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UMM AL-QURA UNIVERSITY

General Biology

Lecture (3): Genetics

College of Applied Sciences
Biology Department

Outline

- **Introduction into Genetics**
- **The Molecular Basis of Inheritance**
  - The Components of Nucleic Acids
  - The Structures of DNA and RNA Molecules
- **The Chromosomal Basis of Inheritance**
  - Chromosome Theory
  - Inheritance of Genes
- **The Flow of Genetic Information**

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1. Introduction into Genetics

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Overview: Variations on a Theme

- Living organisms are distinguished by their ability to reproduce their own kind.
- **Genetics** is the scientific study of heredity and variation.
- **Heredity** is the transmission of traits from one generation to the next.
- **Variation** is demonstrated by the differences in appearance that offspring show from parents and siblings.

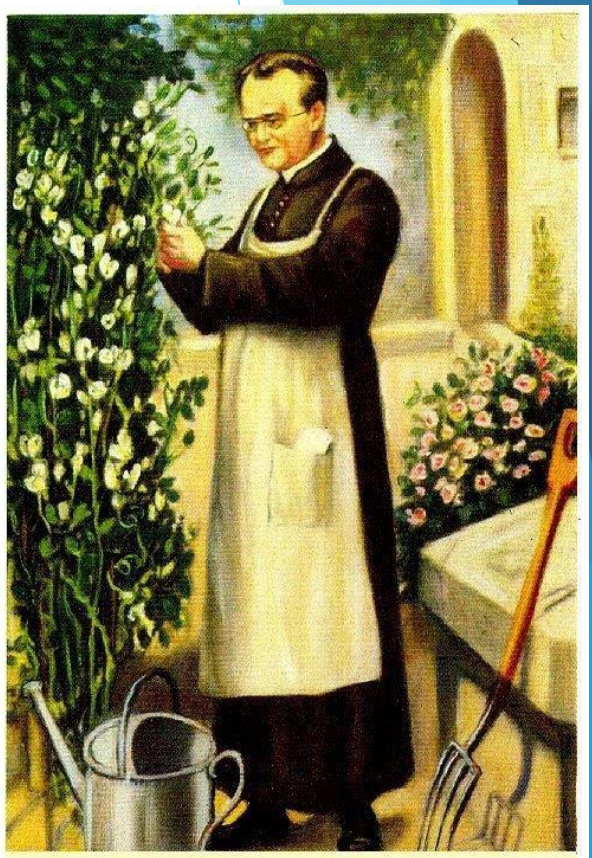
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2.The Molecular Basis of Inheritance

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Mendel used the scientific approach to identify two laws of inheritance

- The "particulate" hypothesis is the idea that parents pass on discrete heritable units (genes)
- Mendel documented a particulate mechanism through his experiments with garden peas.
- Mendel discovered the basic principles of heredity by breeding garden peas in carefully planned experiments.



GREGOR MENDEL

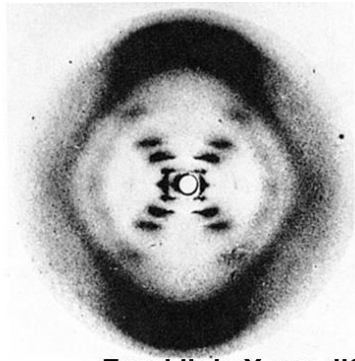
Overview: Life's Operating Instructions

- In 1953, James Watson and Francis Crick shook the world With an elegant double-helical model for the structure of deoxyribonucleic acid, or DNA.
- Watson and Crick deduced that DNA was a double helix, through observations of the X-ray crystallographic images of DNA
- The role of DNA in heredity worked out by studying bacteria and the viruses that infect them.
- DNA, the substance of inheritance and the most celebrated molecule of our time.





