Pendahuluan

Prof. Drs. Sutarno, MSc., PhD.

Biology & Molecular Biology

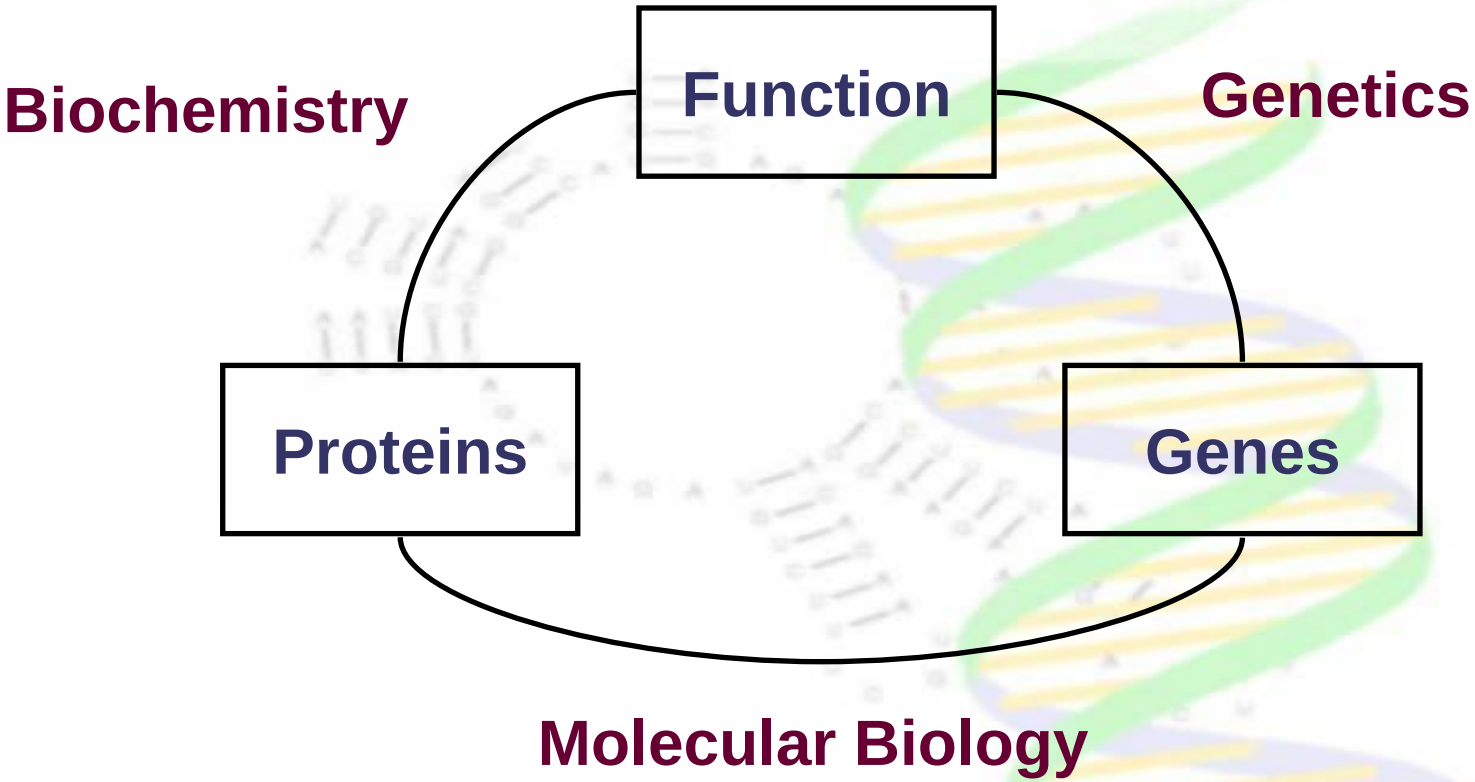
- **Biology is Study of Life**

>>> Studying life at a molecular level is Molecular Biology → modern Biology

- **The molecules of interest are**
  - **DNA,**
  - **RNA &**
  - **Proteins**

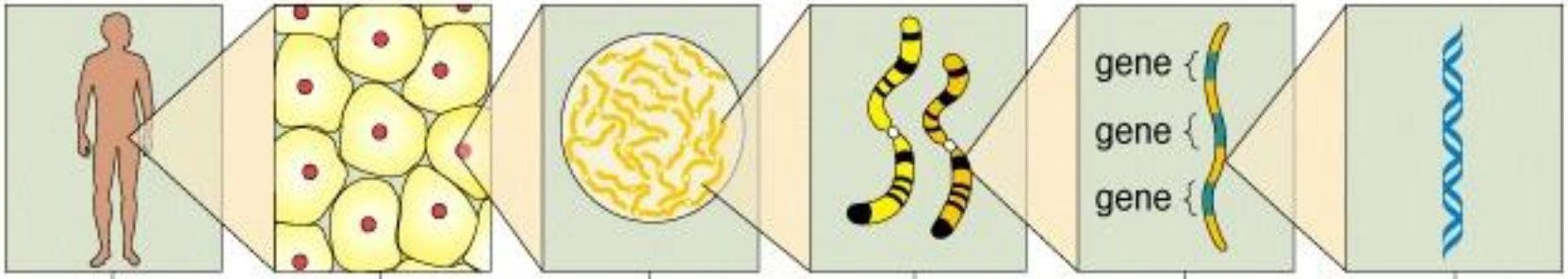
Molecular Biology

- **The field overlaps with other areas of biology, particularly genetics and biochemistry**
- **Molecular biology concerns itself with: understanding the interactions between the various systems of a cell, including the interrelationship of DNA, RNA and protein synthesis and learning how these interactions are regulated.**


Biochemistry
Function
Genetics
Proteins
Genes
Molecular Biology

Cell Nucleus

- **Nucleus is the control & Command center as is brain in, for example, a human body**



Organism (human)

A human body is made up of trillions of cells.

Each cell nucleus contains an identical complement of chromosomes.

One specific chromosome pair

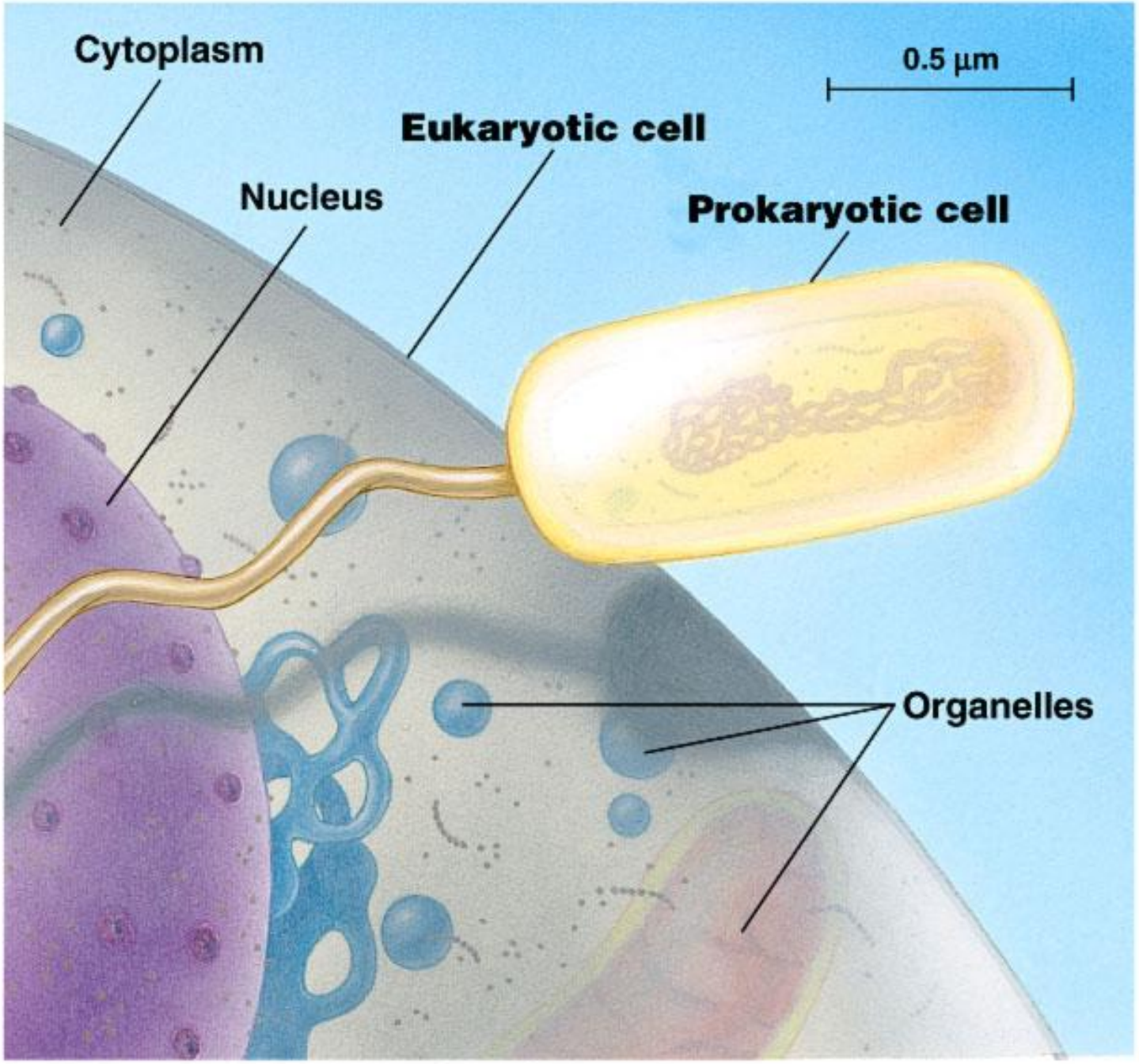
Each chromosome is one long DNA molecule, and genes are functional regions of this DNA.

