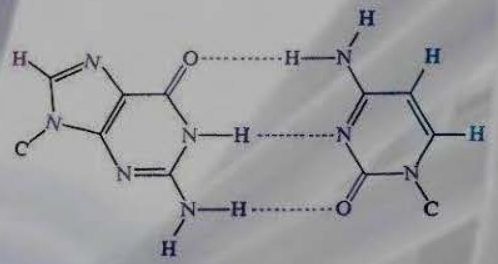
DNA

Essentials topics

Dr. Mushtak Talib Salih



deoxyribonucleic acid

Genome- Complete complement of an organism's DNA.

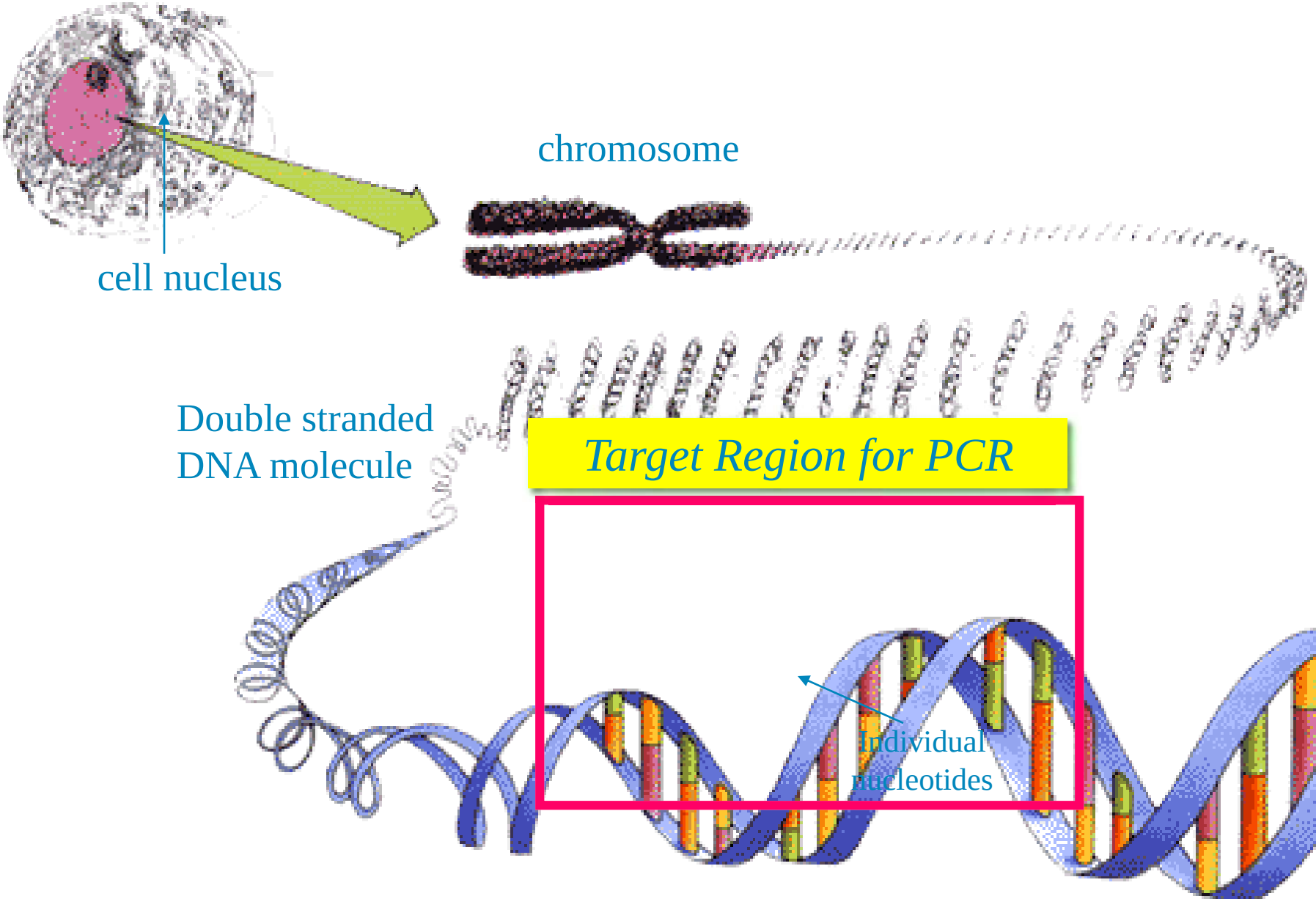
- **Chromosomes - carry genes.**
- **Gene – "unit of heredity" made of DNA.**

The Genome Is Packaged into Chromosomes and Replicated During Cell Division

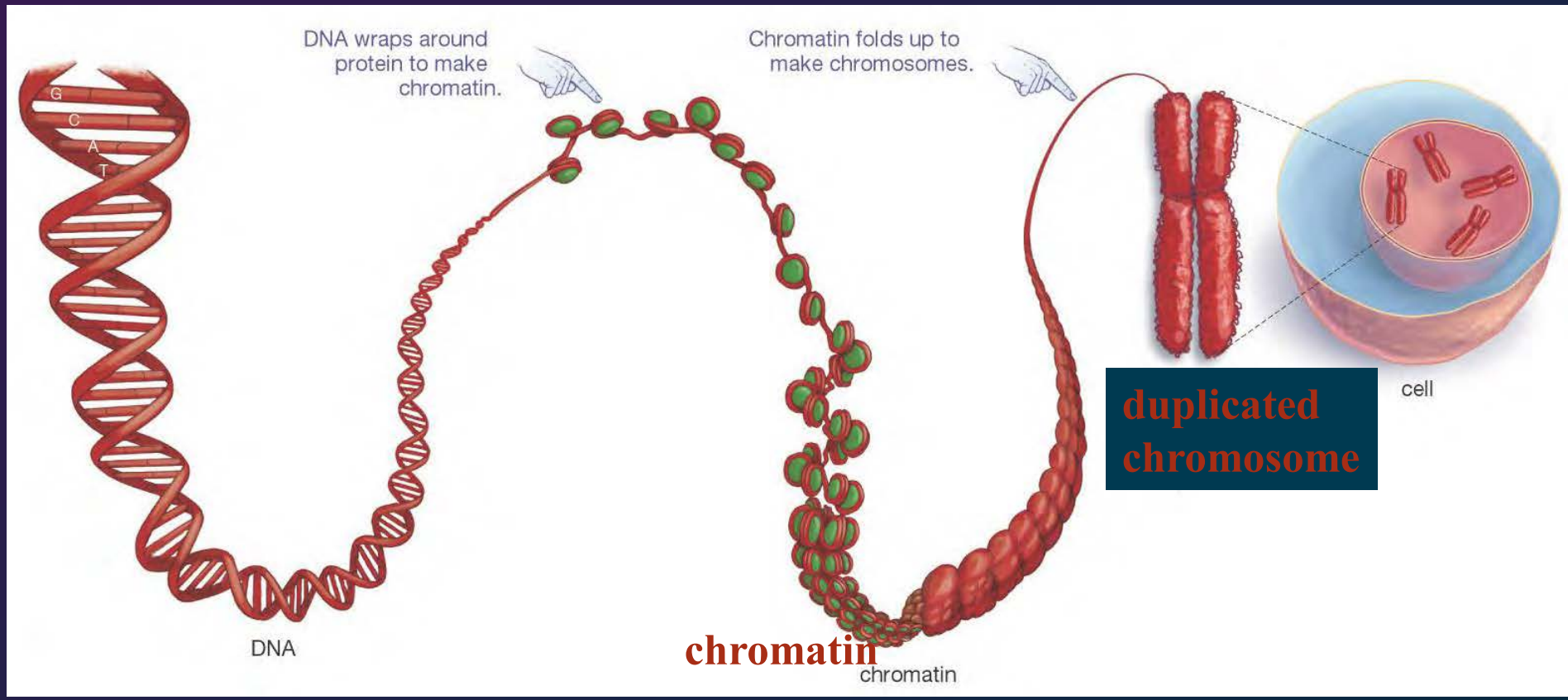
- Most of the DNA in eukaryotic cells is located in the nucleus, extensively folded into the familiar structures we know as chromosomes. Each chromosome contains a single linear DNA molecule associated with certain proteins. In prokaryotic cells, most or all of the genetic information resides in a single circular DNA molecule about a millimeter in length. The genome of an organism comprises its entire complement of DNA. With the exception of eggs and sperm, every normal human cell has 46 chromosomes. Half of these, and thus half of the genes, can be traced back to Mom; the other half, to Dad.

- Every time a cell divides, a large multiprotein replication machine, the replisome, separates the two strands of doublehelical DNA in the chromosomes and uses each strand as a template to assemble nucleotides into a new complementary strand. The outcome is a pair of double helices, each identical to the original. DNA polymerase, which is responsible for linking nucleotides into a DNA strand. The molecular design of DNA and the remarkable properties of the replisome assure rapid, highly accurate copying. Many DNA polymerase molecules work in concert, each one copying part of a chromosome. Because of the accuracy of DNA replication, nearly all the cells in our bodies carry the same genetic instructions, and we can inherit Mom's brown hair and Dad's blue eyes

DNA in the Cell



DNA is Packaged into Chromosomes



DNA in the cell is virtually always associated with proteins. Pattern of DNA coiling. DNA is wound around histones to form nucleososmes. These organized into solenoids, which in turn compose chromatin loops and eventually chromosome.

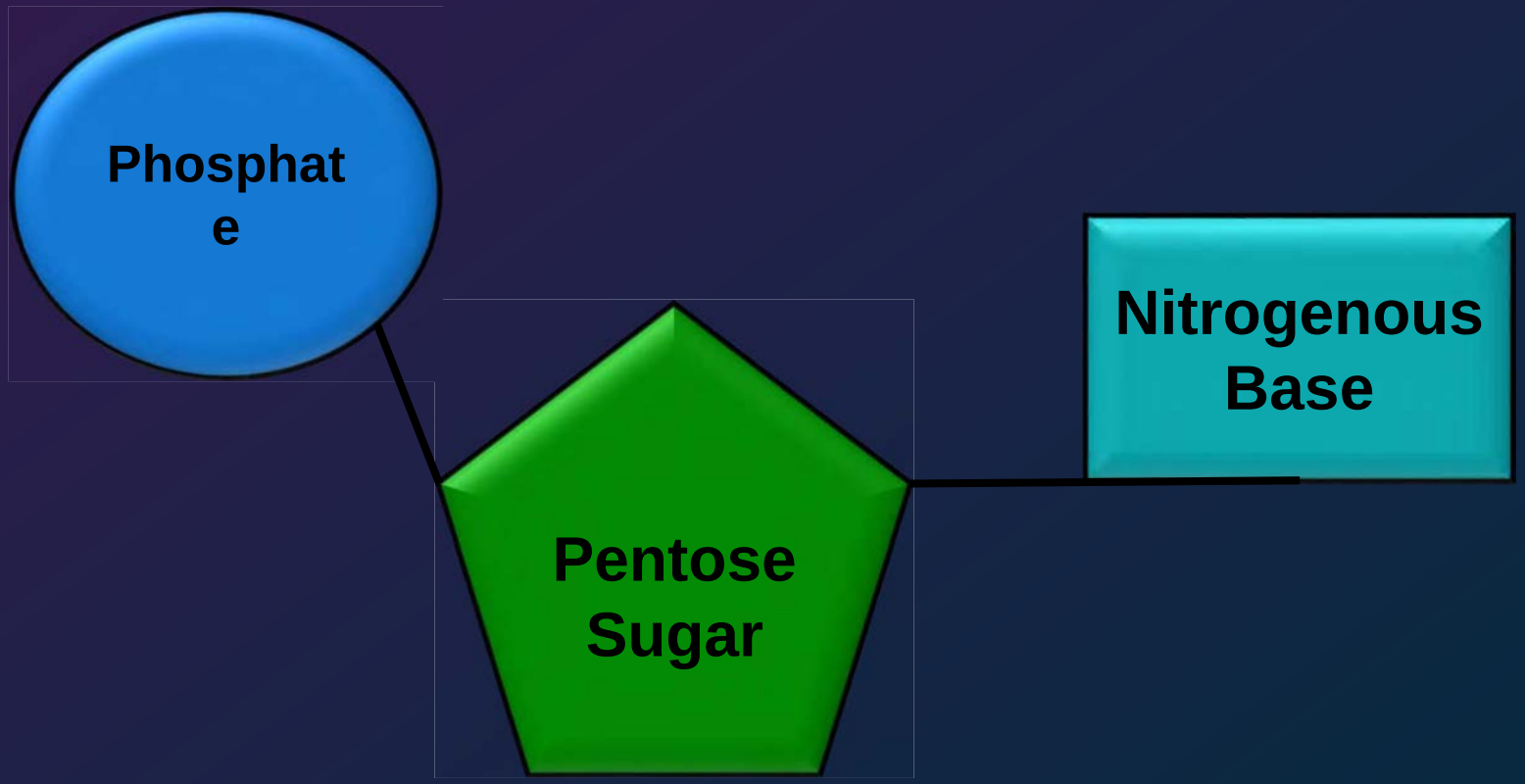
DNA Structure

- DNA consists of two molecules that are arranged into a ladder-like structure called a Double Helix.