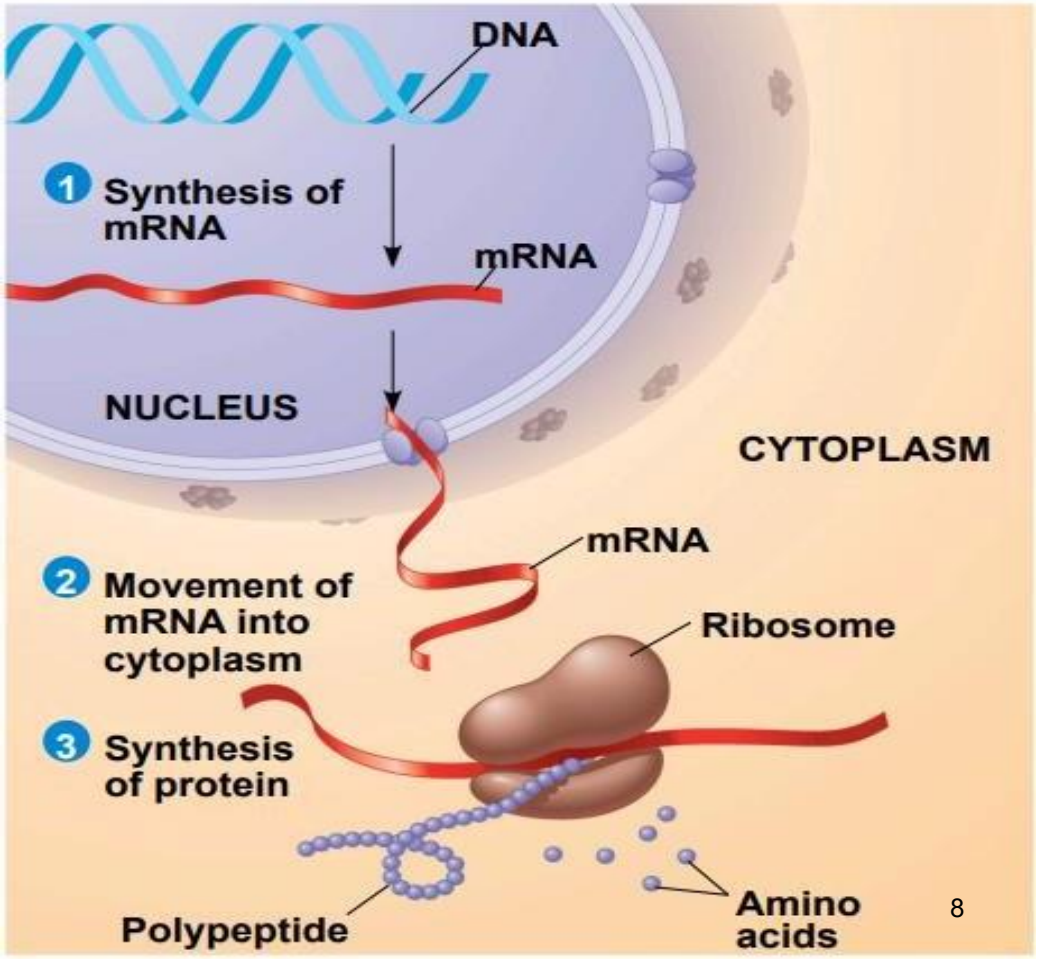
(a) Rosalind Franklin



(b) Franklin's X-ray diff Photograph of DNA

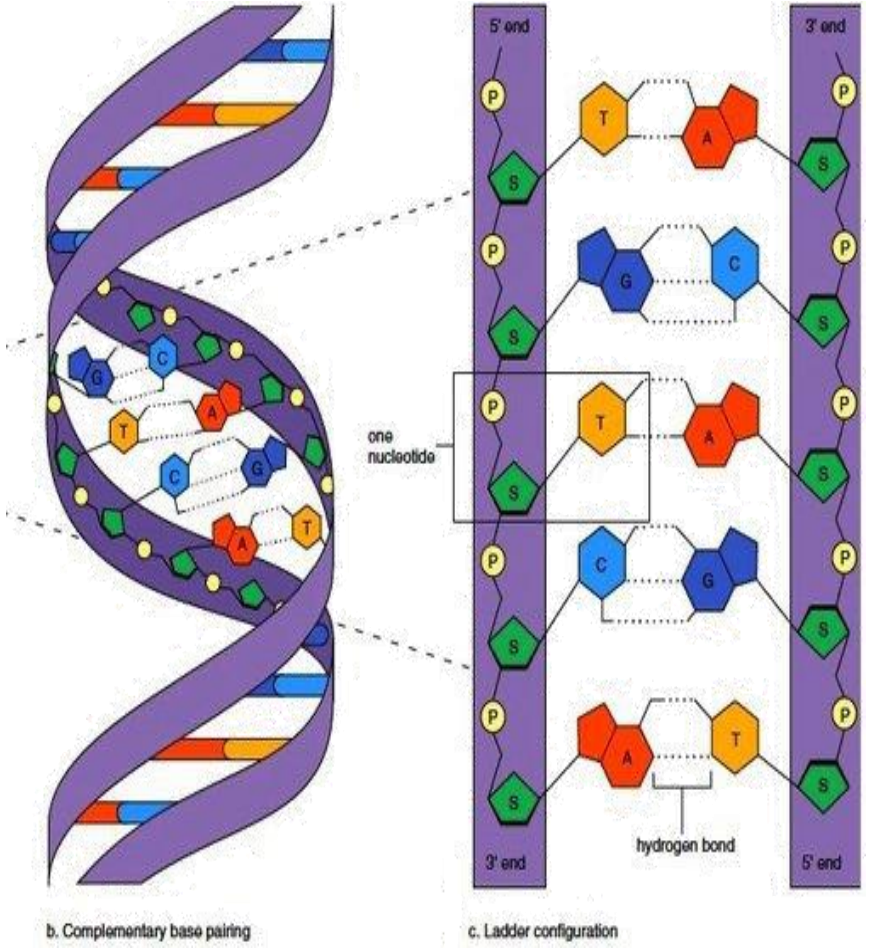
Nucleic acids store, transmit, and express hereditary information