DNA is a double helix.

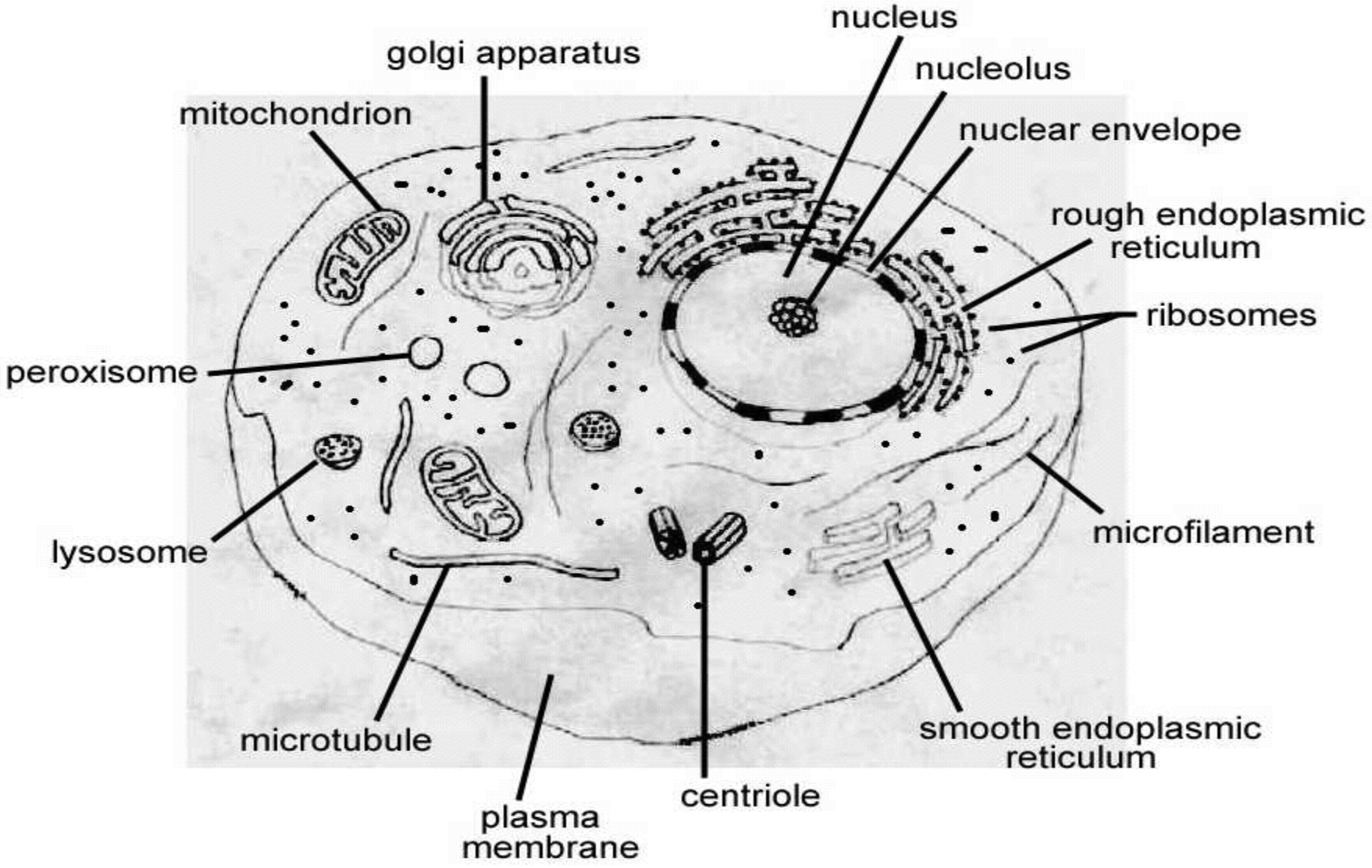
Organisms Types

- **Eukaryotes: Cells contain a membrane bound nucleus and organelles (plants, animals, fungi,…)**
- **Prokaryotes: Cells lack a true membrane-bound nucleus and organelles (single-celled, includes bacteria)**