- A molecule of DNA is made up of millions of tiny subunits called Nucleotides.

- Each nucleotide consists of:
  1. Phosphate group
  2. Pentose sugar
  3. Nitrogenous base

Nucleotides



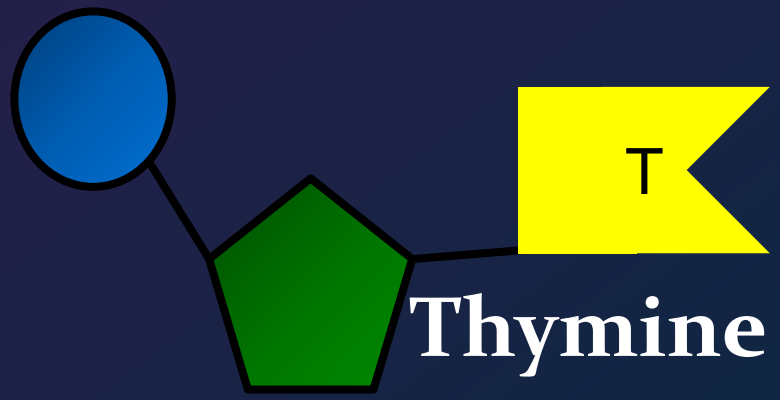
Nucleotides

- The phosphate and sugar form the backbone of the DNA molecule, whereas the bases form the “rungs”.

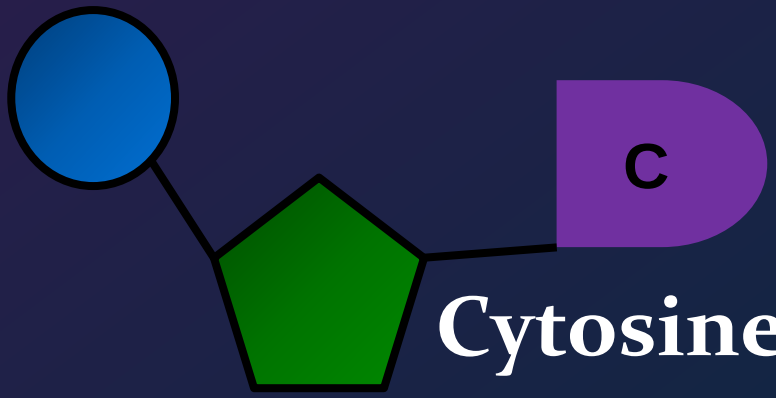
- There are four types of nitrogenous bases.

Nucleotides

Adenine



Thymine



Cytosine

Guanine

Nucleotides

- Each base will only bond with one other specific base.

- Adenine (A)
- Thymine (T)

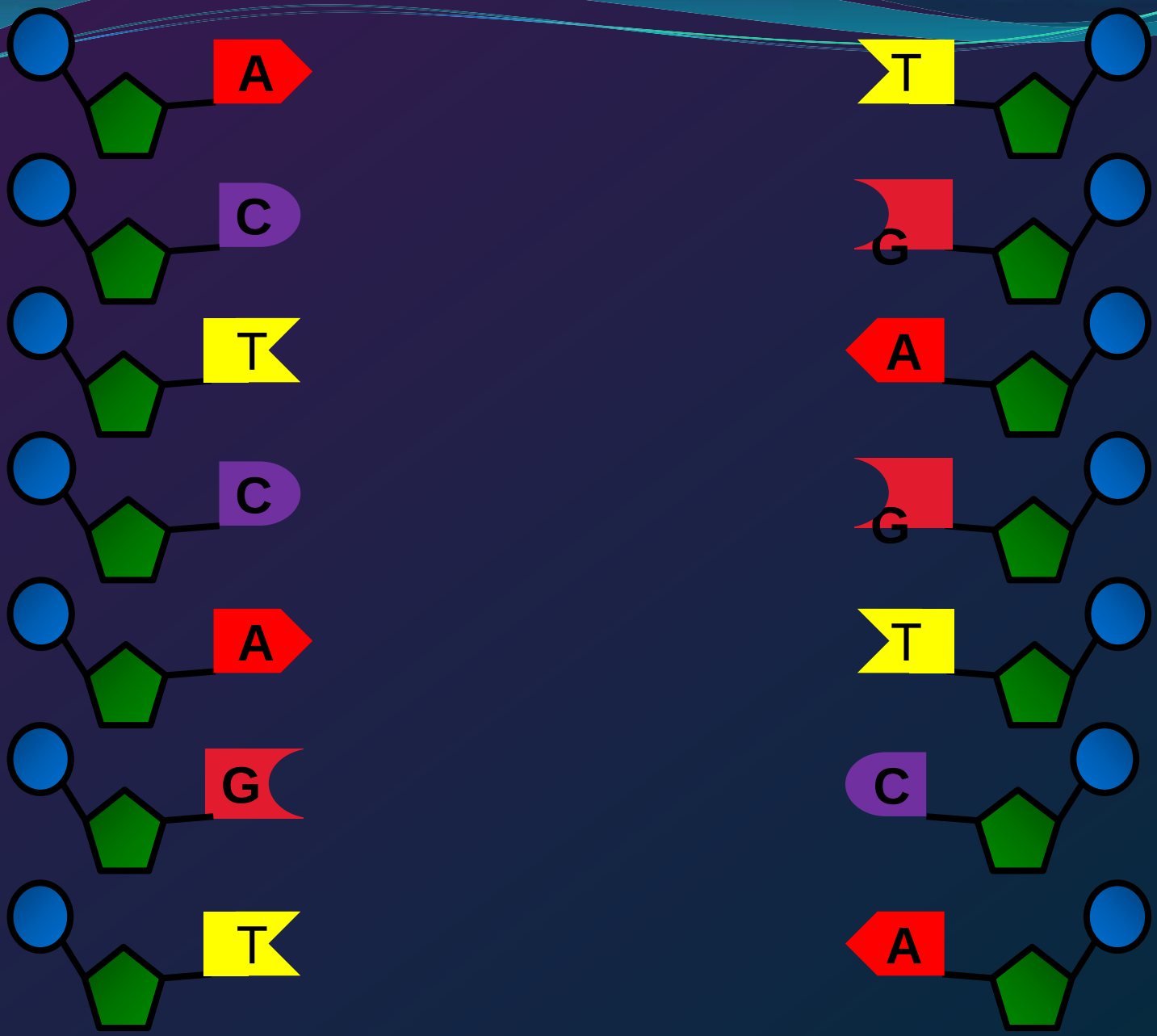
} Form a base pair.

- Cytosine (C)
- Guanine (G)

} Form a base pair.

DNA Structure

- Because of this complementary base pairing, the order of the bases in one strand determines the order of the bases in the other strand.


A
C
T
C
A
G
T
T
G
A
G
T
C
A

DNA Structure

- To crack the genetic code found in DNA we need to look at the sequence of bases.

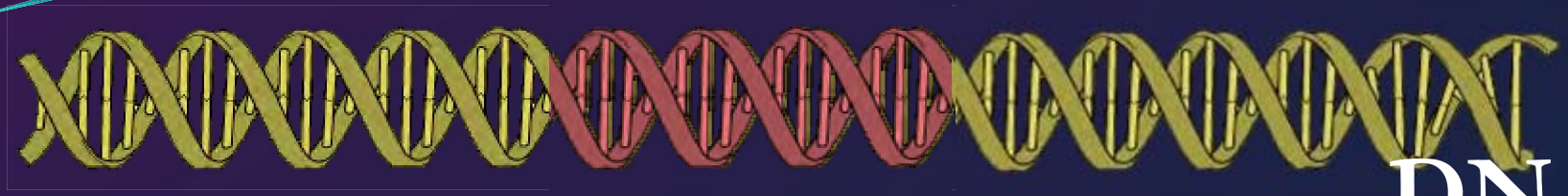
- The bases are arranged in triplets called codons.

A G G - C T C - A A G - T C C - T A G

T C C - G A G - T T C - A G G - A T C

DNA Structure

- A gene is a section of DNA that codes for a protein.
- Each unique gene has a unique sequence of bases.
- This unique sequence of bases will code for the production of a unique protein.
- It is these proteins and combination of proteins that give us a unique phenotype.



DNA

Gene

Protein

Trait

Your Task

- Draw a flow chart to show how to get from:

DNA stands for **deoxyribose nucleic acid**

This chemical substance is present in the nucleus of all cells in all living organisms

DNA controls all the chemical changes which take place in cells

The kind of cell which is formed, (muscle, blood, nerve etc) is controlled by DNA

The kind of organism which is produced (buttercup, giraffe, herring, human etc) is controlled by DNA

DNA is a very large molecule made up of a long chain of sub-units

The sub-units are called **nucleotides**

Each nucleotide is made up of

a sugar called **deoxyribose**

a phosphate group **-PO_4** and

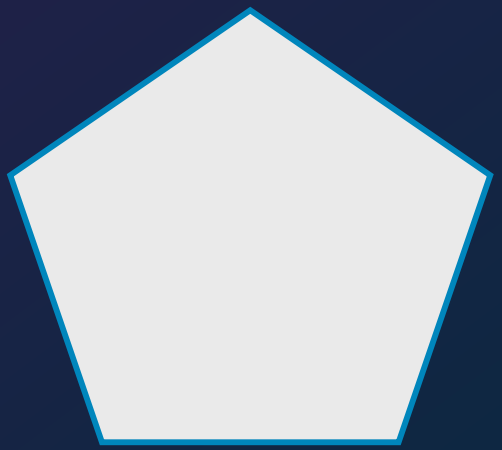
an **organic base**

deoxyribose

Ribose is a sugar, like glucose, but with only five carbon atoms in its molecule

Deoxyribose is almost the same but lacks one oxygen atom

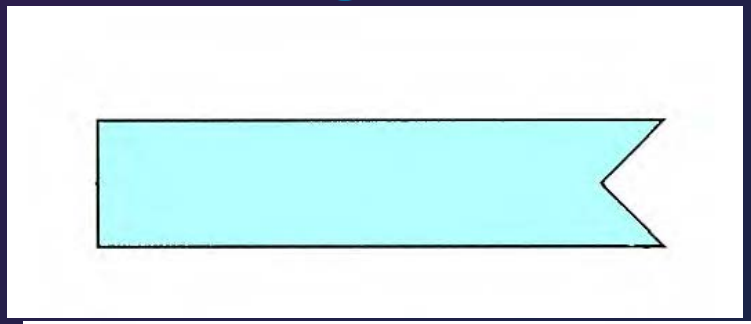
Both molecules may be represented by the symbol



The bases

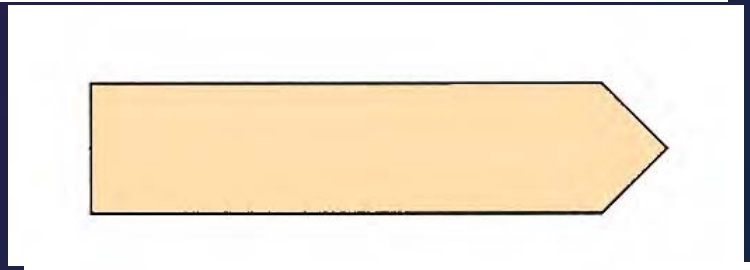
The most common organic bases are

Adenine



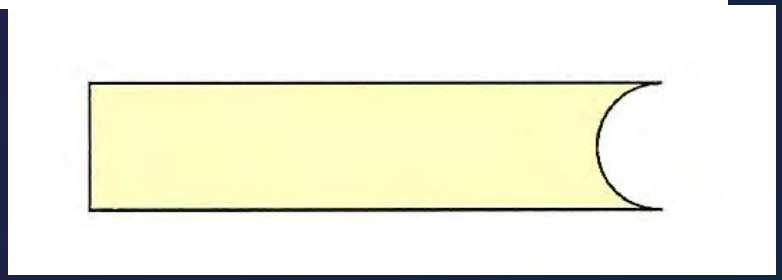
(A)

Thymine



(T)