- The amino acid sequence of a polypeptide is programmed by a unit of inheritance called a gene.
- Genes are made of DNA, a nucleic acid made of monomers called nucleotides .
- There are two types of nucleic acids:
  - Deoxyribonucleic acid (DNA)
  - Ribonucleic acid (RNA)
- DNA provides directions for its own replication.
- DNA directs synthesis of messenger RNA (mRNA) and, through mRNA, controls protein synthesis.
- Protein synthesis occurs on ribosomes.

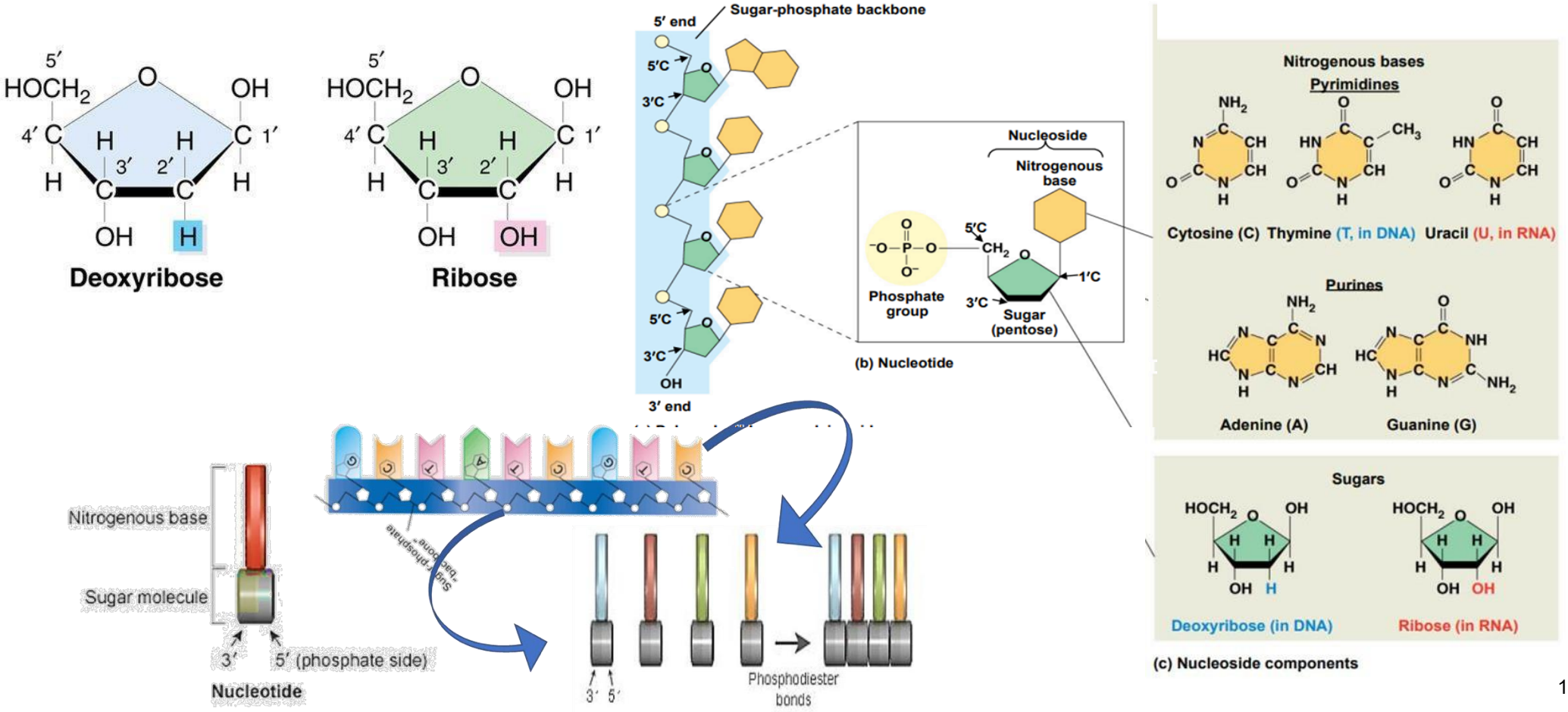


The Components of Nucleic Acids

- Nucleic acids are polymers called polynucleotides.
- Each polynucleotide is made of monomers called nucleotides.
- Each nucleotide consists of a nitrogenous base, a pentose sugar, and one or more phosphate groups.
- There are two families of nitrogenous bases
  - Pyrimidines (cytosine, thymine, and uracil)
  - Purines (adenine and guanine).
- In the DNA double helix, the two backbones run in opposite 5' to 3' directions from each other, an arrangement referred to as antiparallel.