- ***Not all single celled organisms are prokaryotes!***

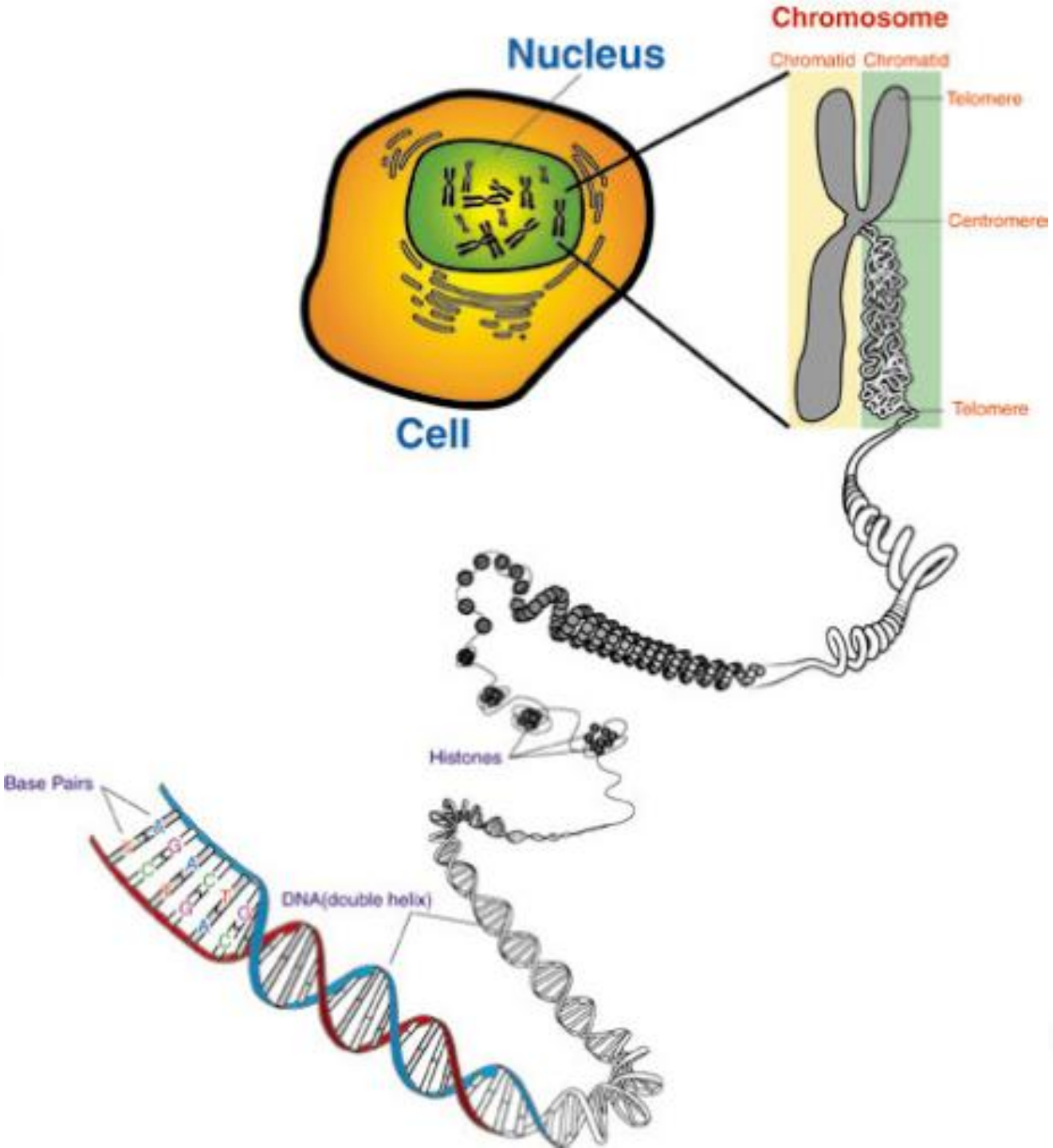


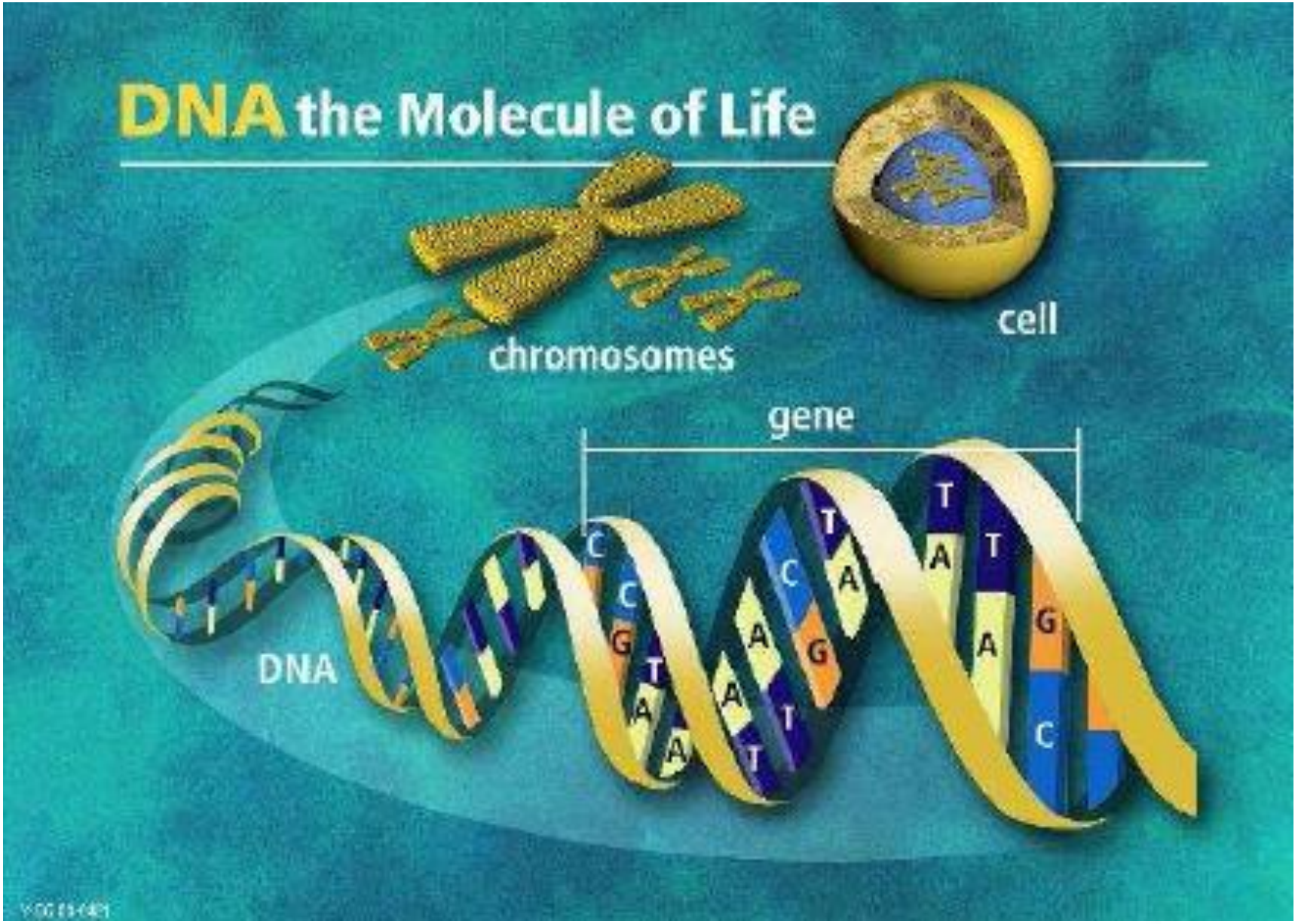
Eukaryotic cell



Chromosomes

- **Chromosomes are made up of Proteins and DNA**
- **DNA carries the genetic information**
- **This information is similar to digital**
- **information**


Chromosome
Nucleus
Chromatid
Chromatid
Telomere
Centromere
Telomere
Cell
Histones
Base Pairs
DNA(double helix)

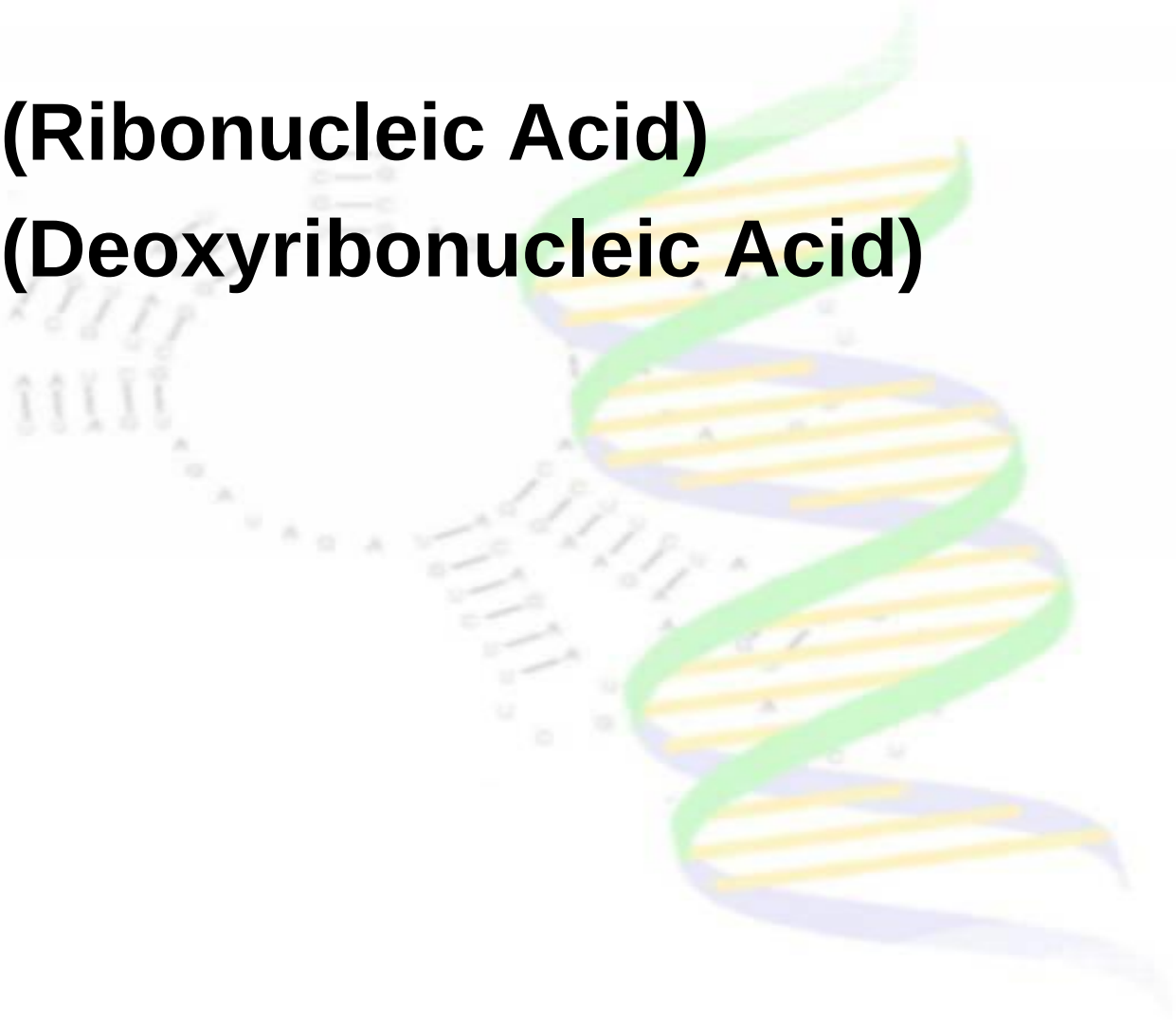

DNA the Molecule of Life
chromosomes
cell
gene
DNA

Essential Molecules

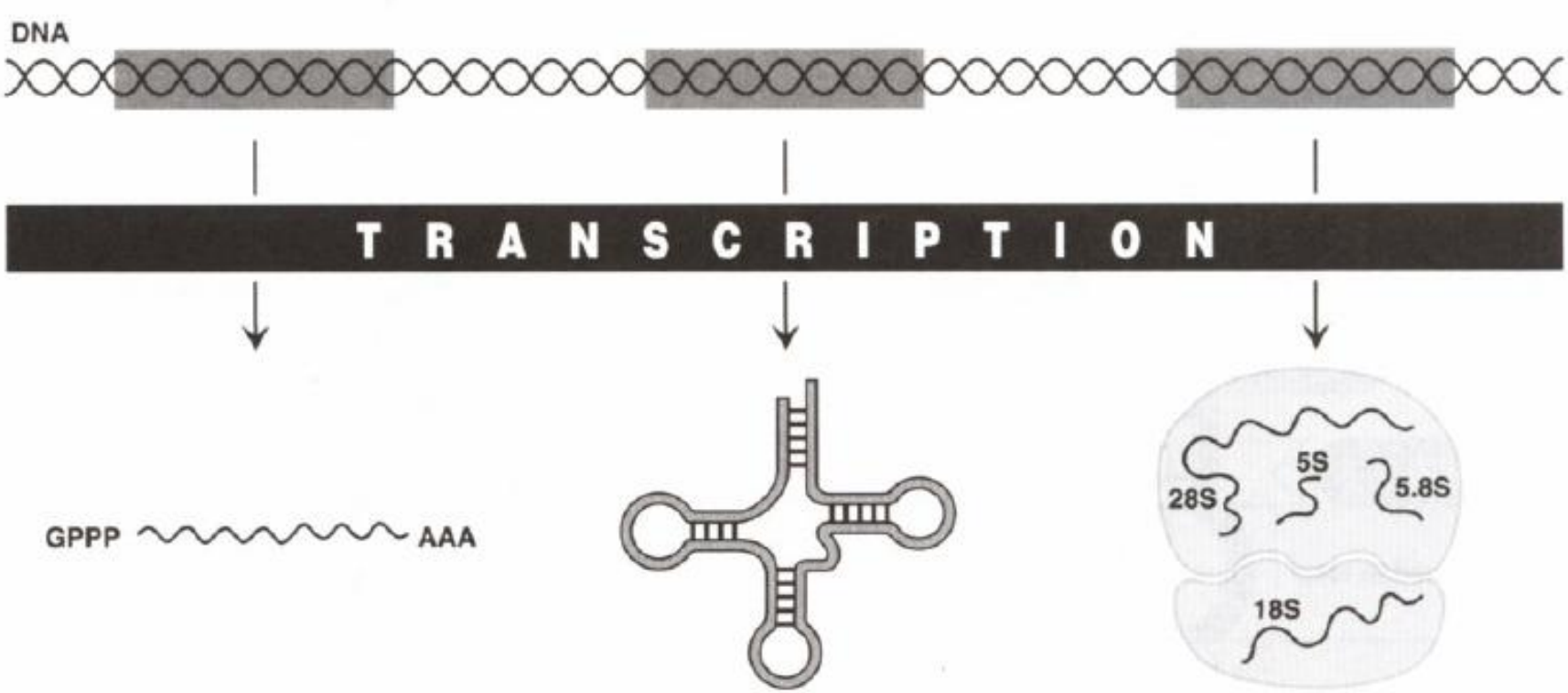
- **Proteins make up the cell matrix as well as carry out all biochemical reactions which sustain life as we know it**
- **So DNA & Proteins are both essential molecules of life**