Cytosine

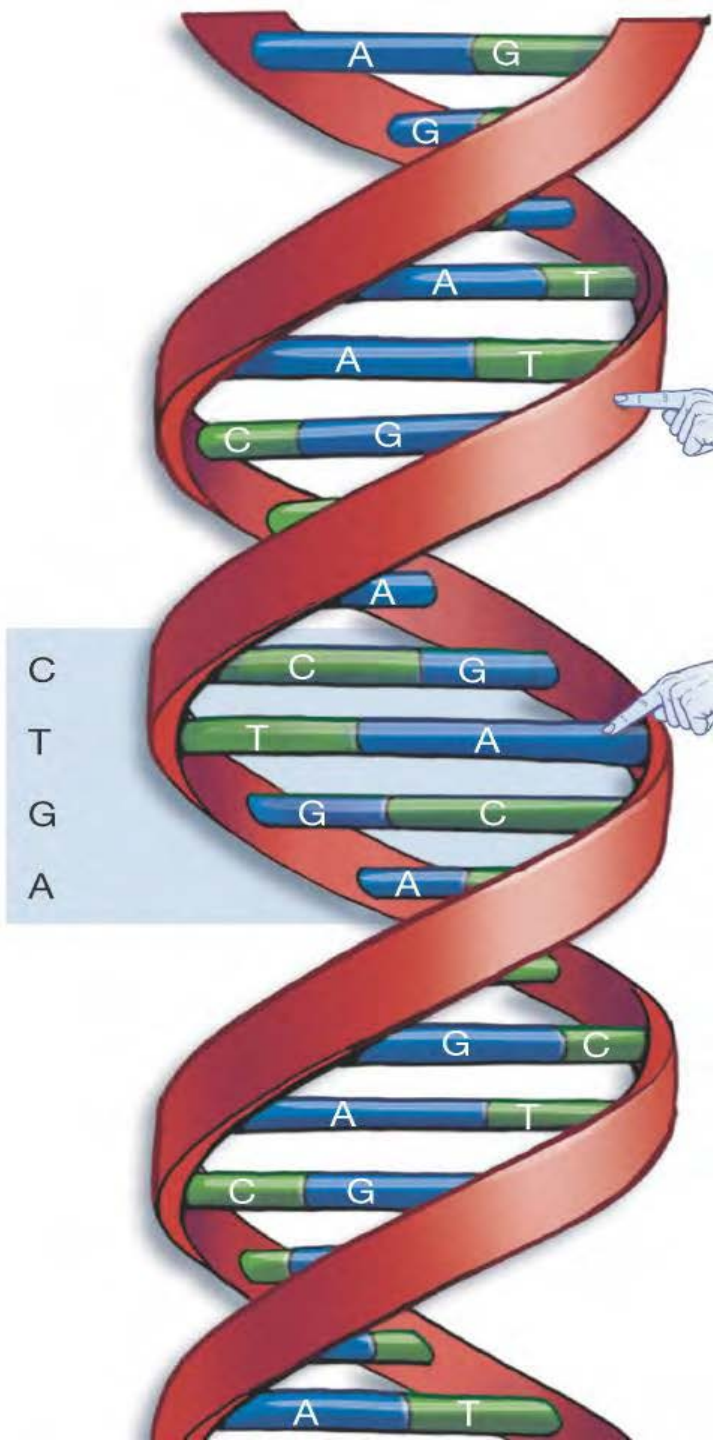


(C)

Guanine

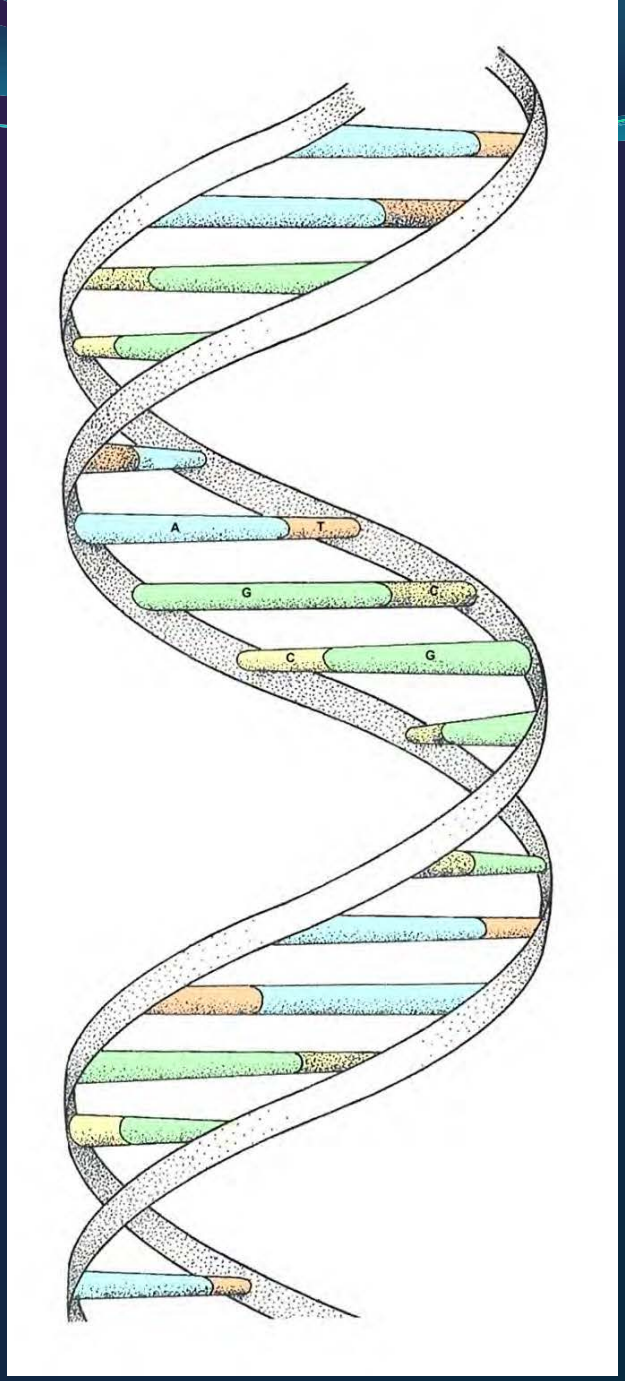
(G)

DNA and Its Faithful Replication – The Knit of Identity



Because DNA stores genetic information and is faithfully replicated, information is passed largely unaltered from cell-to-cell, generation-to- generation.

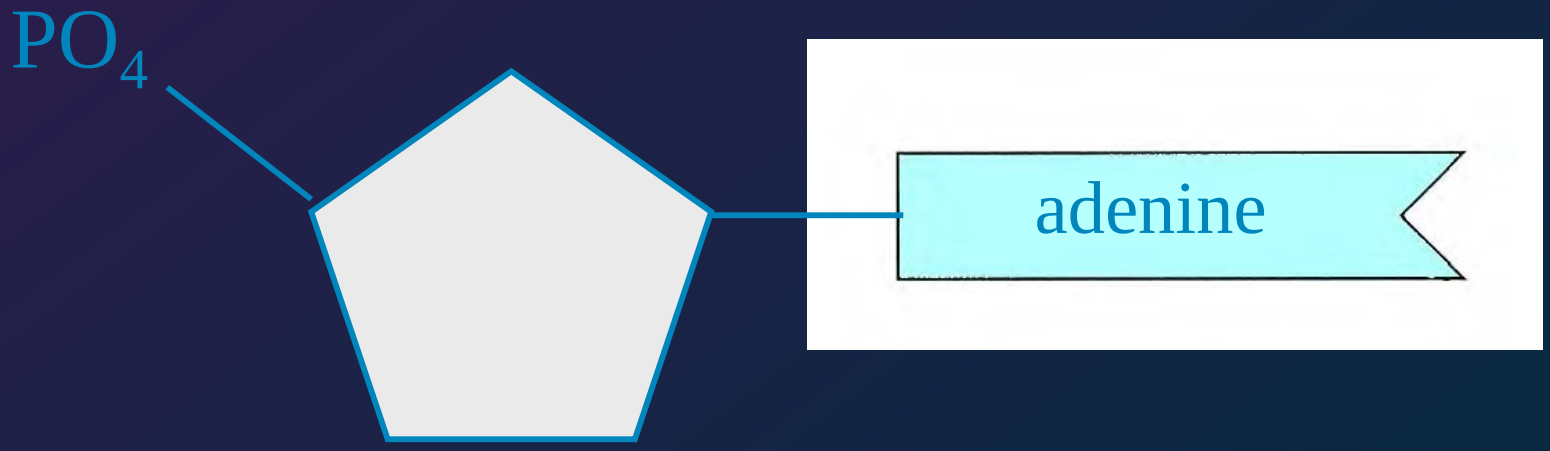
DNA



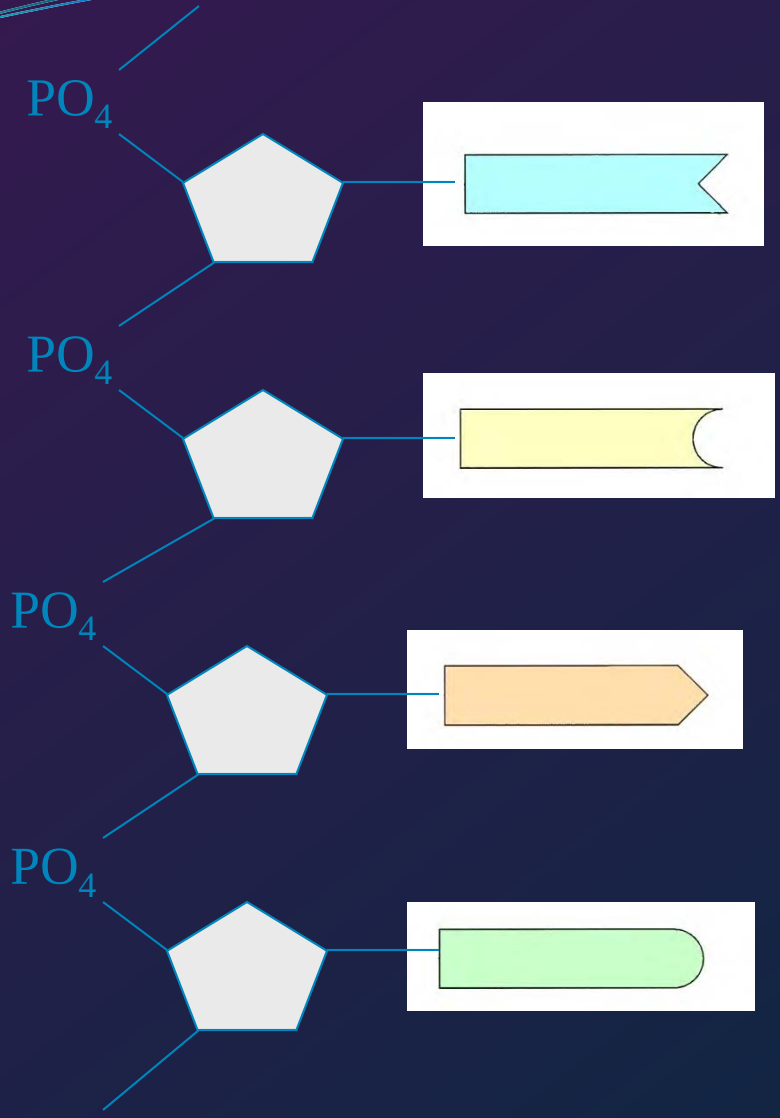
Nucleotides

The deoxyribose, the phosphate and one of the bases

Combine to form a nucleotide



Joined nucleotides



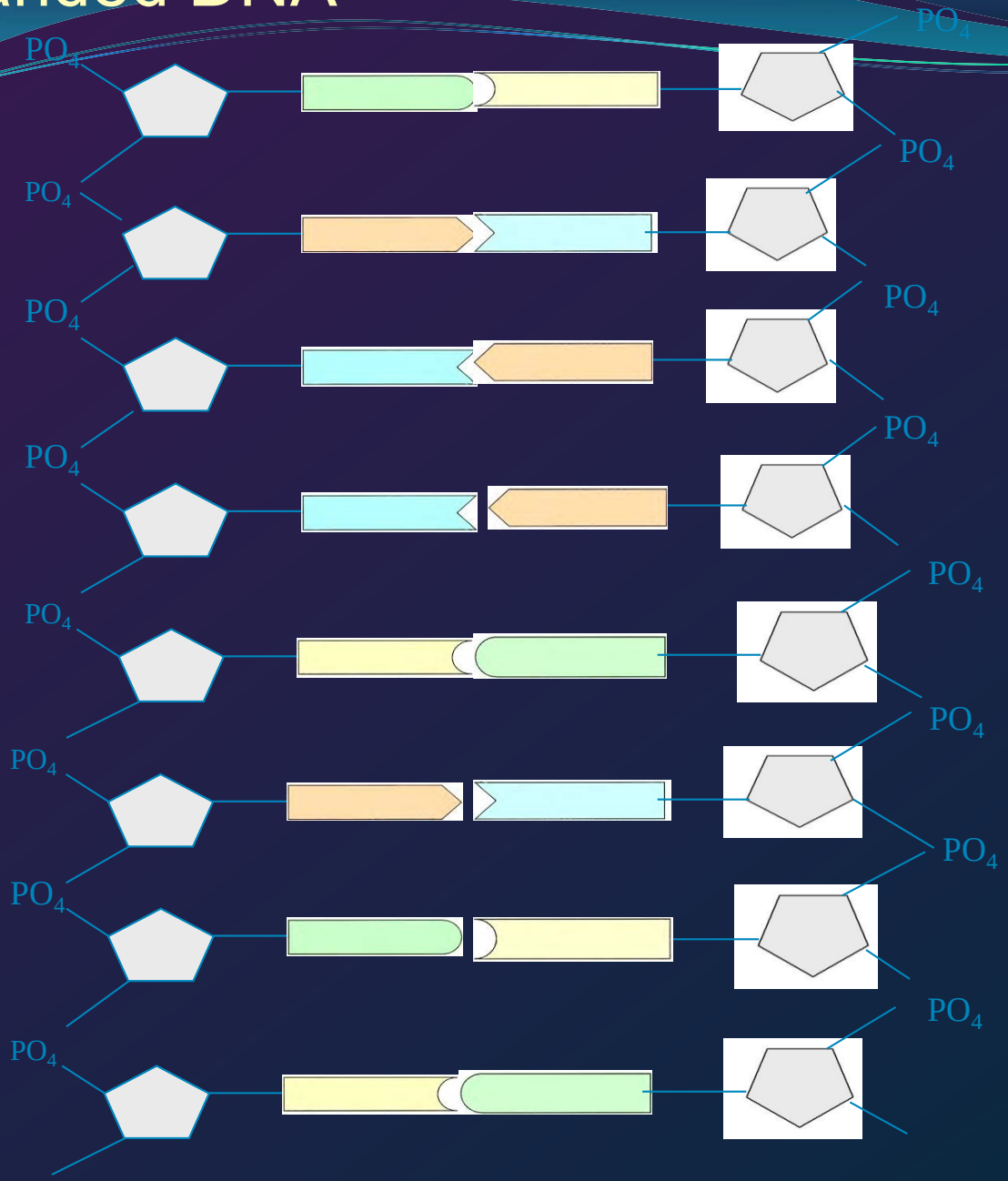
A molecule of DNA is formed by millions of nucleotides joined together in a long chain

sugar-phosphate backbone **+ bases**

In fact, the DNA usually consists of a double strand of nucleotides

The sugar-phosphate chains are on the outside and the strands are held together by chemical bonds between the bases