- The nitrogenous bases in DNA pair up and form hydrogen bonds: adenine (A) always with thymine (T), and guanine (G) always with cytosine (C). Called complementary base pairing.



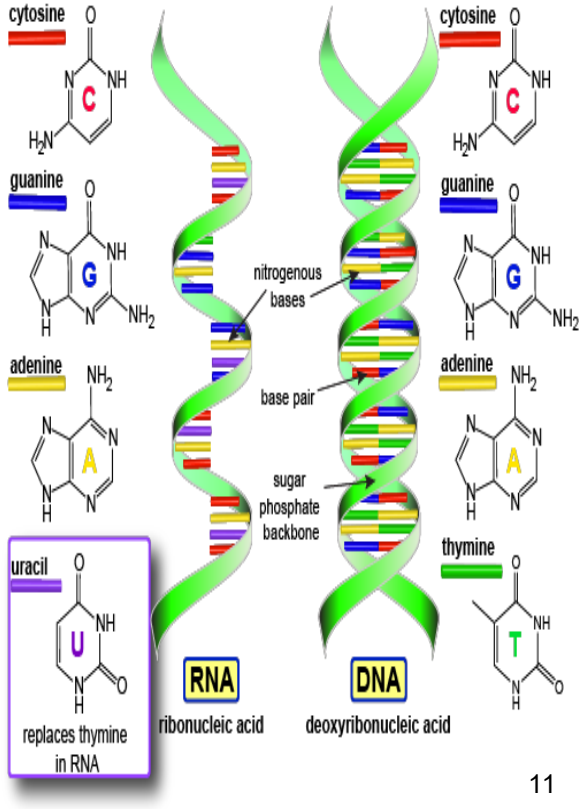
The Structures of DNA and RNA Molecules



The Structures of DNA and RNA Molecules

- RNA is slightly different from DNA in the following aspects

	DNA (Deoxyribonucleic acid)	RNA (Ribonucleic acid)
Location	Nucleus and mitochondria, chloroplast.	Nucleus and cytoplasm,
Structure	Double strand helix.	Single-strand helix.
Sugar	It contains Deoxyribose.	It contains Ribose.
Nitrogenous Bases	AT (adenine-thymine). GC (guanine-cytosine).	AU (adenine-uracil). GC (guanine-cytosine).
Length	Long with high molecular mass.	Short with low molecular mass.
Propagation	DNA is self-replicating.	RNA is synthesized from DNA.
Function	storage and transmission of genetic information.	Transfers genetic code for protein synthesis.
Type	_____	(tRNA), (rRNA), (mRNA),(snRNA)



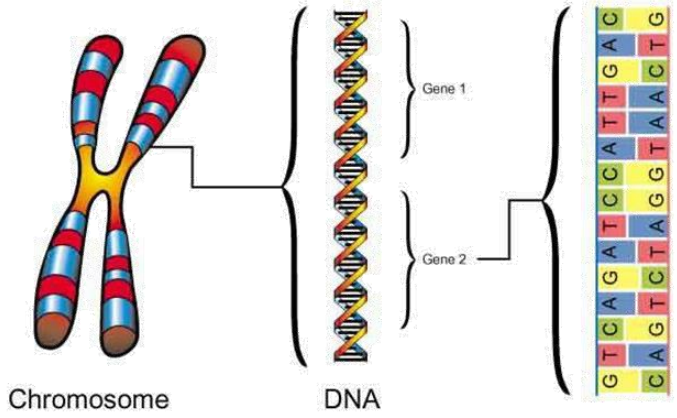
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3. The Chromosomal Basis of Inheritance