Nucleic Acids

- **RNA (Ribonucleic Acid)**
- **DNA (Deoxyribonucleic Acid)**



RNA



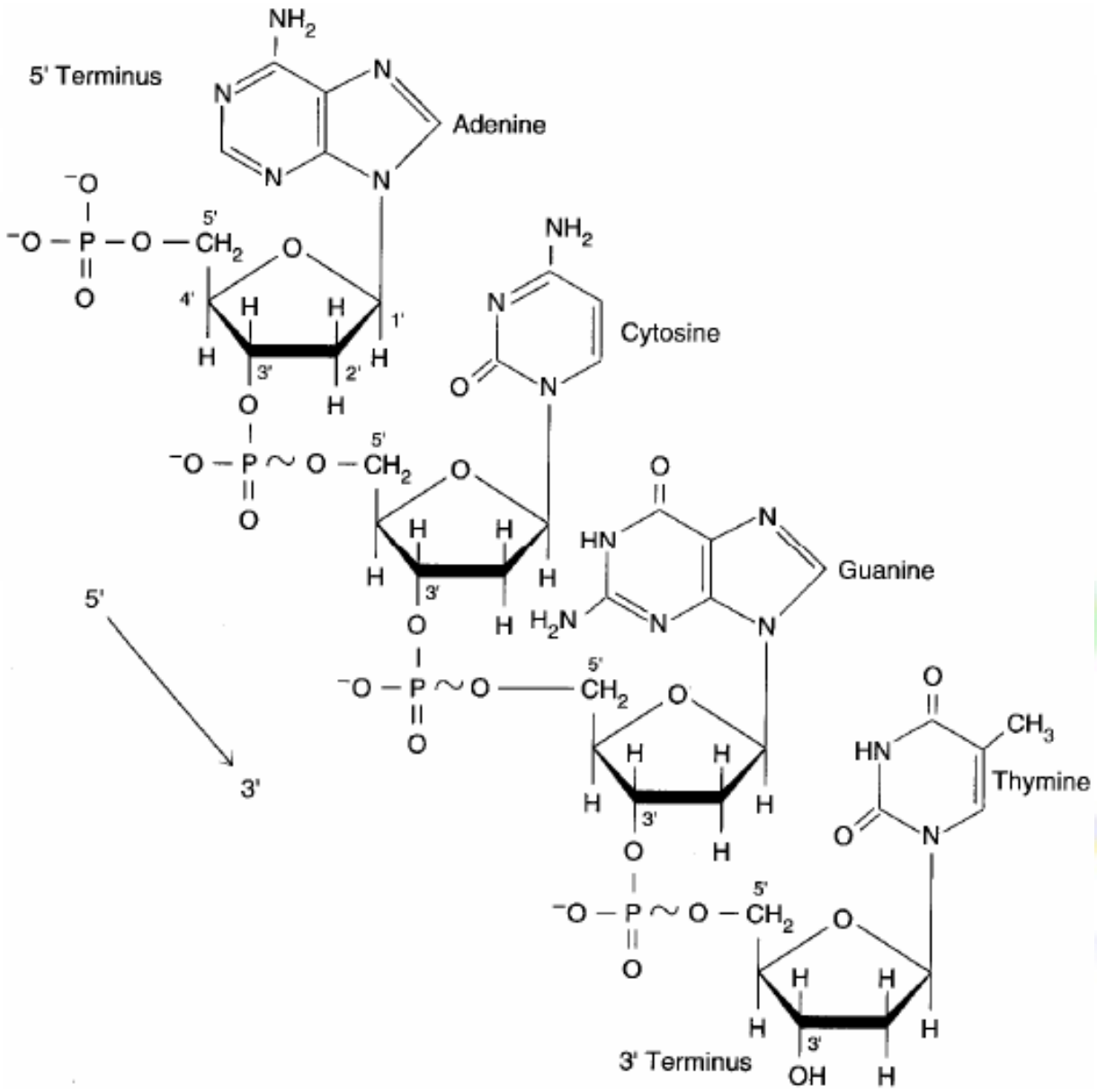
DNA

- The carrier of genetic information
- for all complex organisms.
- • Long polymer consisting of 4 bases

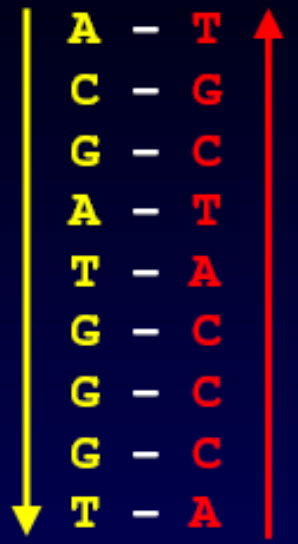
Base, Nucleoside & Nucleotide

- • Nitrogenous bases: **Adenine**
  Guanine
  Cytosin
  Thymine
  uracil
- Nucleoside: **Base + Sugar**
- Nucleotide: **Base + Sugar + Phosphate**