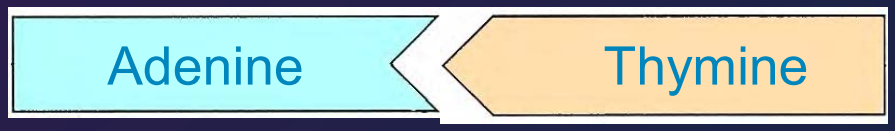
2-stranded DNA



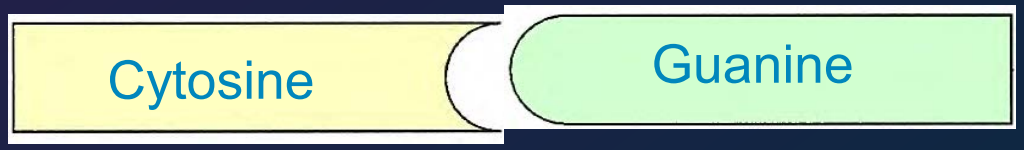
Bonding 1

The bases always pair up in the same way

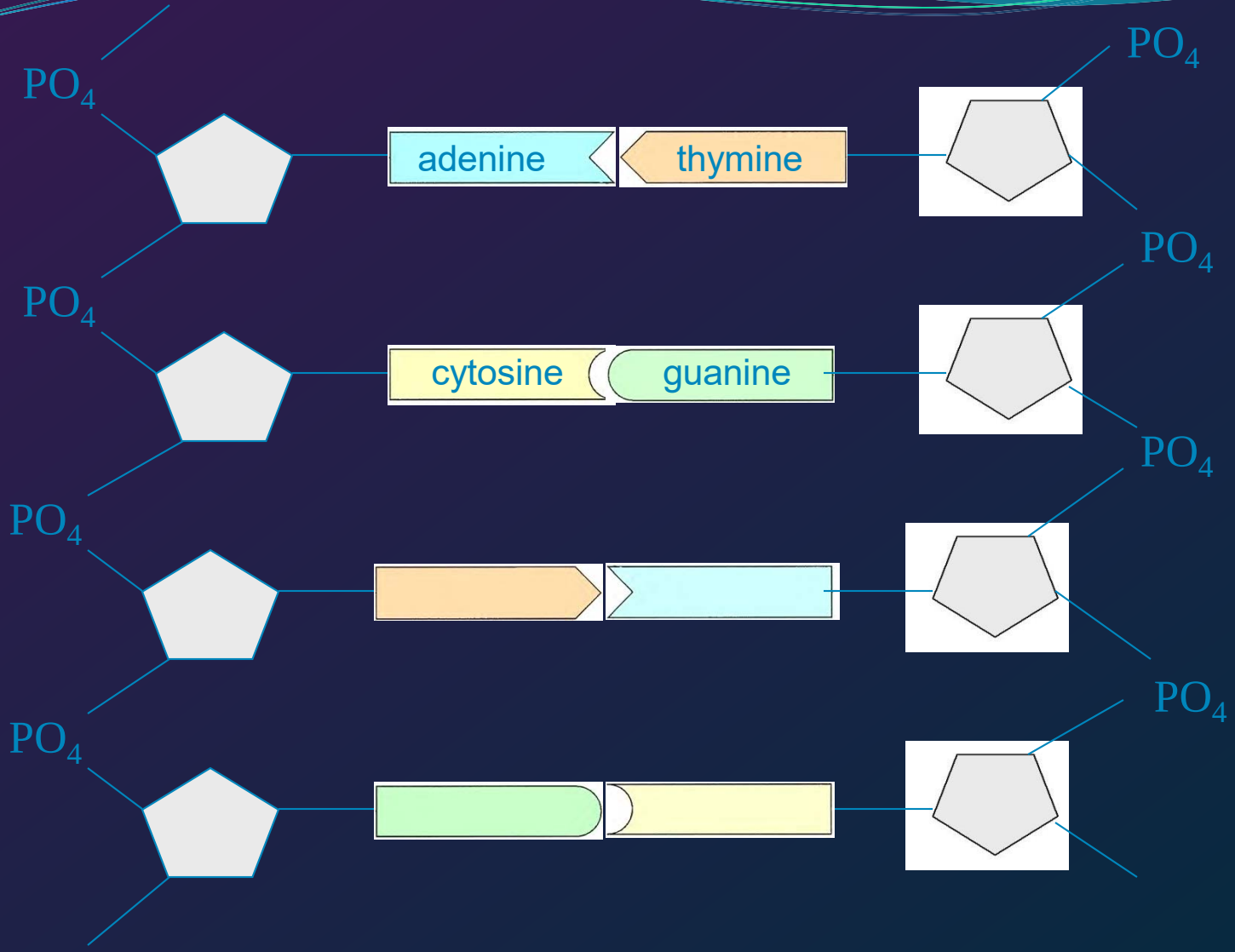
Adenine forms a bond with Thymine



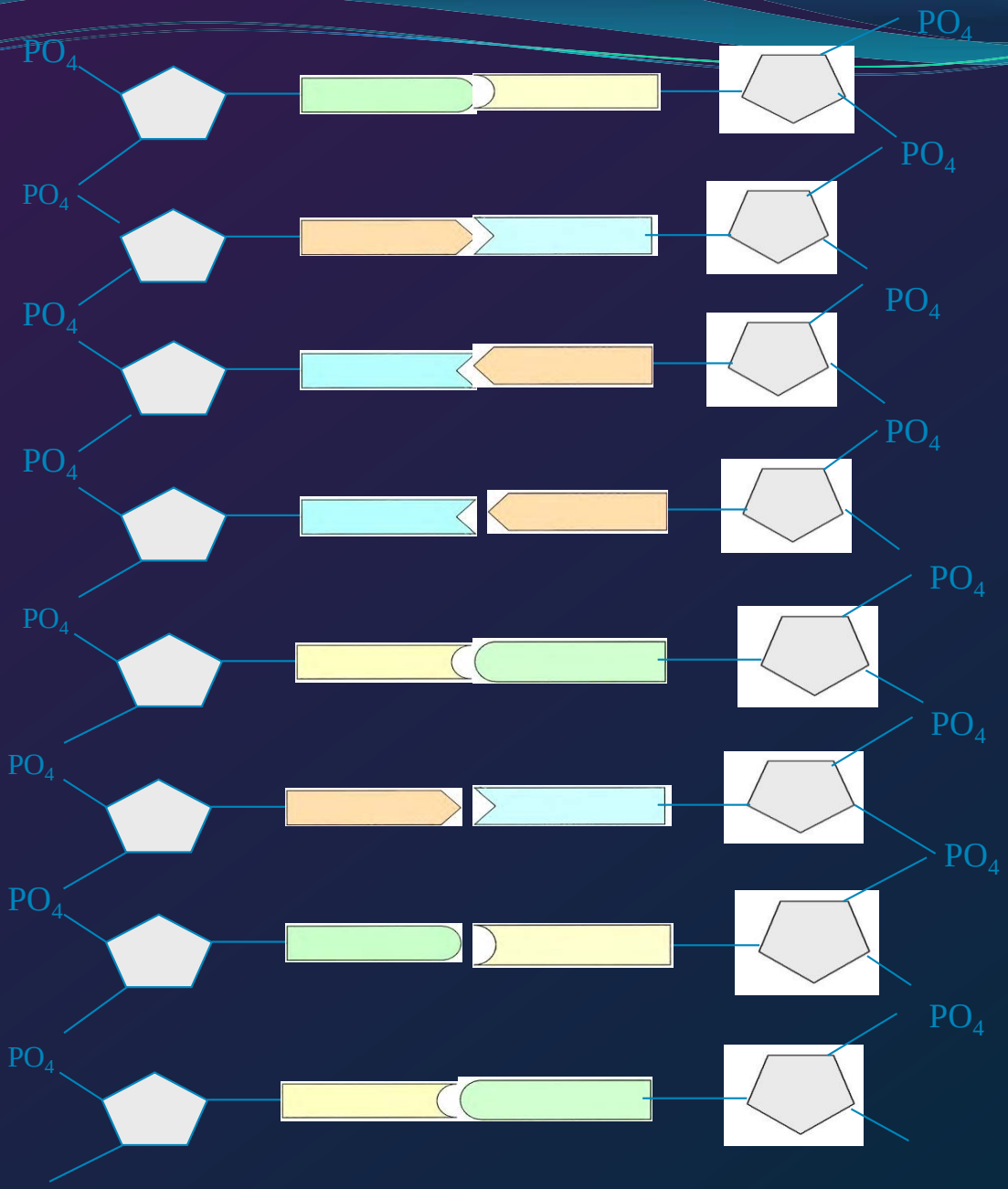
and Cytosine bonds with Guanine



Bonding 2


PO4
PO4
adenine
thymine
PO4
PO4
cytosine
guanine
PO4
PO4
PO4
PO4

Pairing up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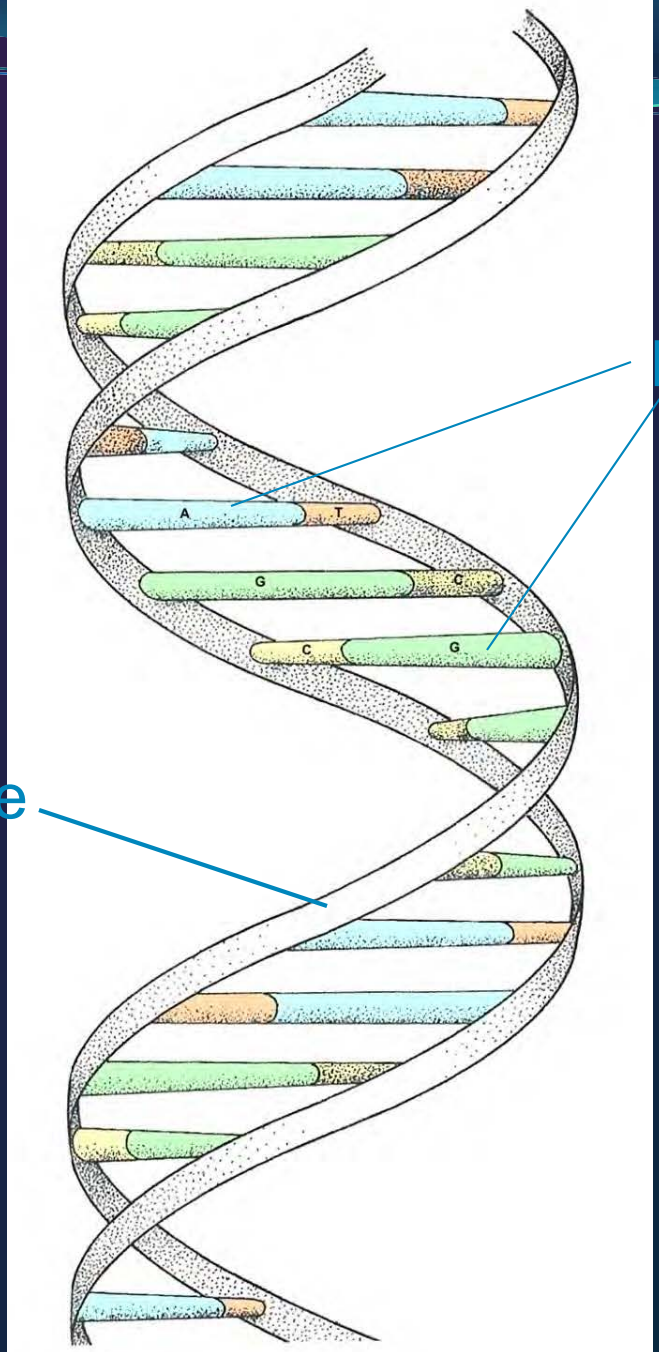
The paired strands are coiled into a spiral called