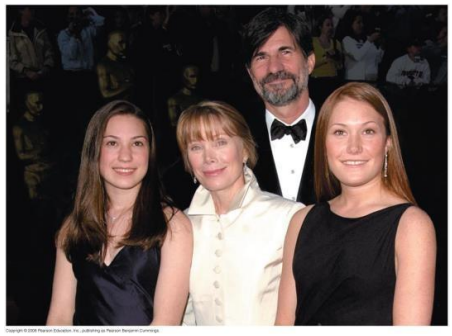
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Inheritance of Genes

- In a literal sense, children do not inherit particular physical traits from their parents.
- It is **genes** that are actually inherited.
- **Genes** are the units of heredity, and are made up of segments of DNA.
- **Genes** are passed to the next generation through reproductive cells called **gametes** (sperm and eggs).
- Each gene has a specific location called a **locus** on a certain chromosome.
- One set of chromosomes is inherited from each parent.
- Most DNA is packaged into chromosomes.

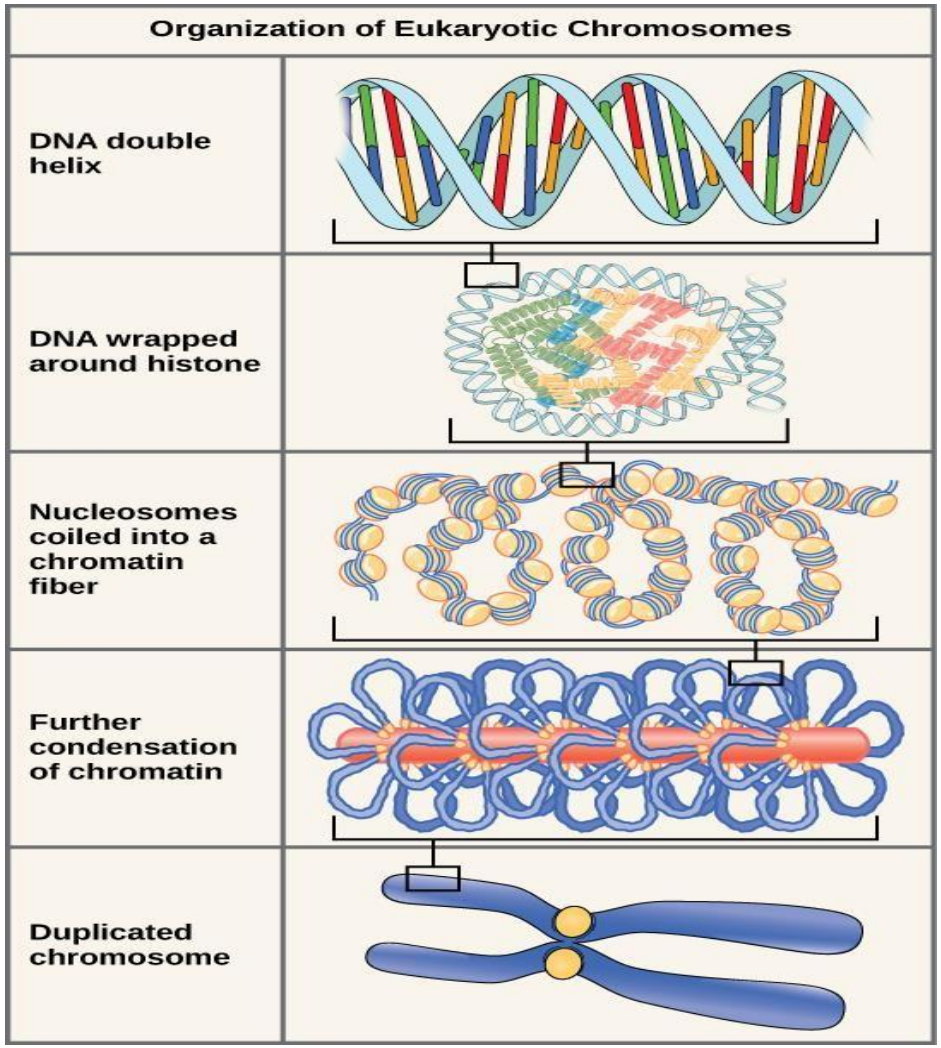


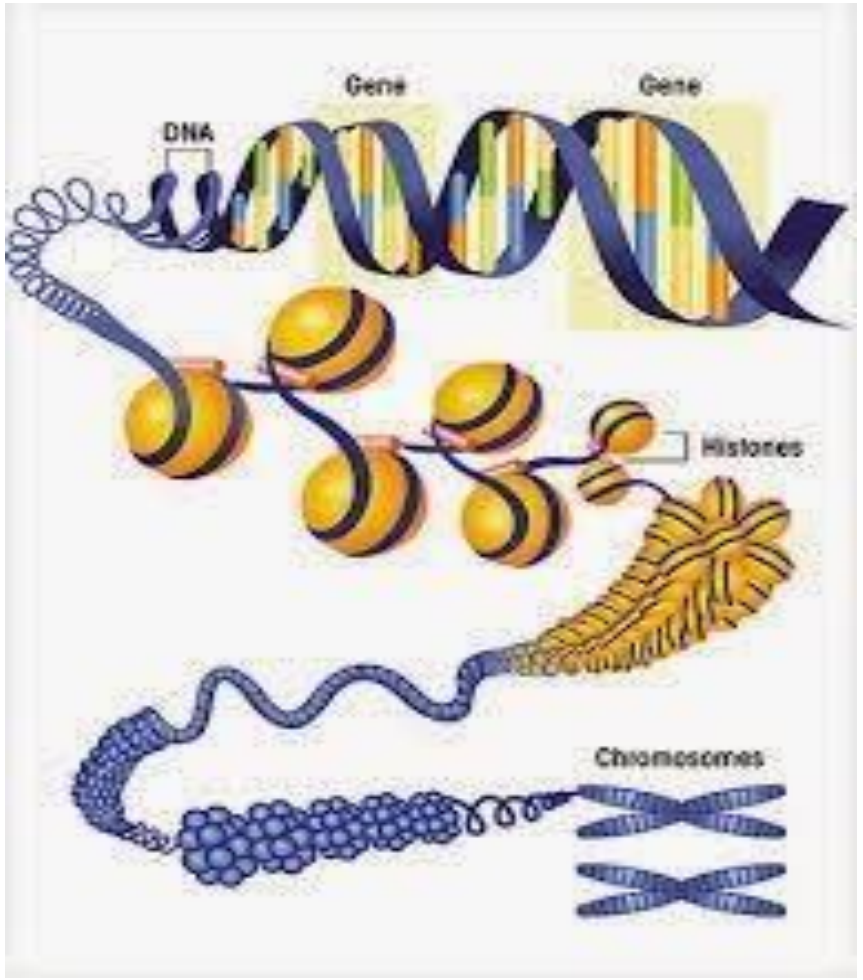
Genes



Offspring acquire genes from parents by inheriting chromosomes

DNA Packaging and Organization into Chromosomes





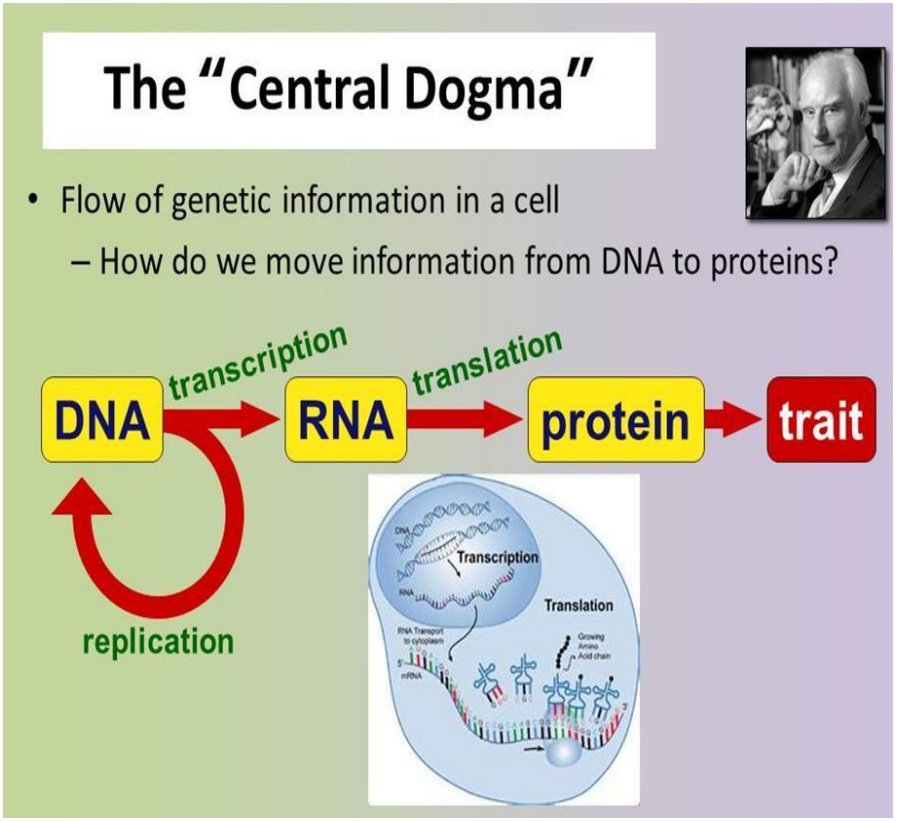
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4. The Flow of Genetic Information