DNA Chain

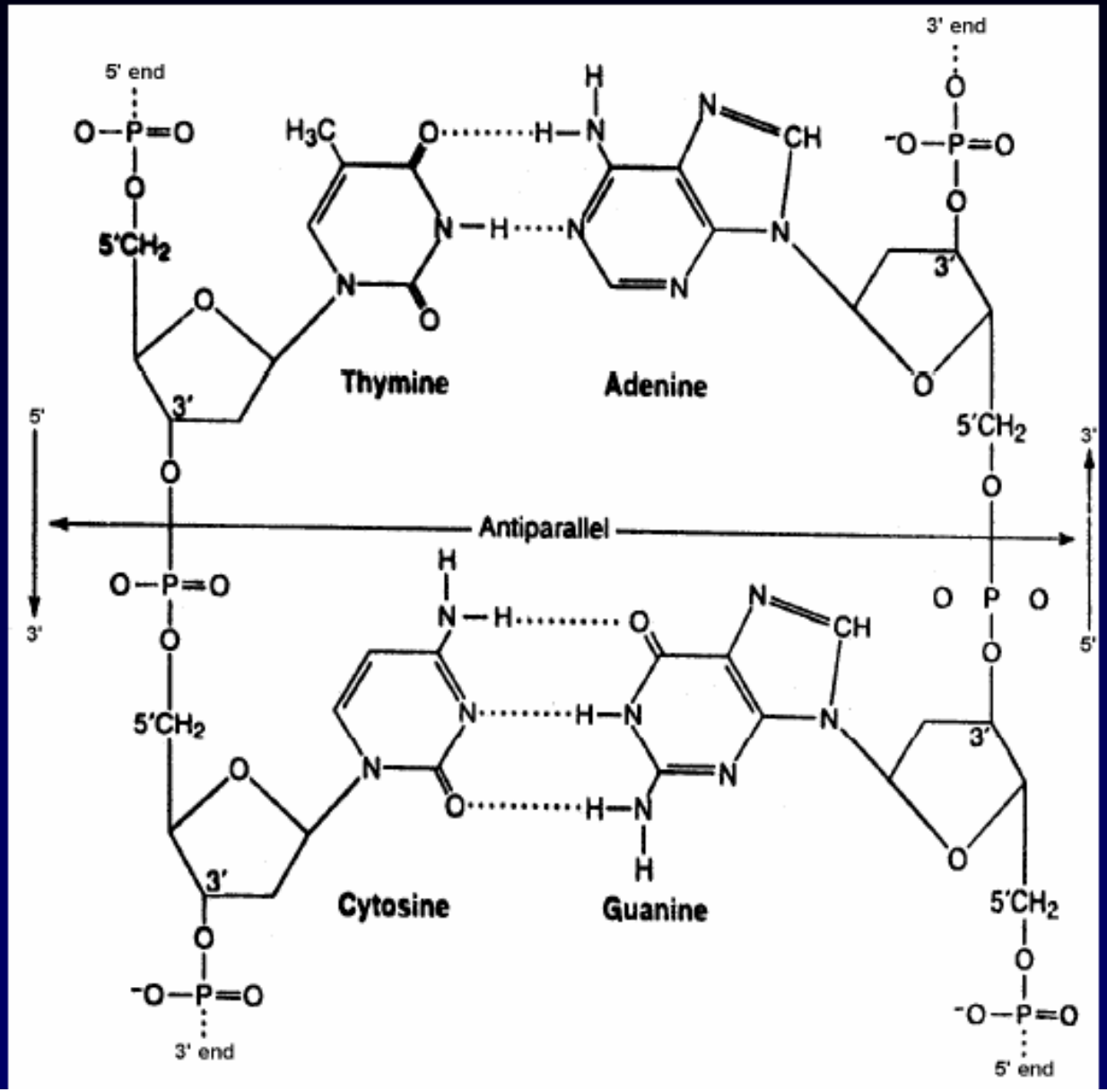

5' Terminus
Adenine
Cytosine
Guanine
Thymine
5'
3'
3' Terminus
OH

Base pairing in DNA double helix

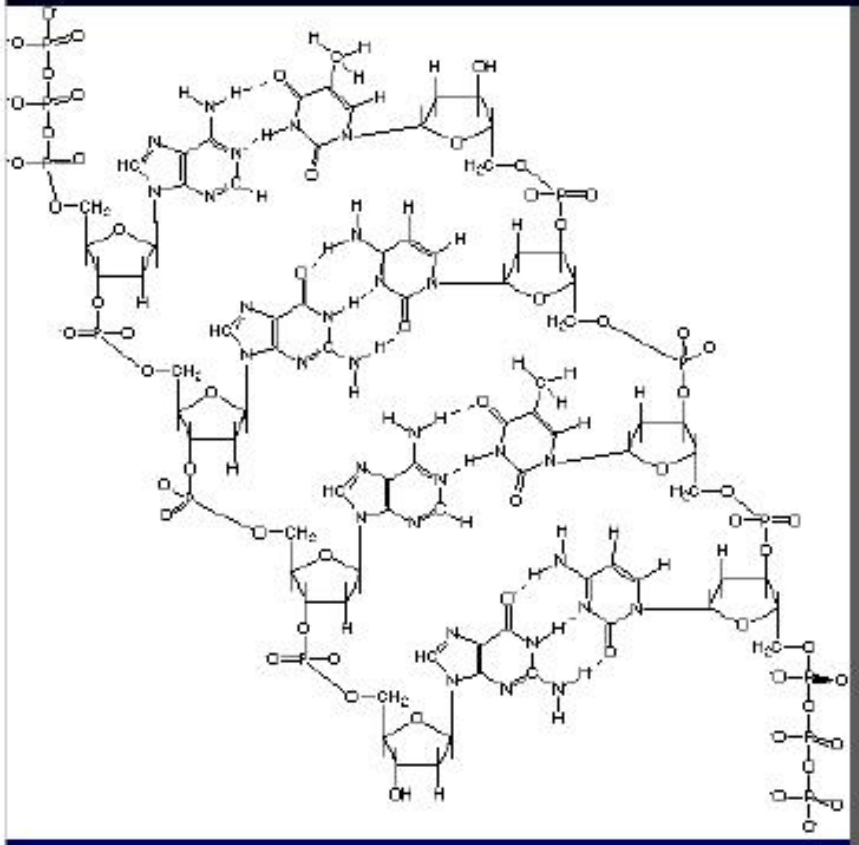


A → T base pairing
C → G base pairing

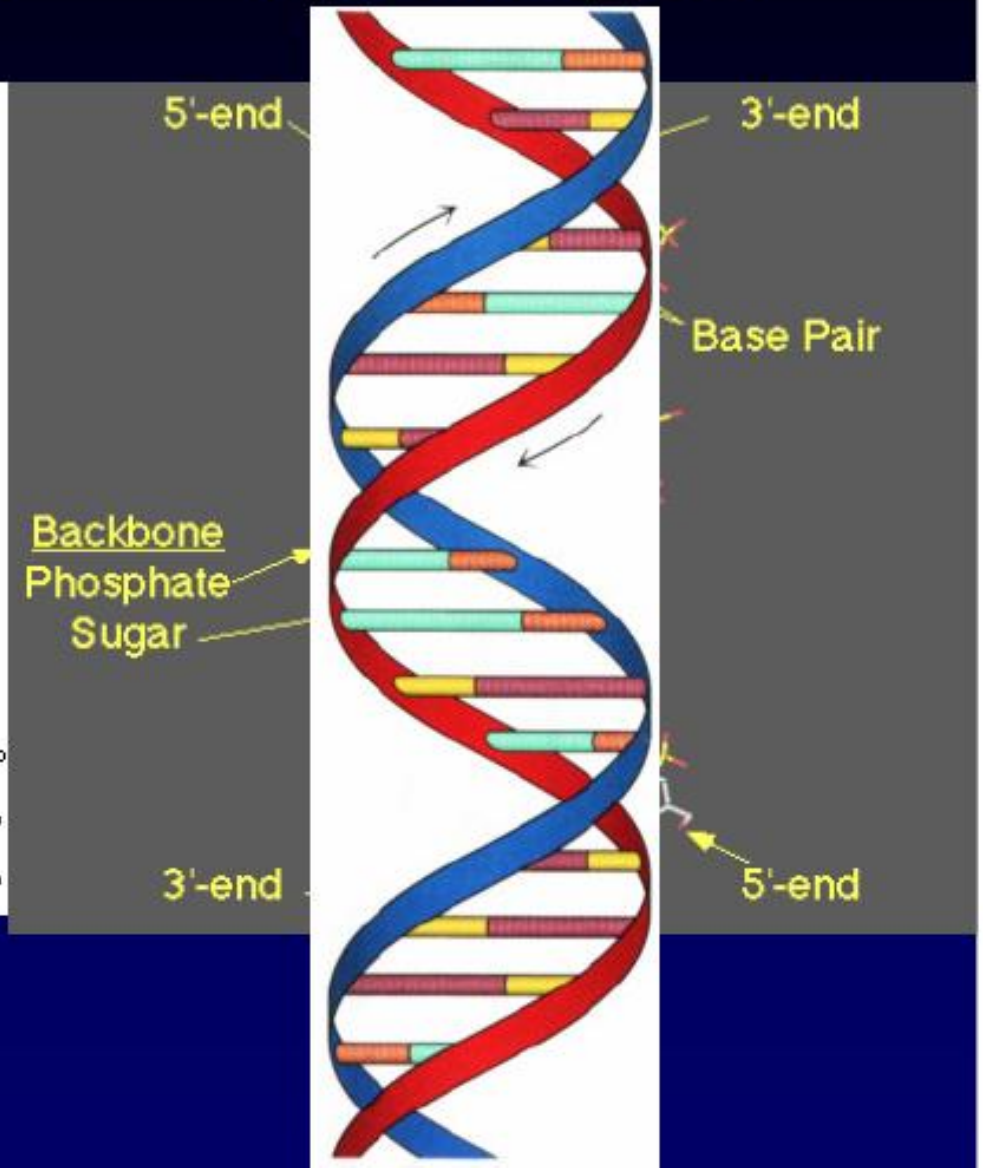
Chargaff (1950)
A/T =1.0
G/C = 1.0



Chemical Structure of DNA

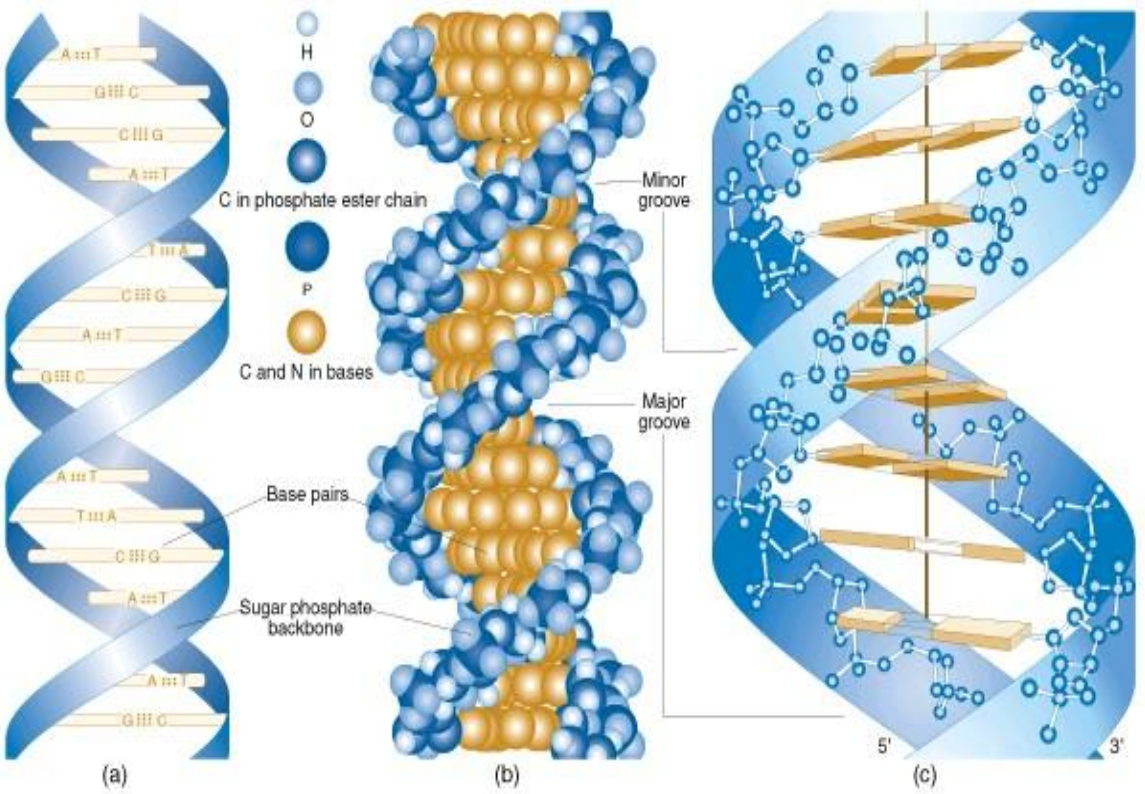


The Double Helix



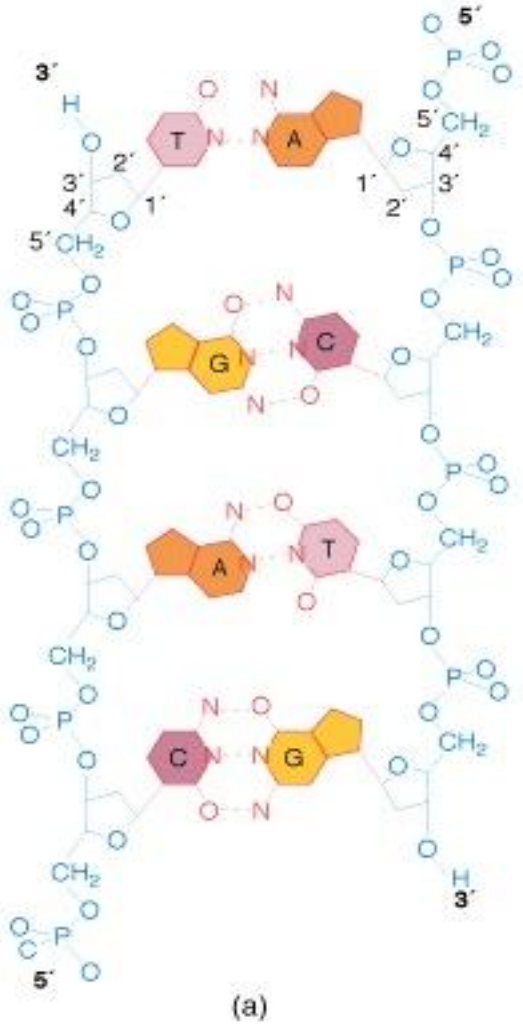
The Double Helix

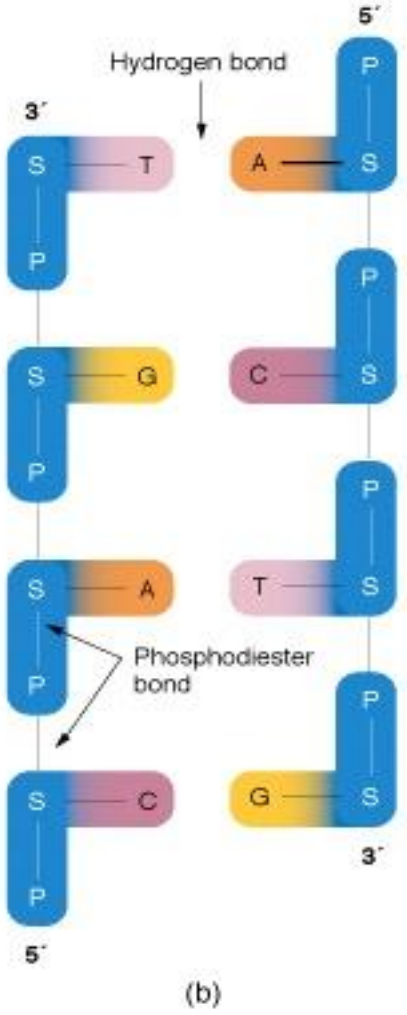