A DOUBLE HELIX

THE DOUBLE HELIX

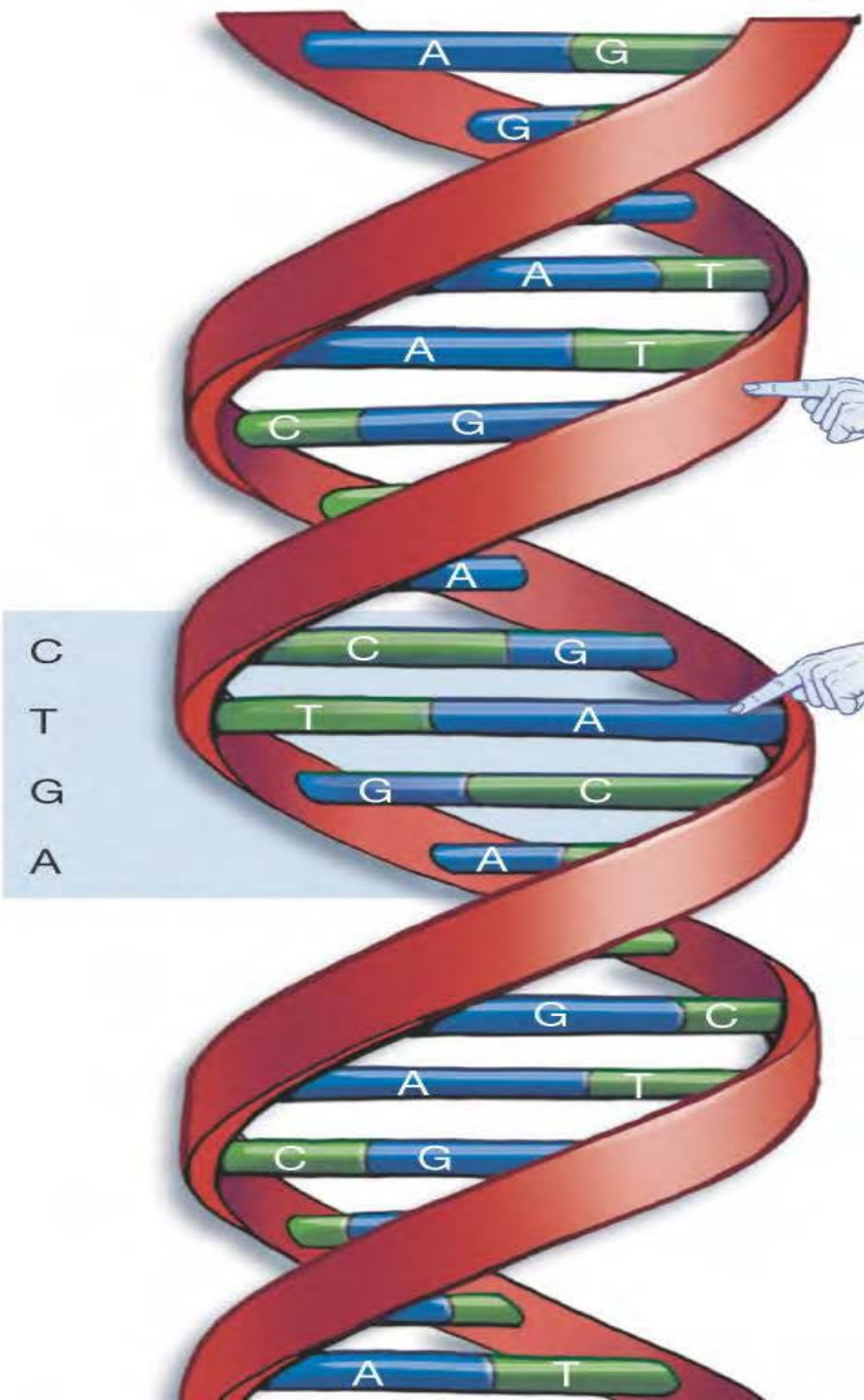


bases

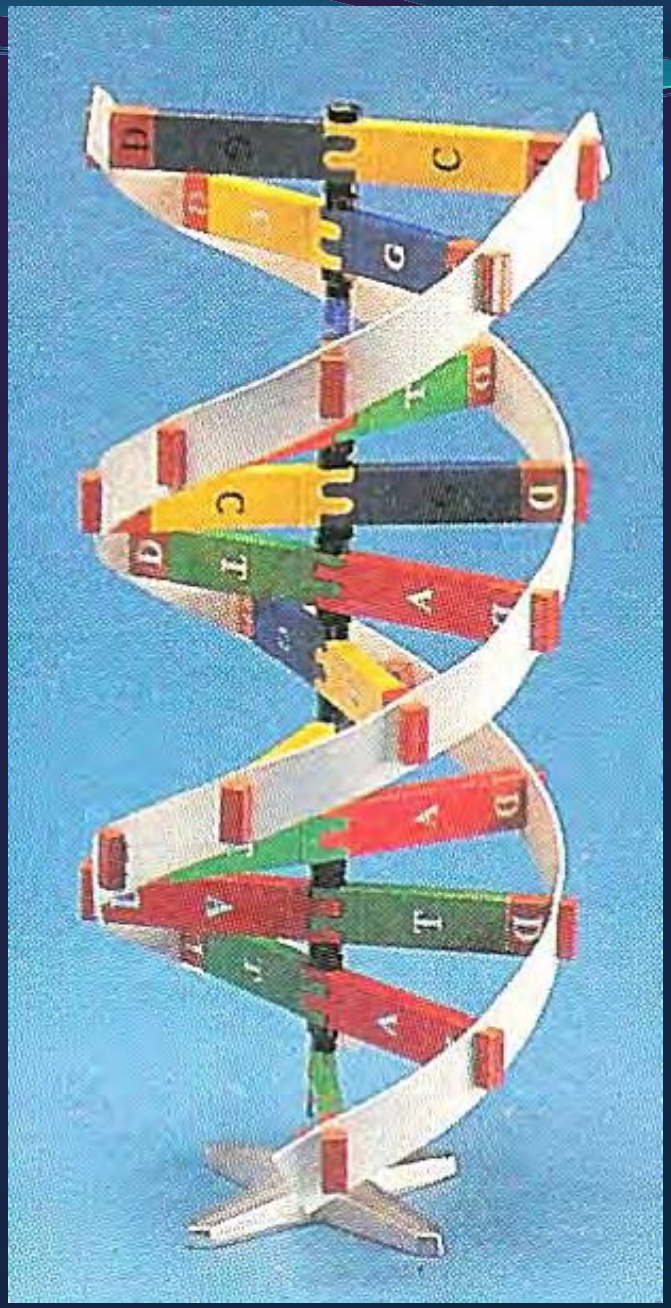
sugar-phosphate chain

DNA and Its Faithful Replication – The Knit of Identity

Because DNA stores genetic information and is faithfully replicated, information is passed largely unaltered from cell-to-cell, generation-to- generation.



A DIY model
of
part of a DNA
molecule



DNA REPLICATION

Before a cell divides, the DNA strands unwind and separate

Each strand makes a new partner by adding the appropriate nucleotides

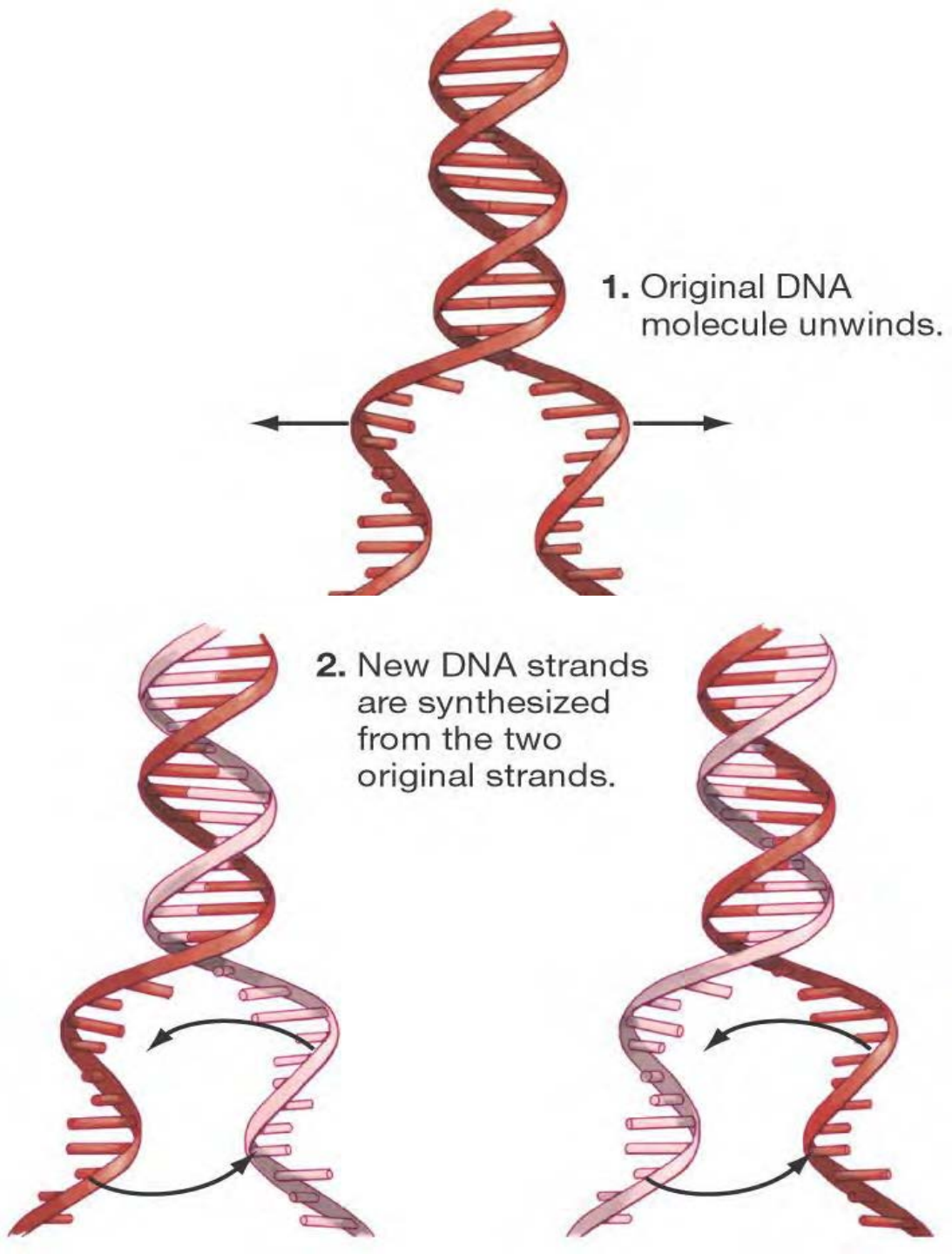
The result is that there are now two double-stranded DNA molecules in the nucleus