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Overview: The Flow of Genetic Information

- **The information content of DNA** is in the form of specific sequences of nucleotides along the DNA strands.
- **The DNA inherited by an organism** leads to specific traits by dictating the synthesis of proteins.
- Cells are governed by a cellular chain of command
  DNA → RNA → protein
- The process by which DNA directs protein synthesis, called **gene expression** includes two stages, called **transcription and translation.**
- Protein are complex molecules, polypeptide are folded, and combined with other polypeptides to form a protein.



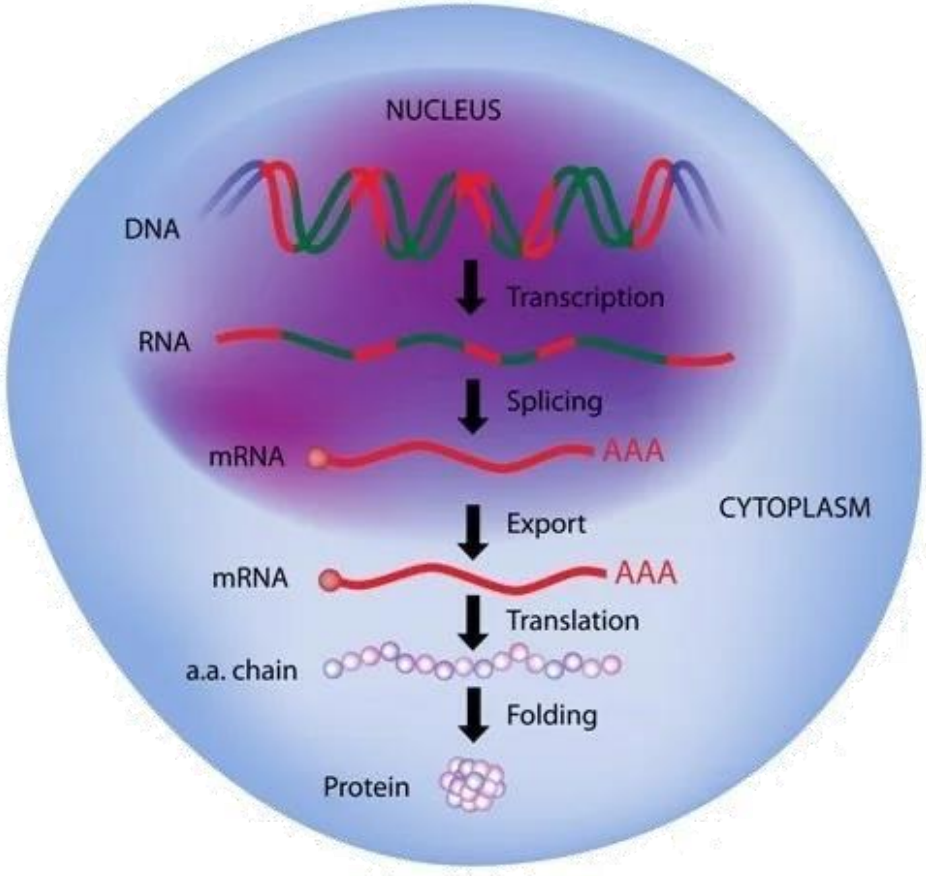
Basic Principles of Transcription and Translation

➢ Transcription:

- The first step in gene expression. It involves copying a gene's DNA sequence to make an **RNA** molecule.