DNA molecules usually consist of two strands arranged in the famous double helix



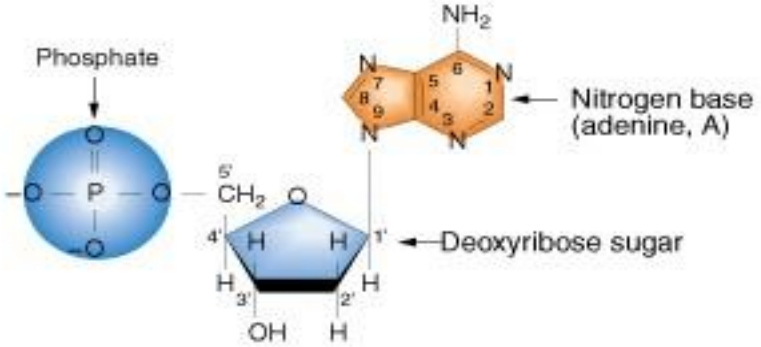
Watson-Crick Base Pairs

- A bonds to T
- C bonds to G

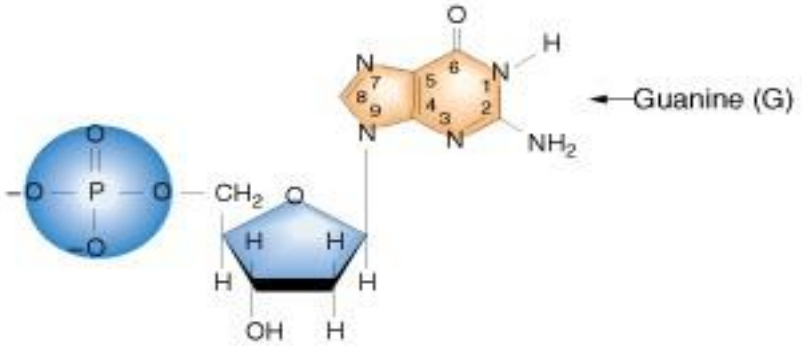




Purine nucleotides

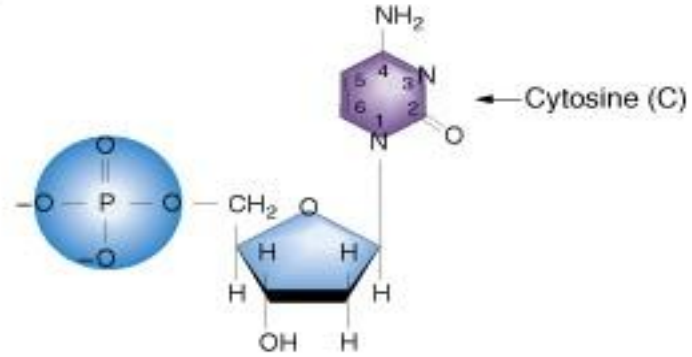


Deoxyadenosine 5'-phosphate (dAMP)

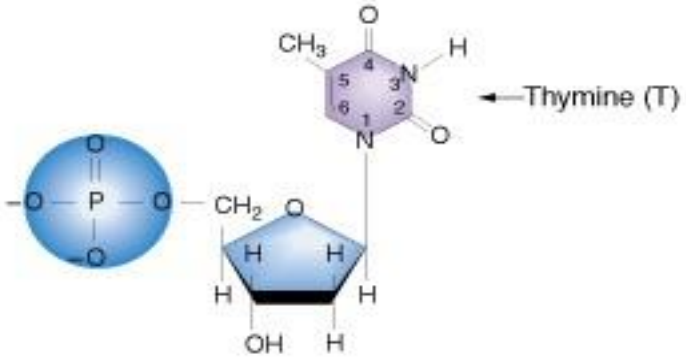


Deoxyguanosine 5'-phosphate (dGMP)

Pyrimidine nucleotides



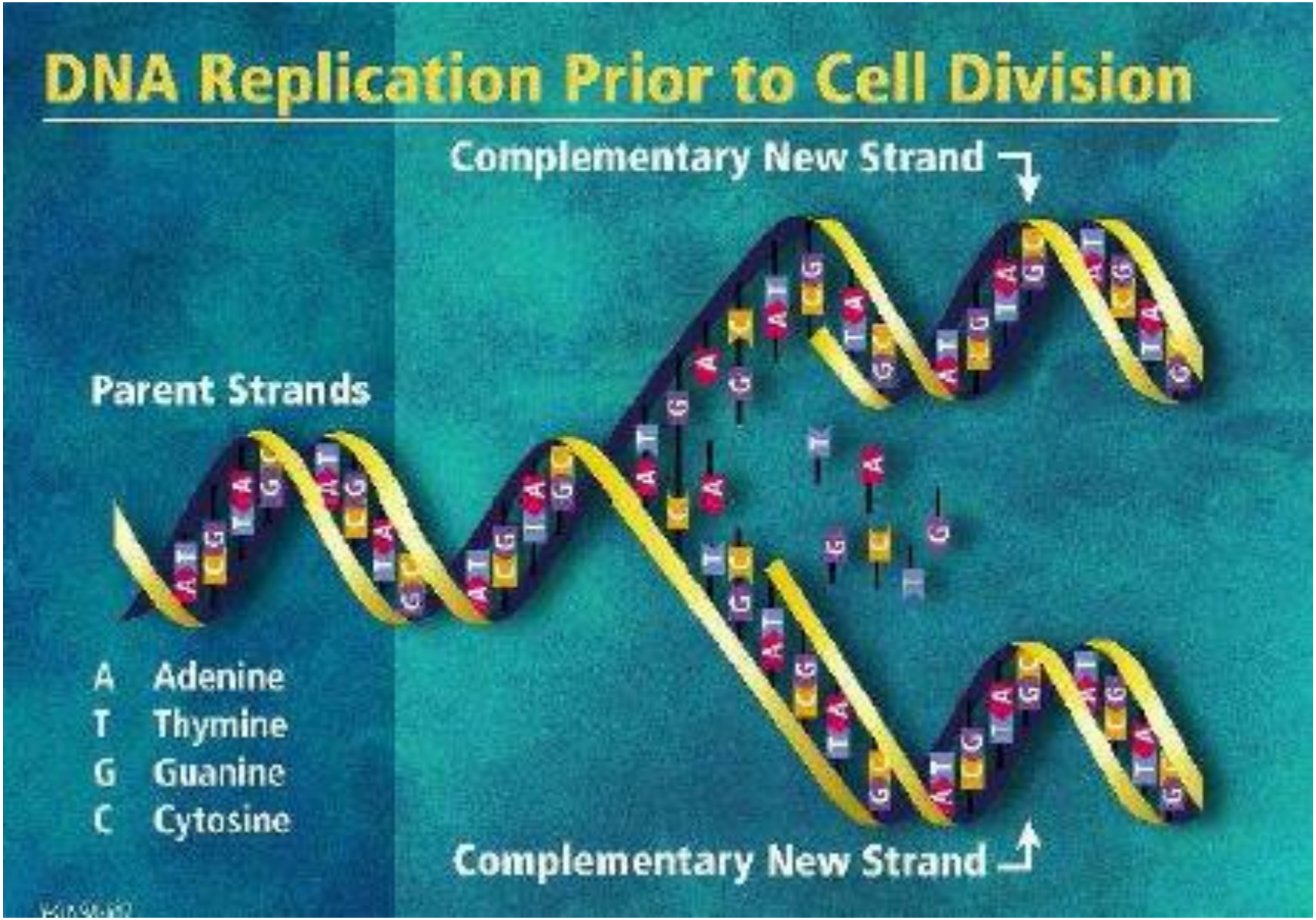
Deoxycytidine 5'-phosphate (dCMP)



Deoxythymidine 5'-phosphate (dTMP)