So that when the cell divides, each nucleus contains identical DNA

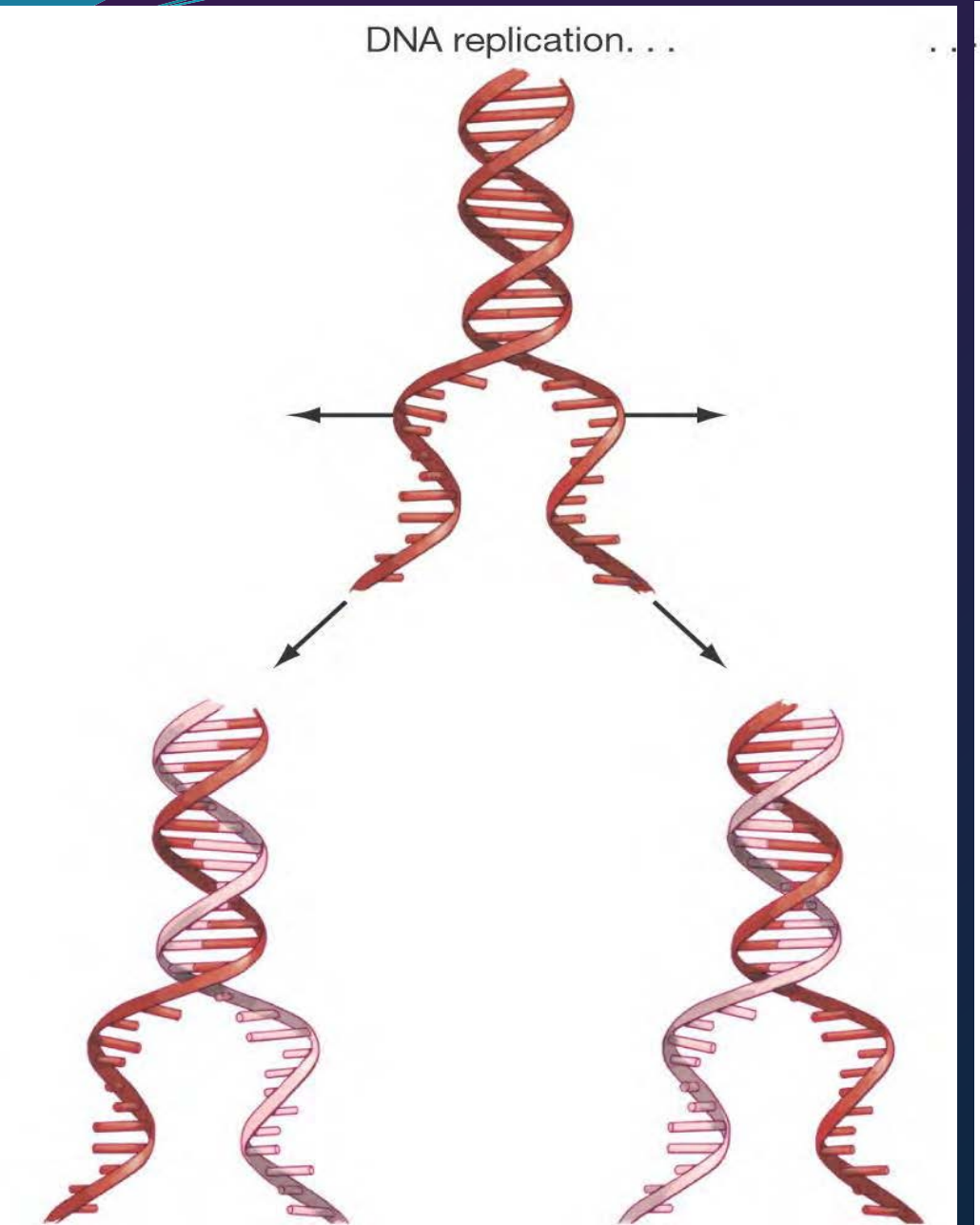
This process is called **replication**

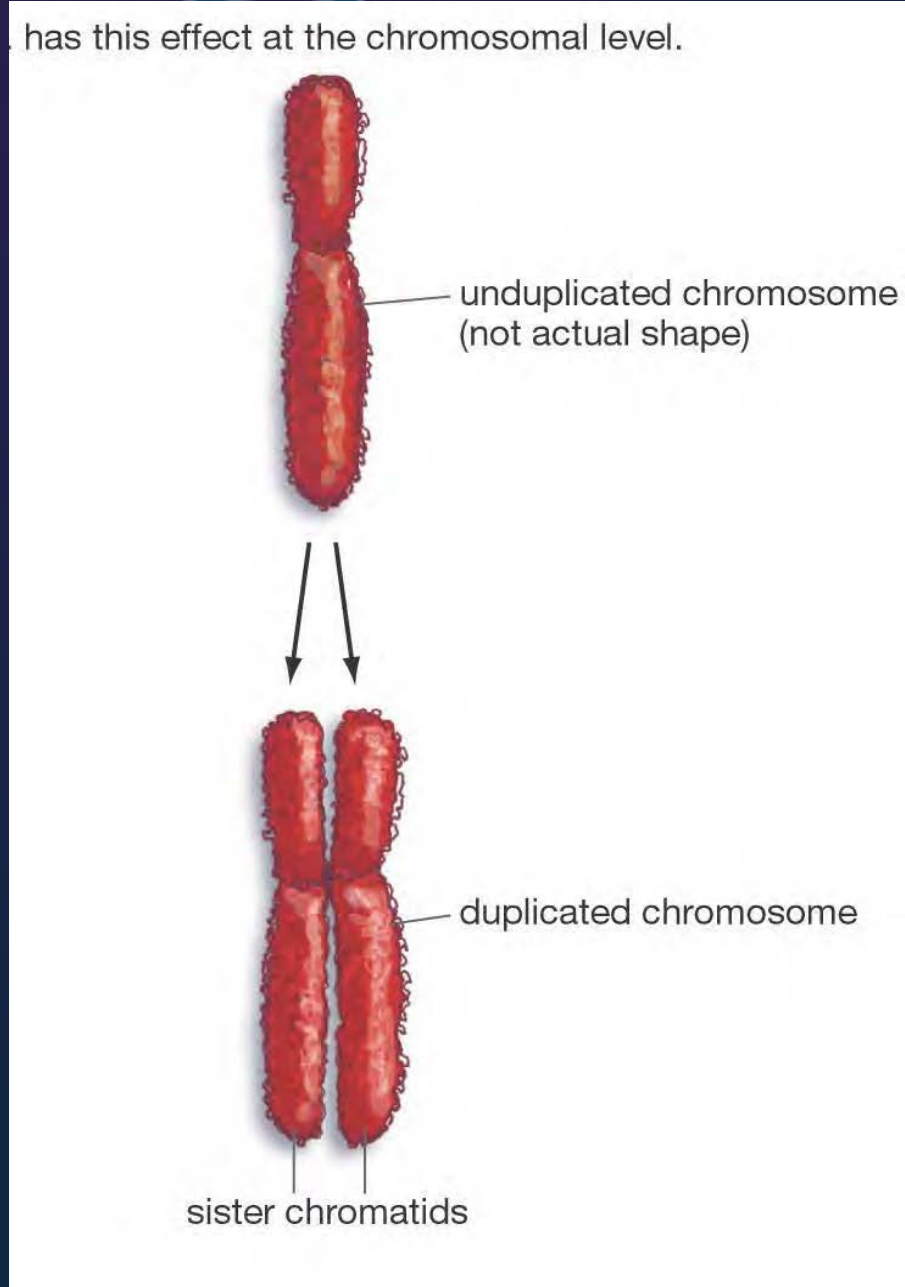
DNA Replication – Simple in Principle, Complicated in Practice

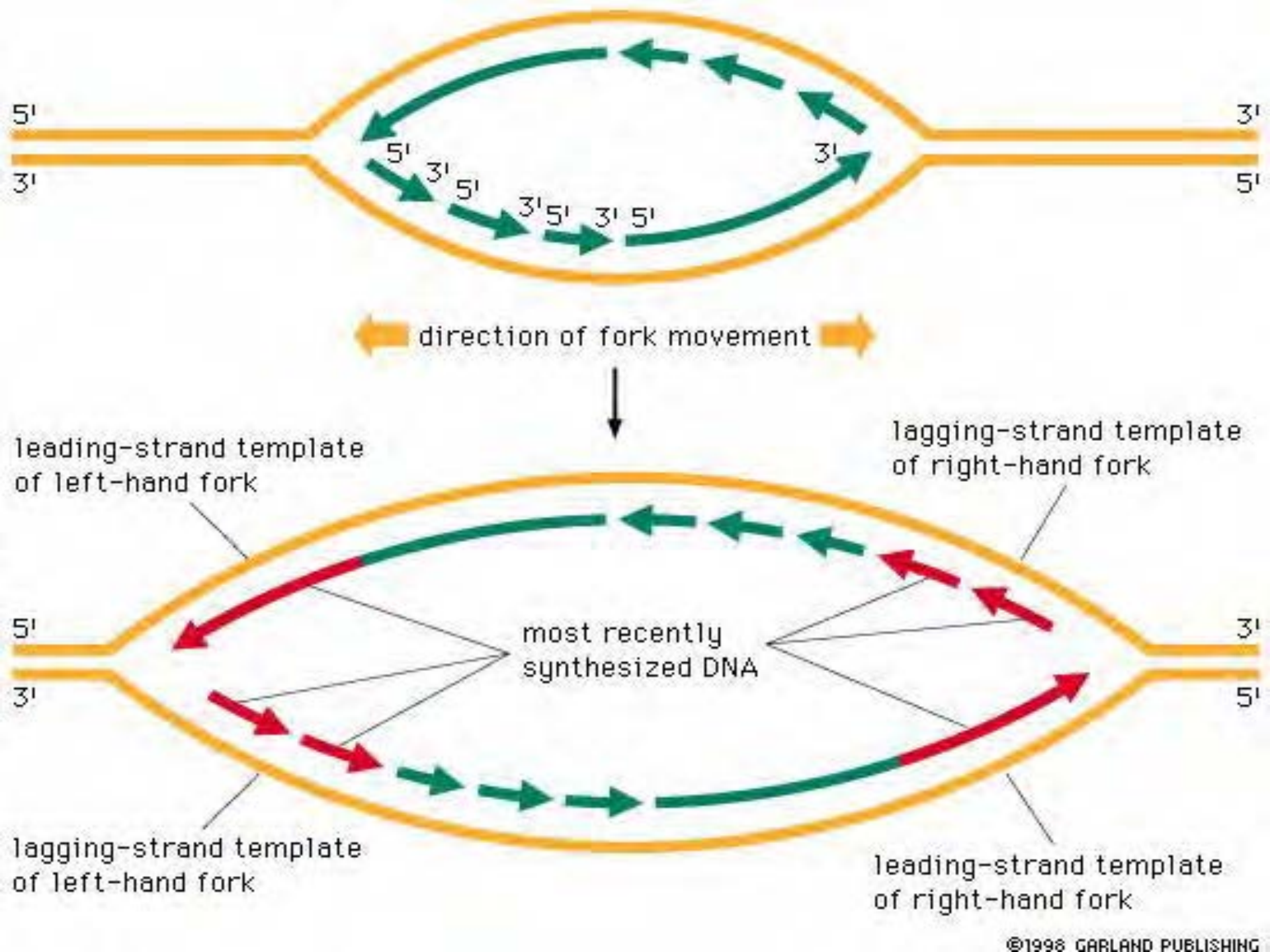
(Semi-conservative DNA replication)



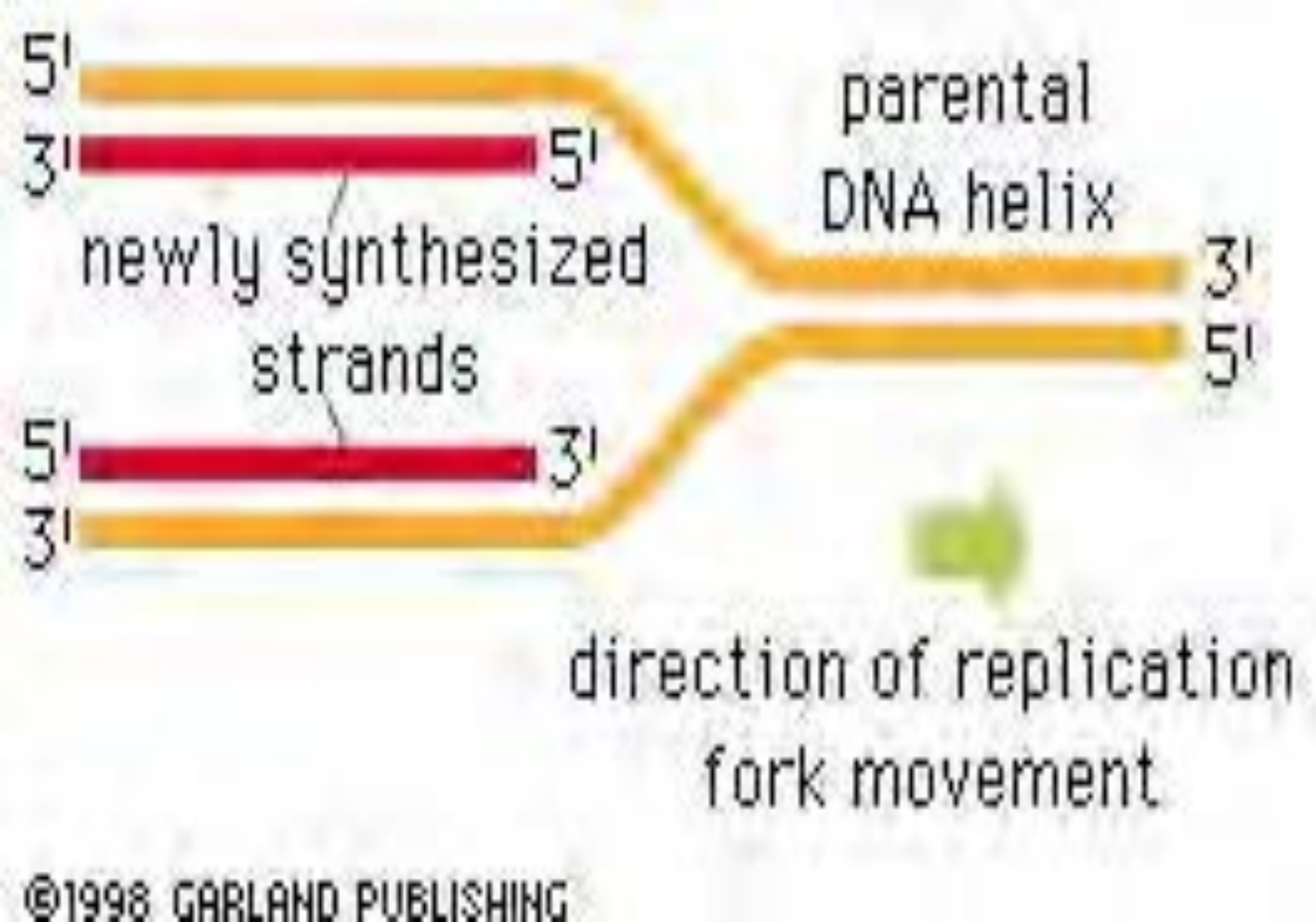
The Link Between DNA Replication and Chromosome Duplication





