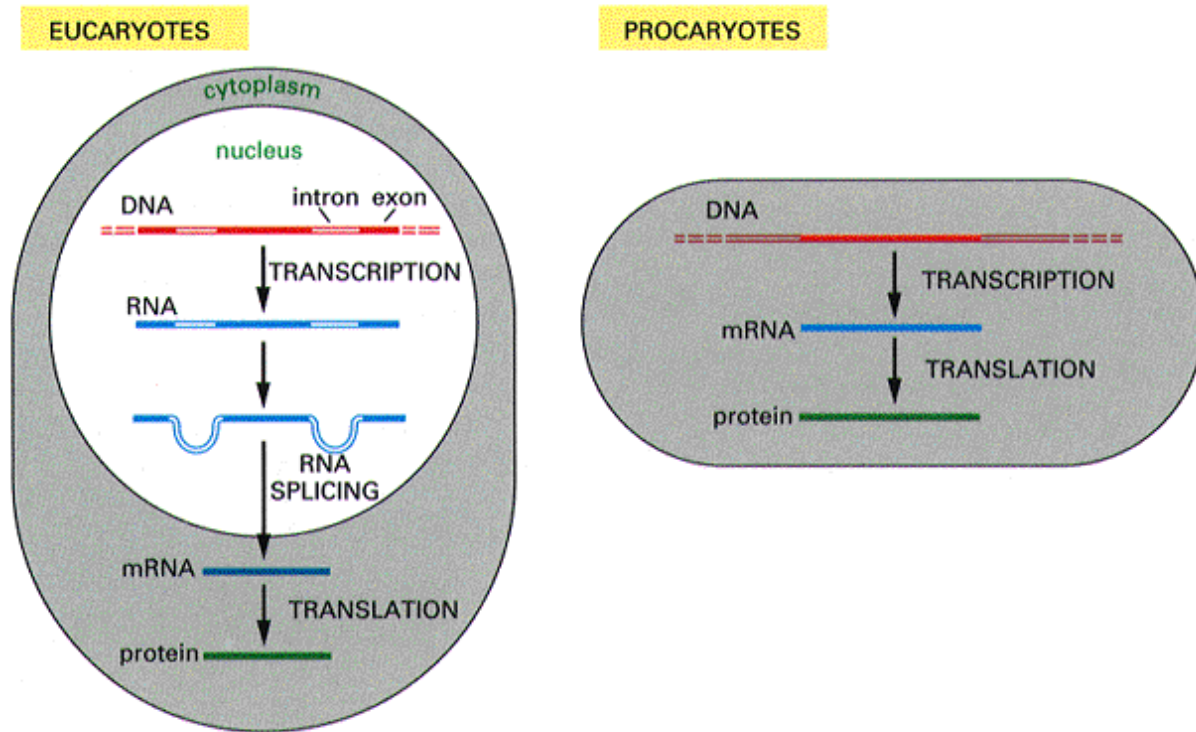
# Genetic Code is Translated by Two Sequential "Adaptors"



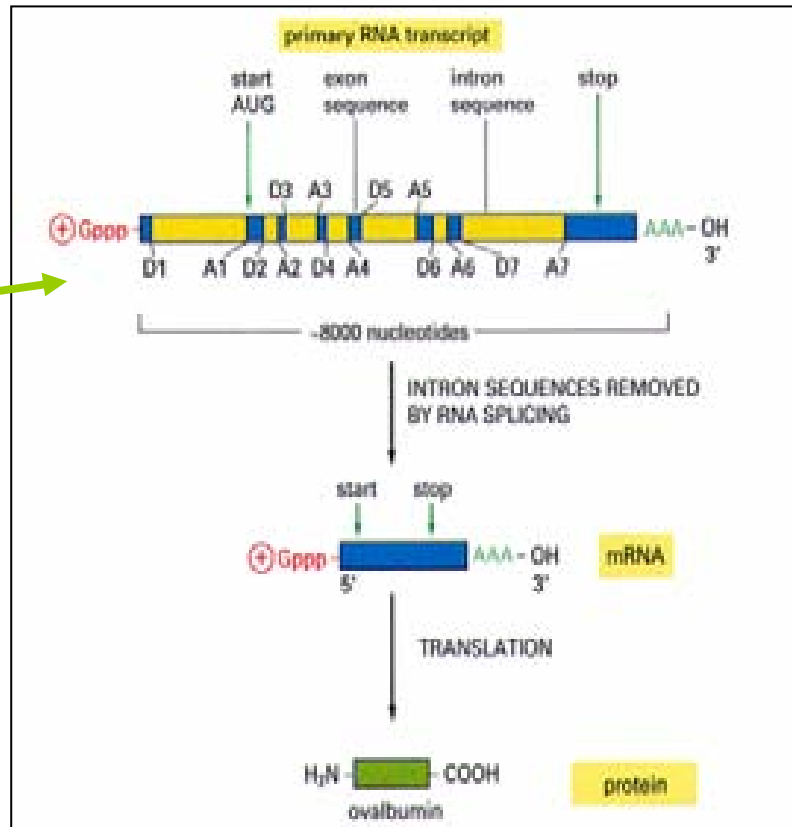
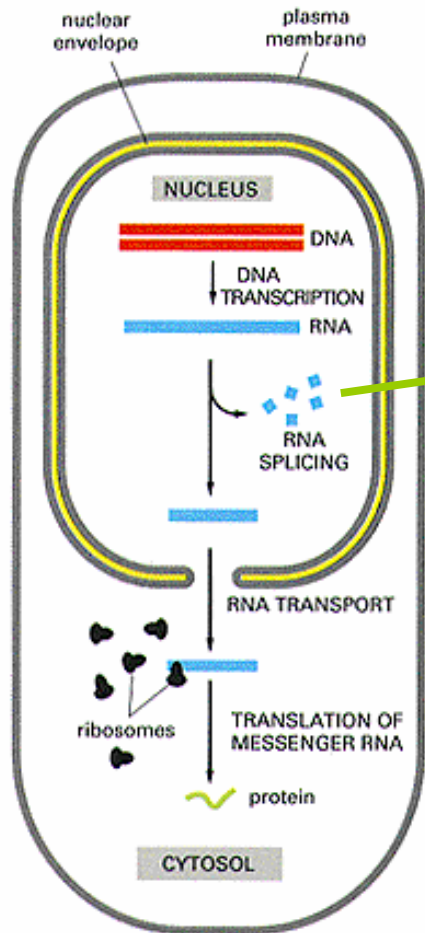
# Proteins are Made on Ribosomes