The Double Helix

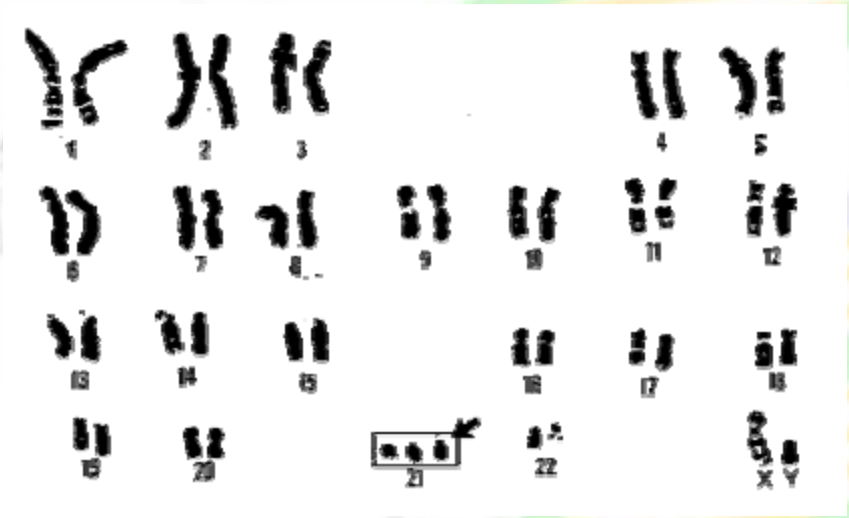
- each strand of DNA has a “direction”
  - at one end, the terminal carbon atom in the backbone is the 5’ carbon atom of the terminal sugar
  - at the other end, the terminal carbon atom is the 3’ carbon atom of the terminal sugar
- therefore we can talk about the *5’* and the *3’* ends of a DNA strand
- in a double helix, the strands are *antiparallel* (arrows drawn from the 5’ end to the 3’ end go in opposite directions)


DNA Replication Prior to Cell Division
Complementary New Strand
Parent Strands
A Adenine
T Thymine
G Guanine
C Cytosine
Complementary New Strand

Chromosomes

- DNA is packaged into individual *chromosomes* (along with proteins)
- *prokaryotes* (single-celled organisms lacking nuclei) have a single circular chromosome
- *eukaryotes* (organisms with nuclei) have a species-specific number of linear chromosomes
- DNA + associated chromosomal proteins = chromatin

Human Chromosomes



Genomes

- the term *genome* refers to the complete complement of DNA for a given species
- the human genome consists of 46 chromosomes.
- every cell (except sex cells and mature red blood cells) contains the complete genome of an organism

Proteins

- proteins are molecules composed of one or more *polypeptides*
- a polypeptide is a polymer composed of *amino acids*
- cells build their proteins from 20 different amino acids
- a polypeptide can be thought of as a string
- composed from a 20-character alphabet

Protein Functions

- structural support
- storage of amino acids
- transport of other substances
- coordination of an organism’s activities
- response of cell to chemical stimuli
- movement
- protection against disease
- selective acceleration of chemical reactions

Amino Acids

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

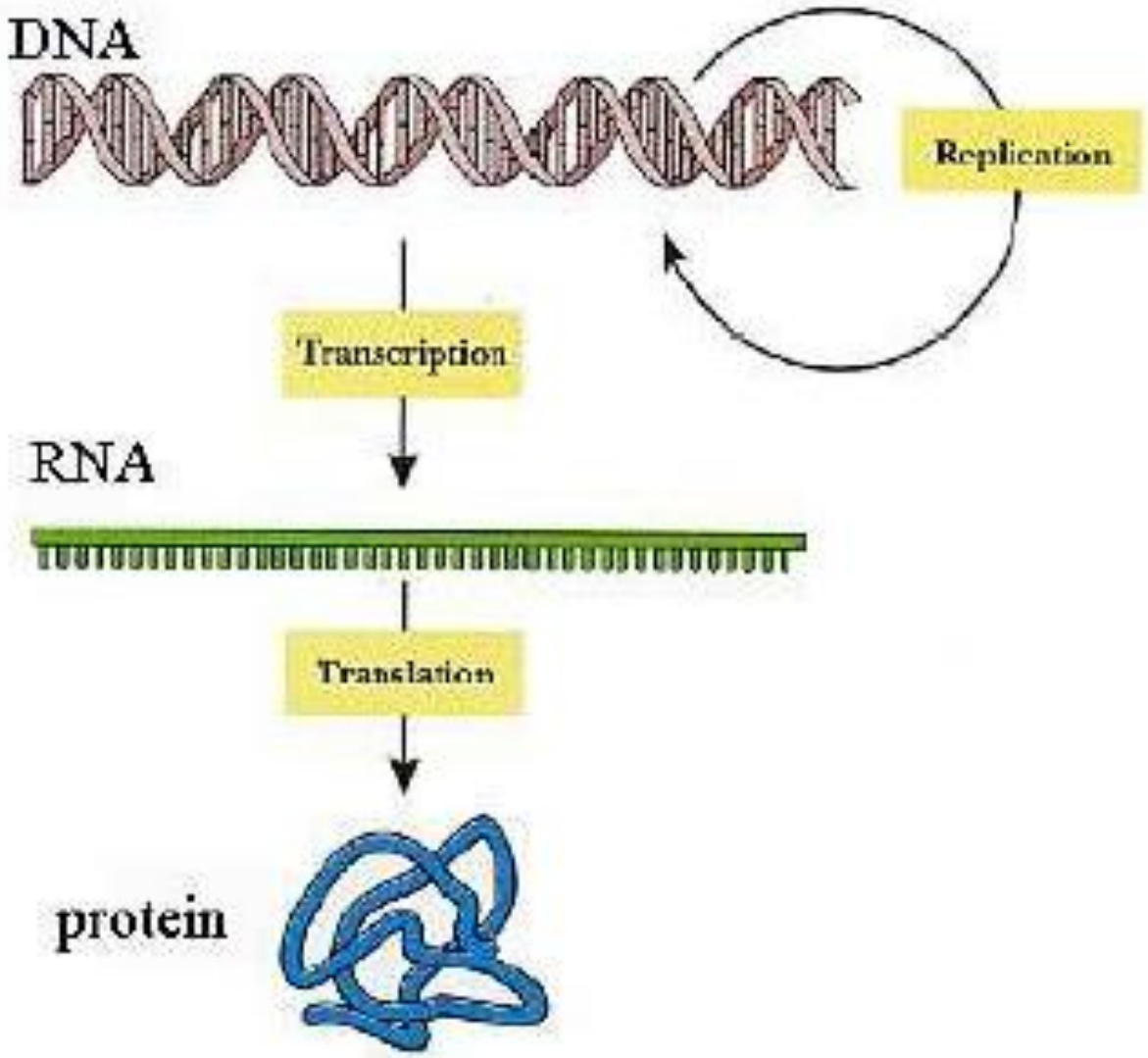
Amino Acid Sequence of Hexokinase

```
        5        10        15        20        25        30
  1 A A S X D X S L V E V H X X V F I V P P X I L Q A V V S I A
 31 T T R X D D X D S A A A S I P M V P G W V L K Q V X G S Q A
 61 G S F L A I V M G G G D L E V I L I X L A G Y Q E S S I X A
 91 S R S L A A S M X T T A I P S D L W G N X A X S N A A F S S
121 X E F S S X A G S V P L G F T F X E A G A K E X V I K G Q I
151 T X Q A X A F S L A X L X K L I S A M X N A X F P A G D X X
181 X X V A D I X D S H G I L X X V N Y T D A X I K M G I I F G
211 S G V N A A Y W C D S T X I A D A A D A G X X G G A G X M X
241 V C C X Q D S F R K A F P S L P Q I X Y X X T L N X X S P X
271 A X K T F E K N S X A K N X G Q S L R D V L M X Y K X X G Q
301 X H X X X A X D F X A A N V E N S S Y P A K I Q K L P H F D
331 L R X X X D L F X G D Q G I A X K T X M K X V V R R X L F L
361 I A A Y A F R L V V C X I X A I C Q K K G Y S S G H I A A X
391 G S X R D Y S G F S X N S A T X N X N I Y G W P Q S A X X S
421 K P I X I T P A I D G E G A A X X V I X S I A S S Q X X X A
451 X X S A X X A
```

Genes

- genes are the basic units of heredity
- a gene is a sequence of bases that carries the information required for constructing a particular protein (polypeptide really)
- such a gene is said to *encode* a protein
- the human genome comprises ~ 35,000 genes
- Those genes encode > 100,000 polypeptides

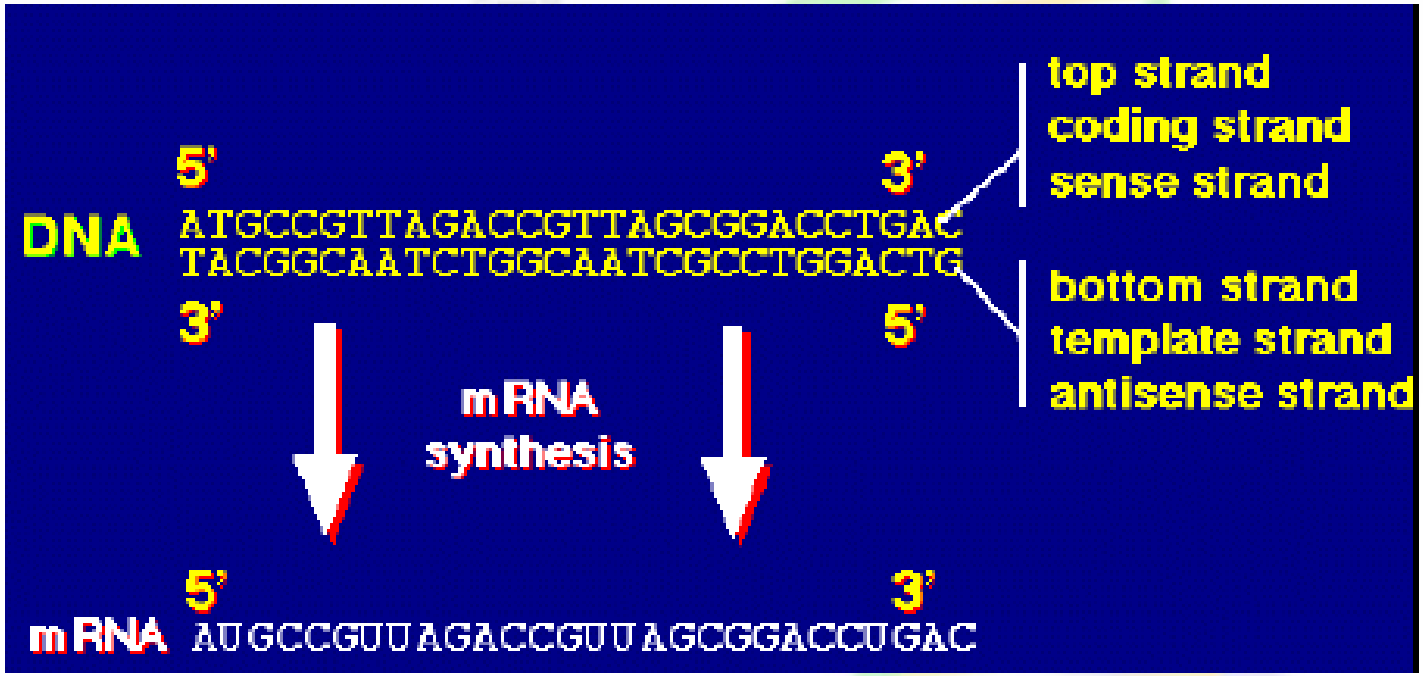
The Central Dogma



RNA

- RNA is like DNA except:
  - backbone is a little different
  - usually single stranded
  - the base uracil (U) is used in place of thymine (T)
- a strand of RNA can be thought of as a string composed of the four letters: A, C, G, U