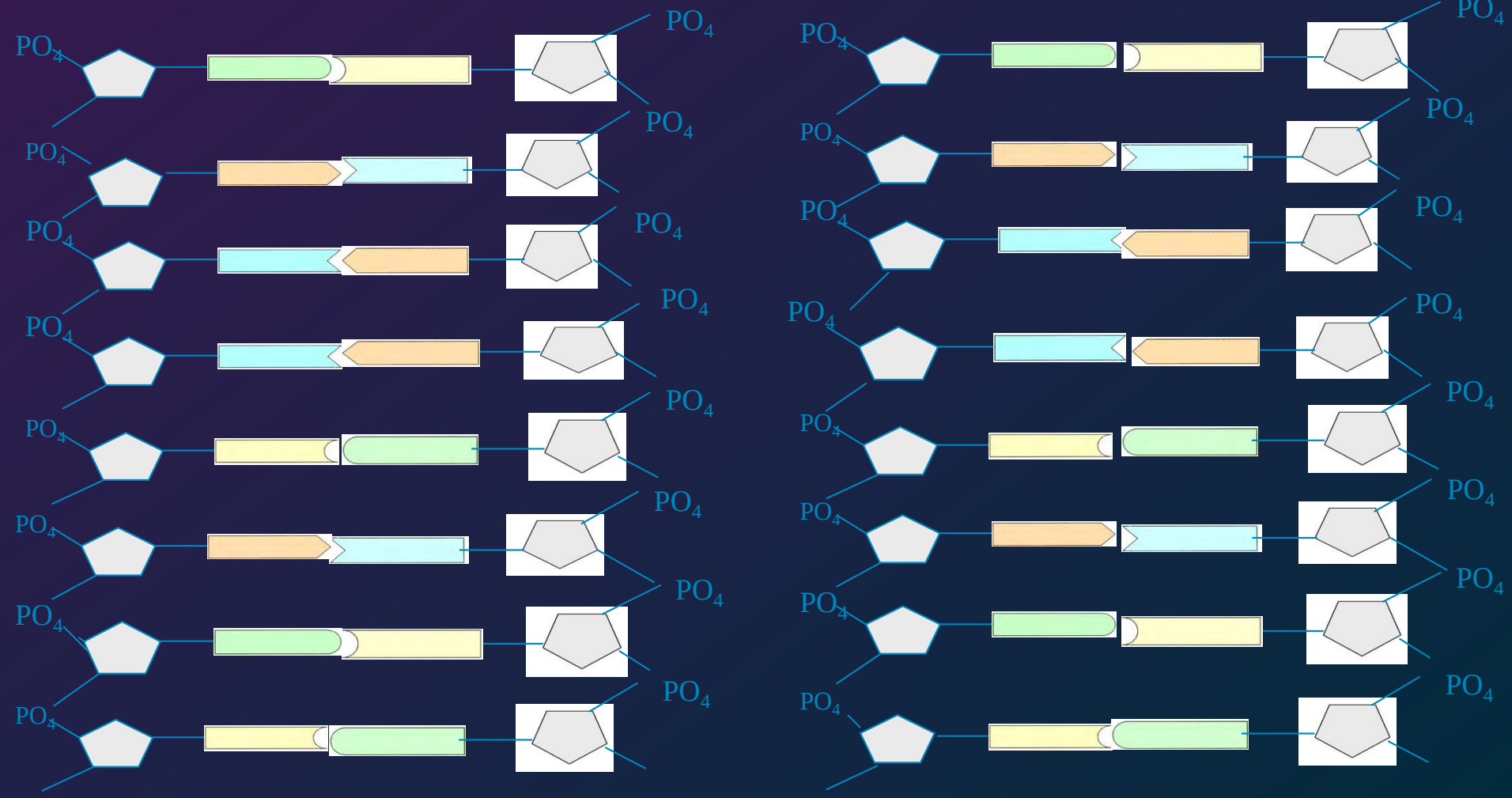

5'
3'
5'
3'
5'
3'
5'
3'
5'
3'
3'
5'
direction of fork movement
leading-strand template
of left-hand fork
lagging-strand template
of right-hand fork
5'
3'
most recently
synthesized DNA
3'
5'
lagging-strand template
of left-hand fork
leading-strand template
of right-hand fork
©1998 GARLAND PUBLISHING

***It is not trivial to replicate both DNA strands in the 5' to 3' direction!



The strands separate

Each strand builds up its partner by adding the appropriate nucleotides



Genetic code 1

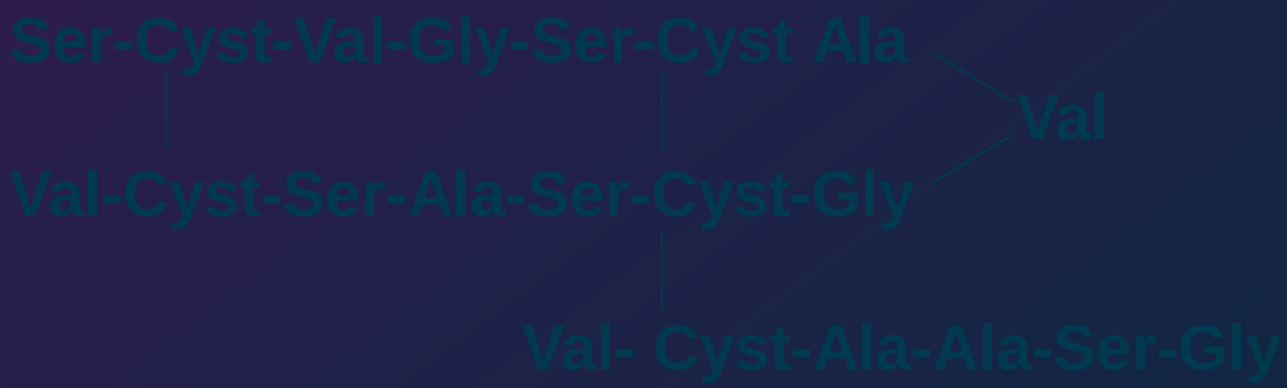
The sequence of bases in DNA forms the **Genetic Code**

A group of three bases (**a triplet**) controls the production of a particular amino acid in the cytoplasm of the cell

The different amino acids and the order in which they are joined up determines the sort of protein being produced

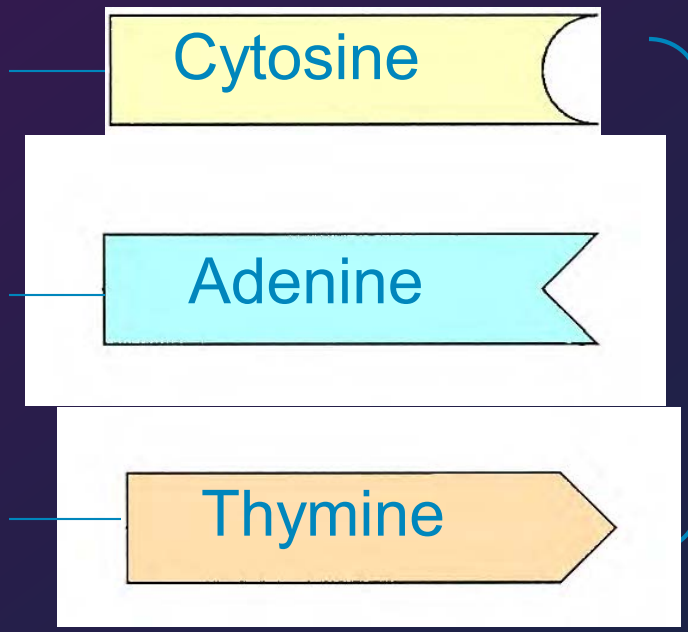
Genetic code 2

This is a small, imaginary protein molecule showing how a sequence of 5 different amino acids could determine the shape and identity of the molecule



Each amino acid (Serine, Cysteine, Valine, Glycine and Alanine) is coded for by a particular triplet of bases

For example



Codes for Valine

Cytosine (C)

Guanine (G)

Adenine (A)

Codes for Alanine

Triplet code

This is known as the **triplet code**

Each triplet codes for a specific amino acid

The amino acids are joined together in the correct sequence to make part of a protein

—Ala—Val— Gly— Gly—Arg— Pro— Leu—Gly—

DNA and enzymes

The proteins build the cell structures

They also make enzymes

The DNA controls which enzymes are made and the enzymes determine what reactions take place

The structures and reactions in the cell determine what sort of a cell it is and what its function is

So DNA exerts its control through the enzymes

Genes

A sequence of triplets in the DNA molecule may code for a complete protein

Such a sequence forms a **gene**

There may be a thousand or more bases in one gene

Ribonucleic acid (RNA)

- **RNA Structure and function:**
- The tertiary structure of RNA is similar to DNA, but there are several important differences:
- RNA usually forms intramolecular base pairs
- the information carried by RNA is not redundant because of these intramolecular base pairs.
- the major and minor grooves are less pronounced
- the structural, informational adaptor and information transfer roles of RNA are all involved in decoding the information carried by DNA

Types of RNA

- Transfer RNA (tRNA)
- Messenger RNA (mRNA)
- Ribosomal RNA (rRNA)
- snRNA

Transfer RNA (tRNA)

- tRNA is the information adapter molecule. It is the direct interface between amino-acid sequence of a protein and the information in DNA. Therefore it decodes the information in DNA. There are > 20 different tRNA molecules. All have between 75-95 nt.

- All tRNA's from all organisms have a similar structure, indeed a human tRNA can function in yeast cells.

Messenger RNA (mRNA)

- Messenger or mRNA is a copy of the information carried by a gene on the DNA. The role of mRNA is to move the information contained in DNA to the translation machinery.

Ribosomal RNA (rRNA)

- Ribosomal RNA (rRNA) is a component of the ribosomes, the protein synthetic factories in the cell. Eukaryotic ribosomes contain four different rRNA molecules: 18 s, 5.8 s, 28 s, and 5 s rRNA. Three of the rRNA molecules are synthesized in the nucleolus, and one is synthesized elsewhere. rRNA molecules are extremely abundant. They make up at least 80% of the RNA molecules found in a typical eukaryotic cell.

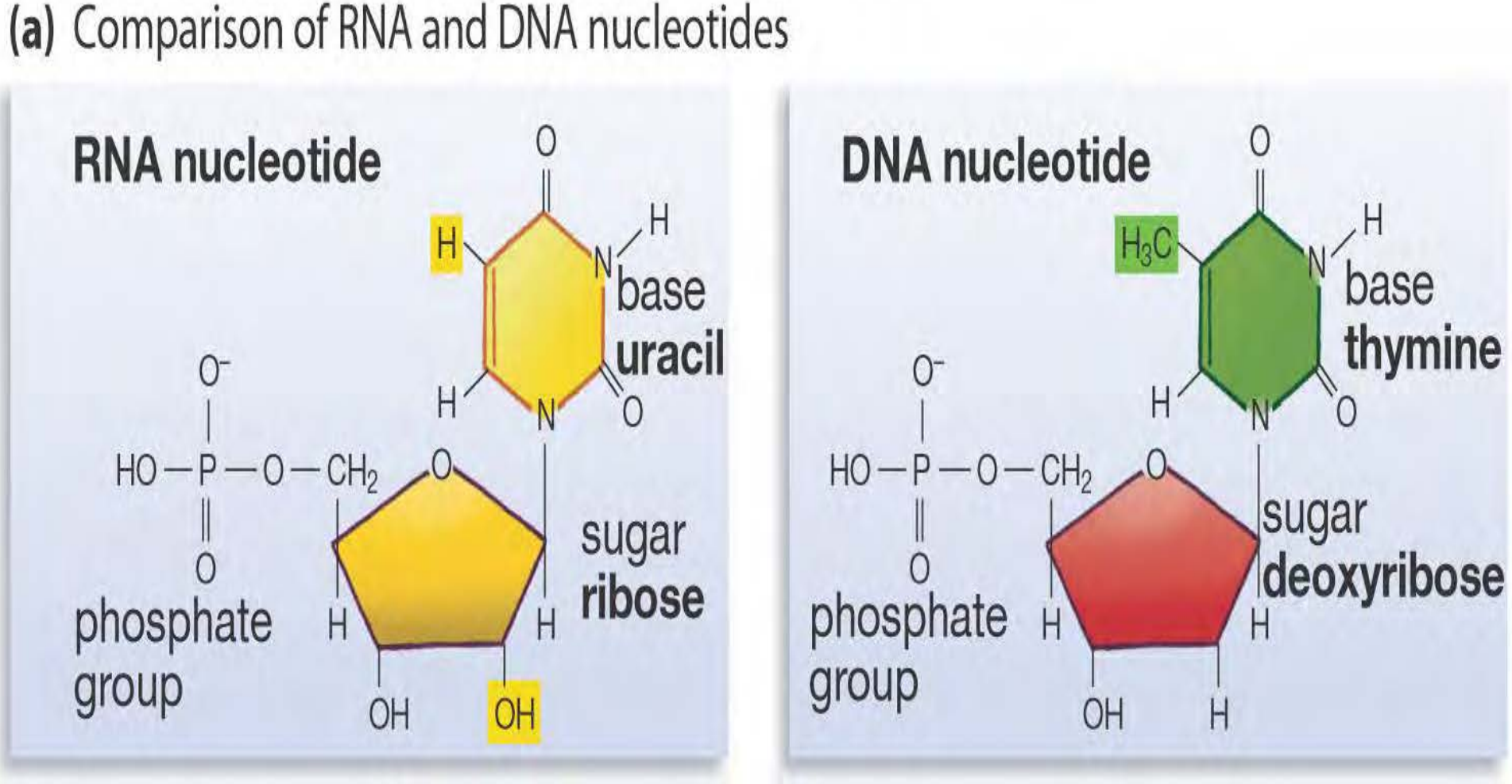
- The rRNA molecules have several roles in protein synthesis. First, the 28 s rRNA has a catalytic role. Second, 18s rRNA has a recognition role.