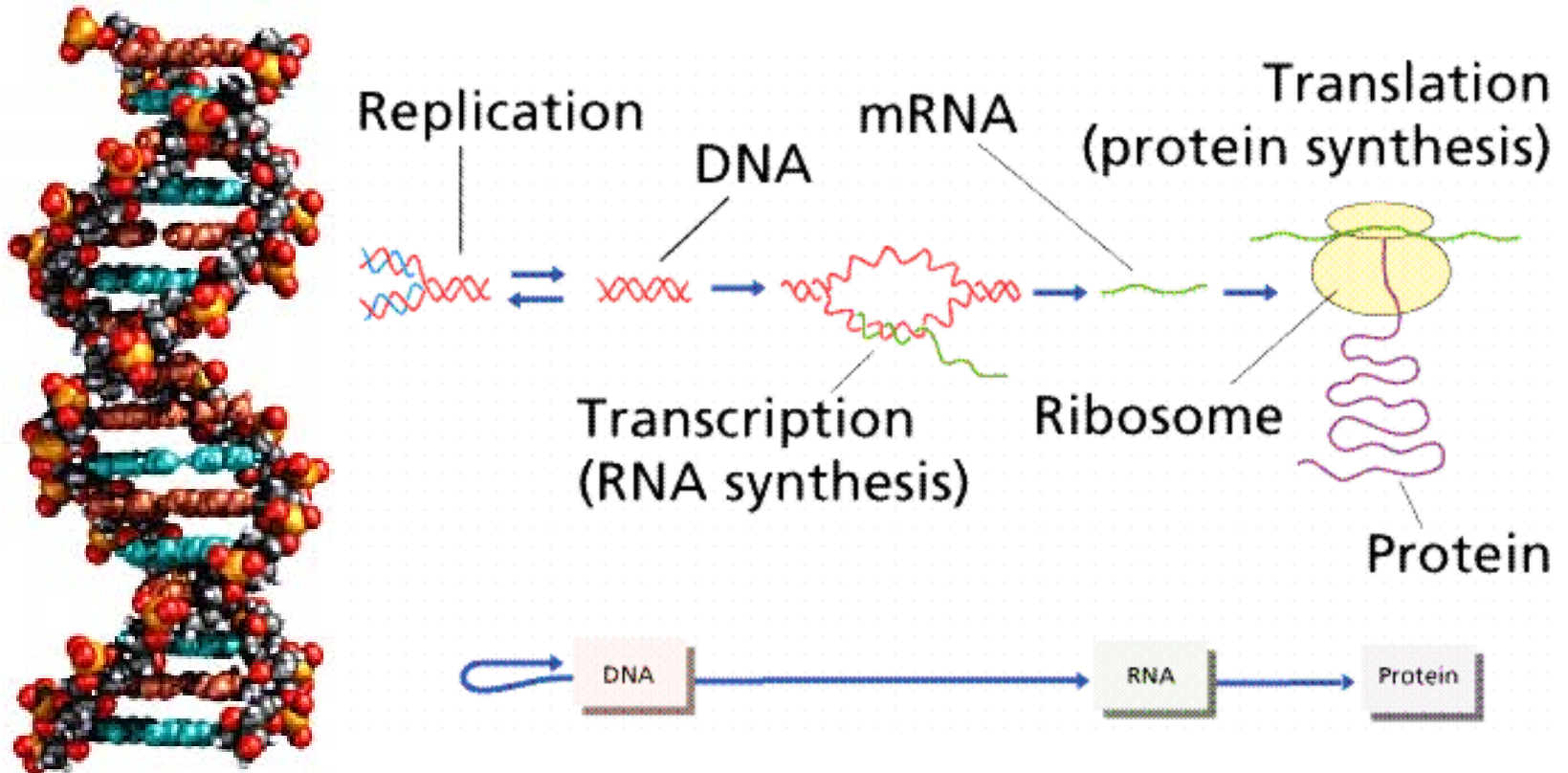
# Information Flow is Simpler in Prokaryotes



# The Structure of Genes in Eucaryotes Can Be Complex



# Relationship Between Genes and Proteins



# So What is Next?

- How does the amino acid sequence of a protein specify its function?
- How about those other parts of cells (such as membranes)? How are they made?
- How are cellular processes regulated?
- How do we study cells and biochemical processes?