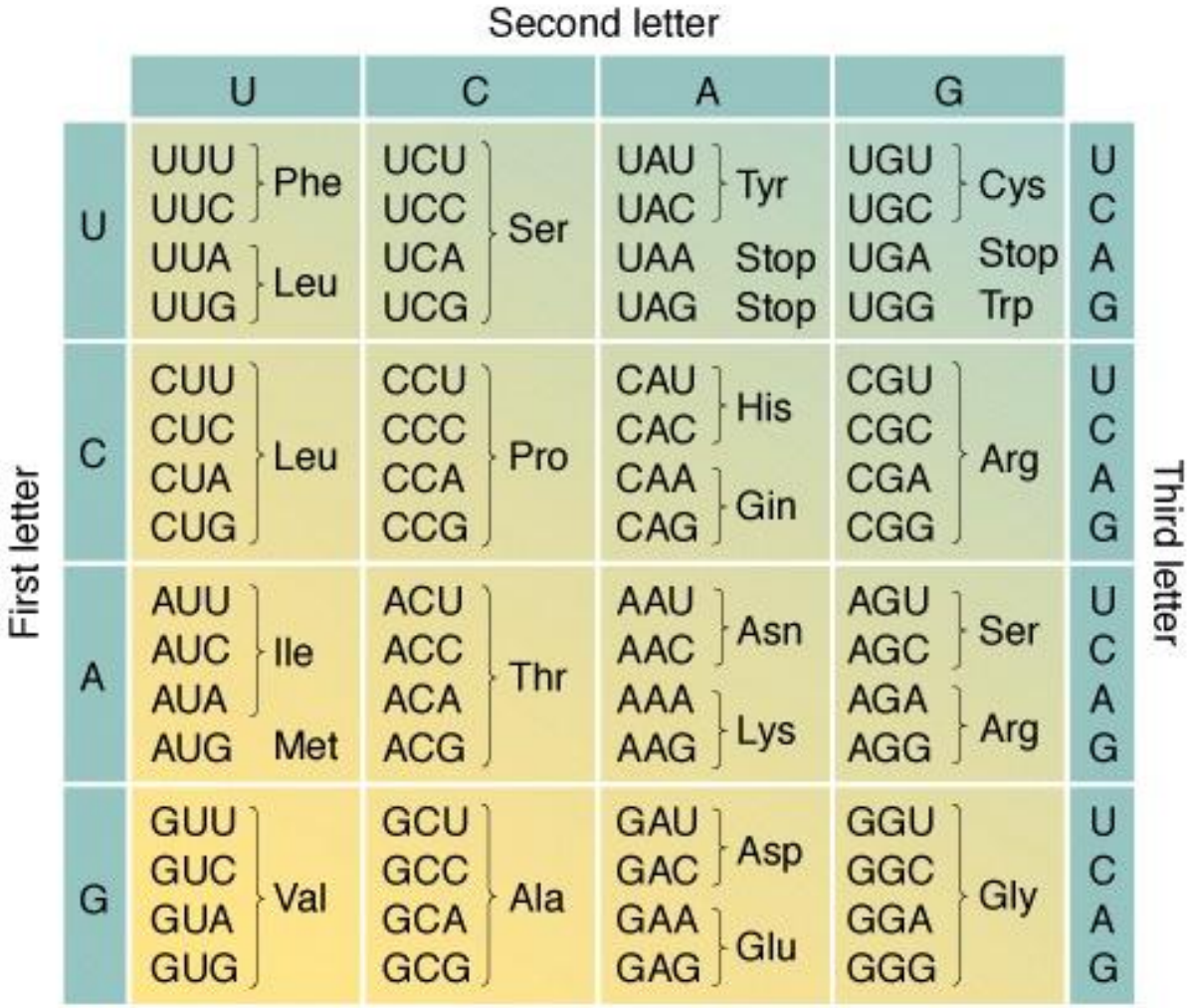
Transcription



Transcription

- *RNA polymerase* is the enzyme that builds an RNA strand from a gene
- RNA that is transcribed from a gene is called *messenger RNA (mRNA)*

The Genetic Code



DNA Genetic Code Dictates Amino Acid Identity and Order

DNA Sequence Is the Genetic Code.

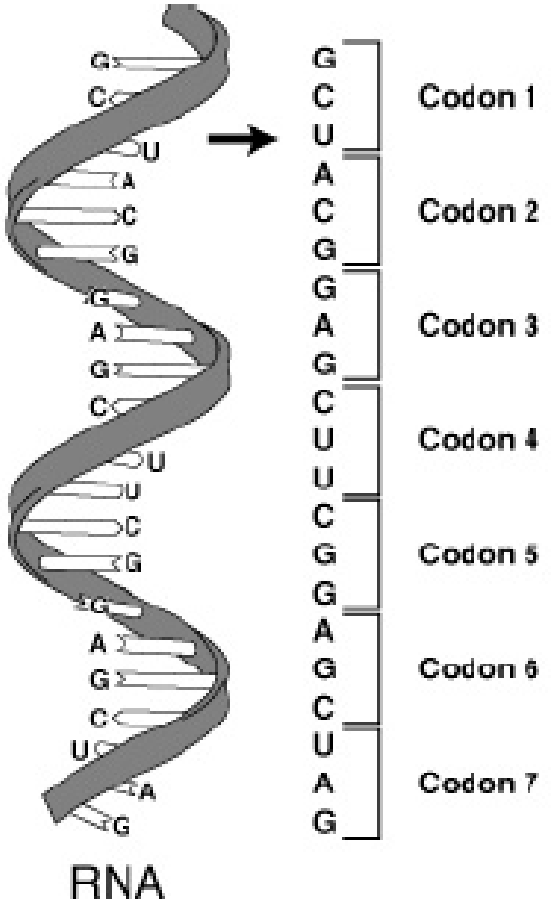
GCA AGA GAT AAT TGT...

. . . Growing Protein Chain

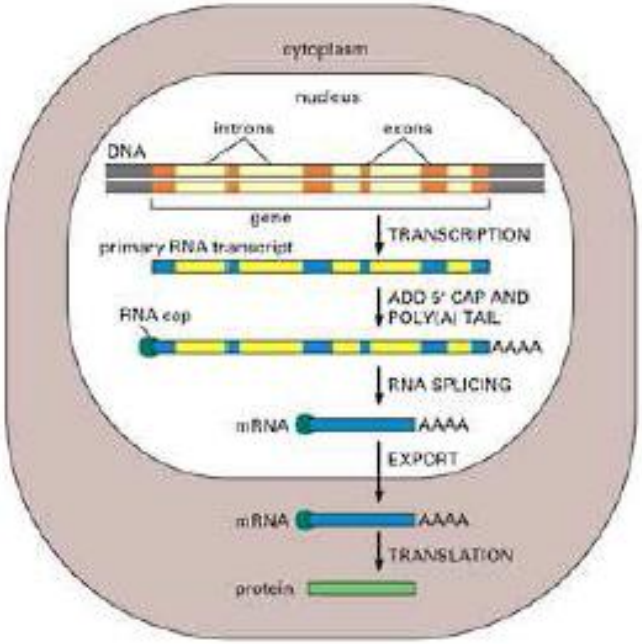
Translation

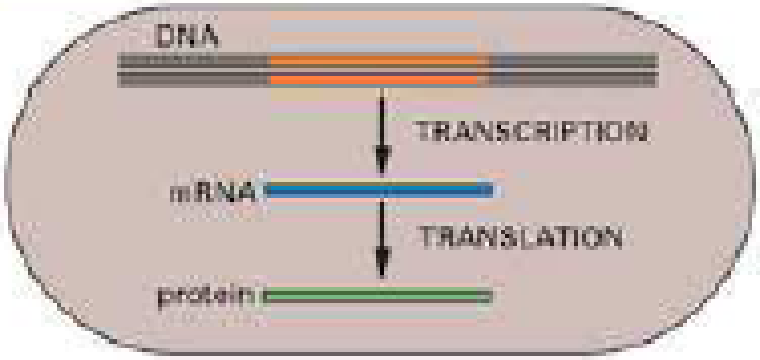
- *ribosomes* are the machines that synthesize proteins from mRNA
- the grouping of codons is called the *reading frame*
- translation begins with the *start codon*
- translation ends with the *stop codon*

Codons and Reading Frames



Protein Synthesis in Eukaryotes vs. Prokaryotes





Genes include both coding regions as well as control regions