Small nuclear RNA (snRNA)

Small nuclear RNA (snRNA) is the name used to refer to a number of small RNA molecules found in the nucleus. These RNA molecules are important in a number of processes including RNA splicing (removal of the introns from hnRNA) and maintenance of the telomeres, or chromosome ends. They are always found associated with specific proteins and the complexes are referred to as small nuclear ribonucleoproteins (SNRNP) or sometimes as snurps.

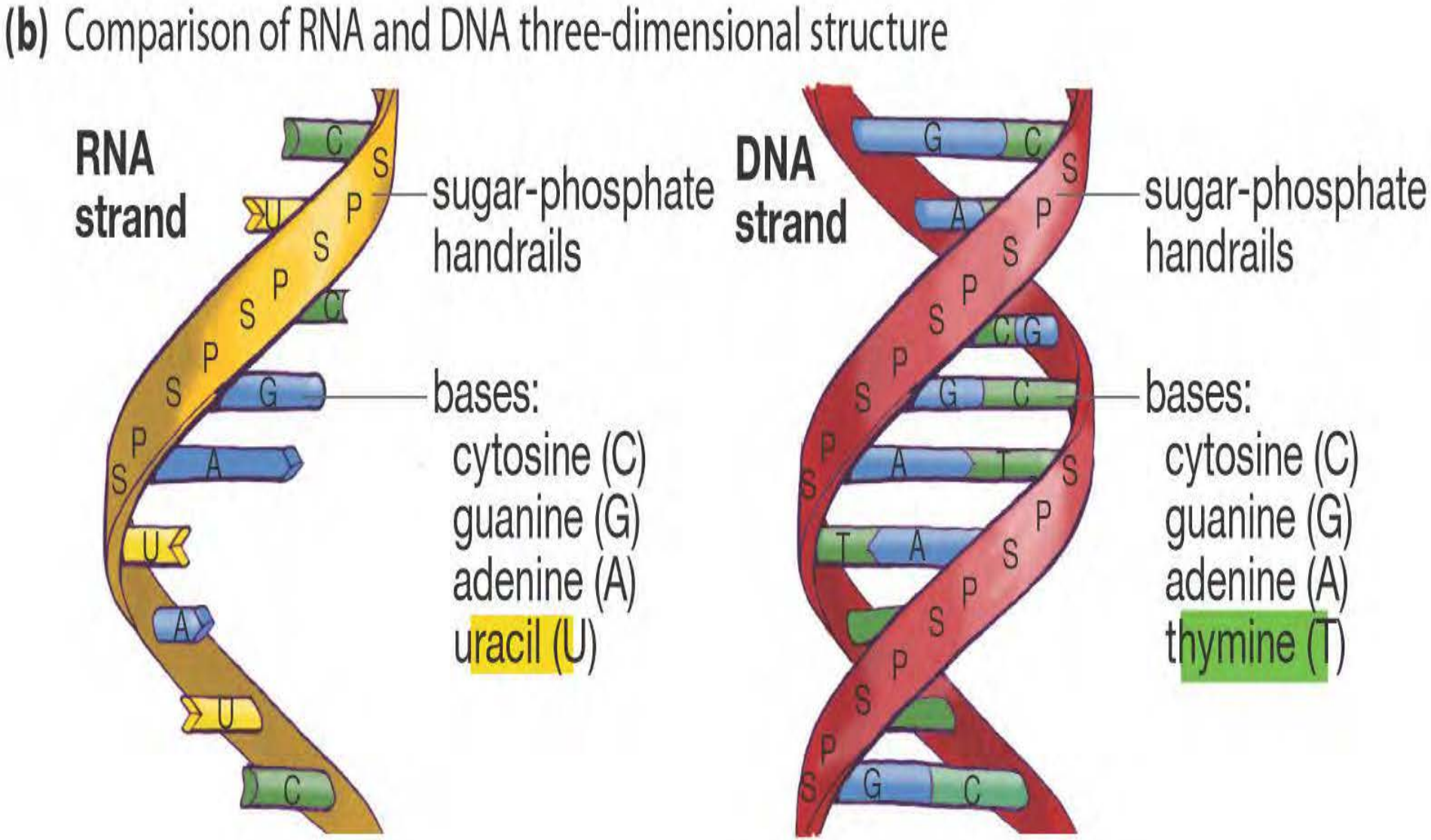
- **Antibodies against snurps are found in a number of autoimmune diseases**

RNA

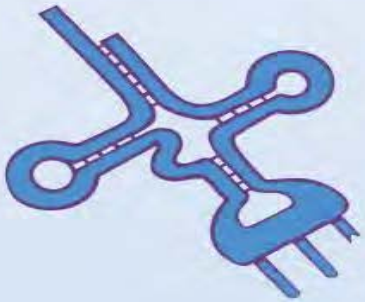


RNA is a nucleic acid polymer that uses a slightly different sugar than DNA and the base uracil (U) in place of thymine (T).

RNA Is Largely Single-Stranded

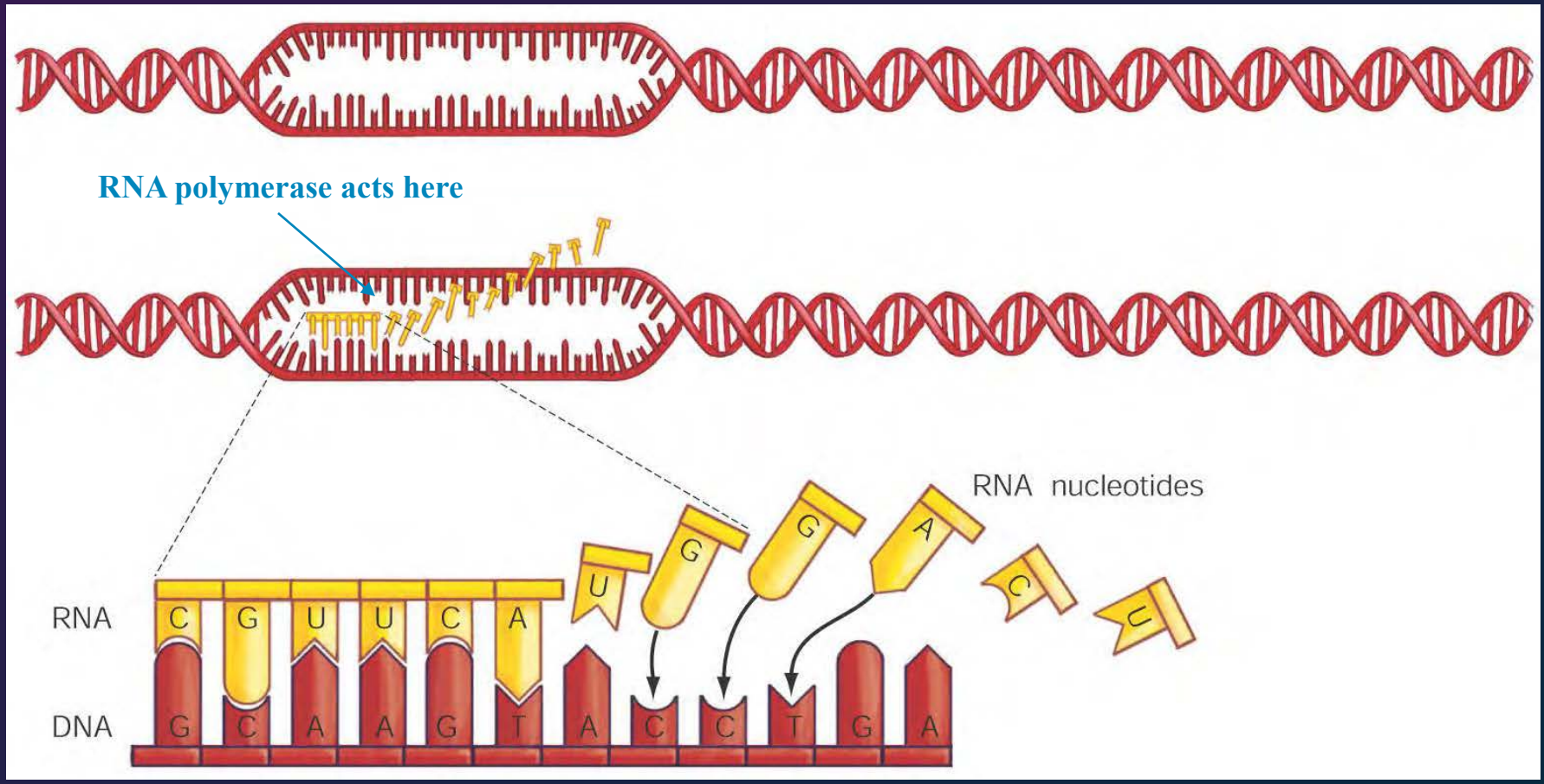


There are Different RNAs with Distinct Functions

Type of RNA	Functions in	Function
Messenger RNA (mRNA) 	Nucleus, migrates to ribosomes in cytoplasm	Carries DNA sequence information to ribosomes
Transfer RNA (tRNA) 	Cytoplasm	Provides linkage between mRNA and amino acids; transfers amino acids to ribosomes
Ribosomal RNA (rRNA) 	Cytoplasm	Structural component of ribosomes

Recently, a new class of RNA, microRNA, has been shown to regulate gene expression.

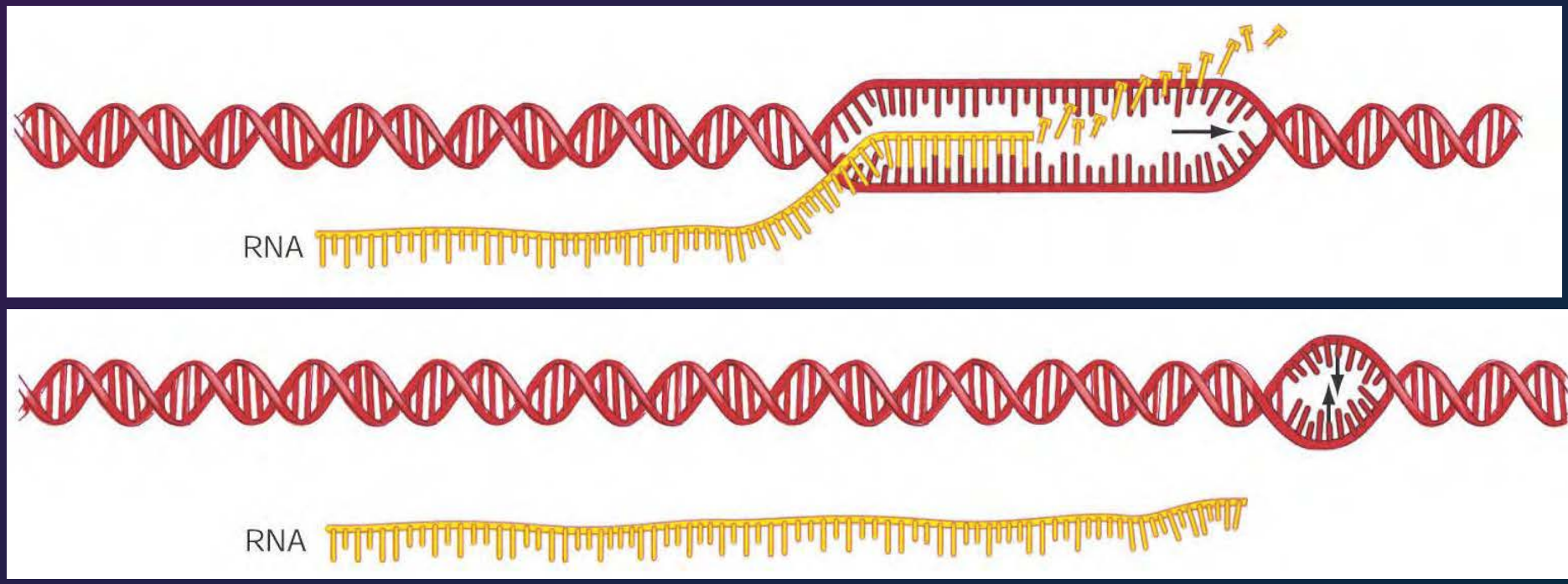
Transcription



The enzyme RNA polymerase opens the DNA strands and synthesizes an RNA complementary to only one of the DNA strands.

Transcription

A gene



The decision to transcribe a gene is the most important step in the control of gene expression.

Transcription starts and stops at distinct sites at the ends of a gene.

Animation

Question 1

Which of the following are components of nucleotides?

(a) deoxyribose 

(b) amino acids 

(c) phosphate 

(d) enzymes 

(e) organic bases 

Question 2

Which of the following represent a correct pairing of bases?

(a) adenine with thymine 

(b) adenine with guanine 

(c) thymine with adenine 

(d) guanine with cytosine 

(e) thymine with thymine 

Question 3

DNA molecules are formed from

(a) organic bases 

(b) amino acids 

(c) deoxyribose 

(d) nucleotides 

Question 4

Which of the following are organic bases?

(a) Valine

(b) Guanine

(c) Thymine

(d) Serine

Question 5

Replication of DNA occurs

(a) During cell division

(b) before cell division

(c) at any time

Question 6

A nucleotide triplet codes for

(a) a protein

(b) an amino acid

(c) an enzyme

(d) an organic base

Answer

CORRECT

Answer

INCORRECT