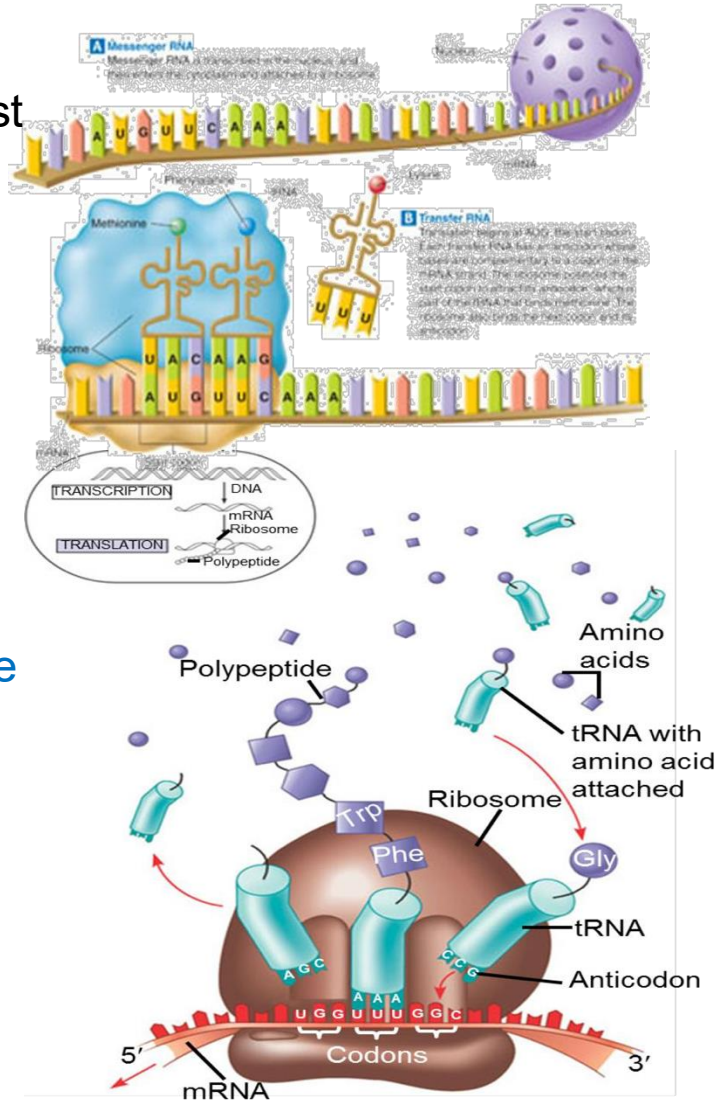
- The main enzyme involved in transcription is **RNA polymerase**, which uses a single-stranded DNA **template** to **synthesize** a **complementary strand** of **RNA**.

- **RNA polymerase** builds an **RNA** strand in the **5'** to **3'** direction by adding each **new nucleotide** to the **3' end** of the strand.



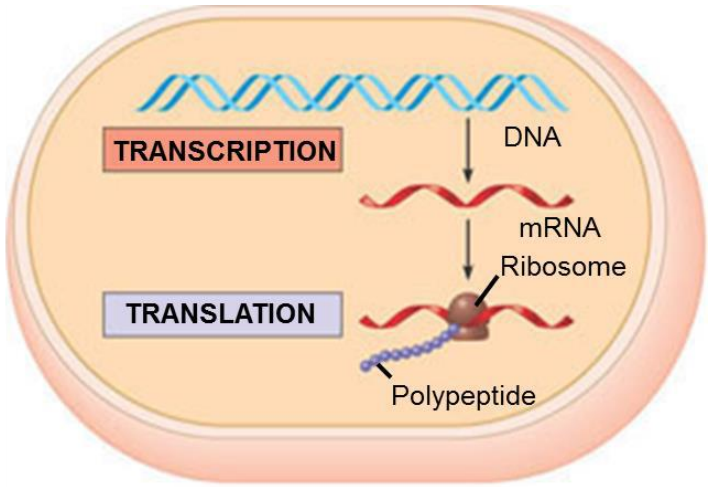
Basic Principles of Transcription and Translation

- **Translation:**
- Once the DNA has been transcribed to mRNA, the codons must be translated to the amino acid sequence of the protein.
- Protein is constructed in the cytoplasm.
- Three steps of translation:
  - Initiation: mRNA is binding with subunit of ribosome and aminoacyl-tRNA.
  - Elongation: Ribosome moves along mRNA, making polypeptide chain and extending protein.
  - Termination: Polypeptide chain is released from tRNA, and ribosome dissociates from mRNA.



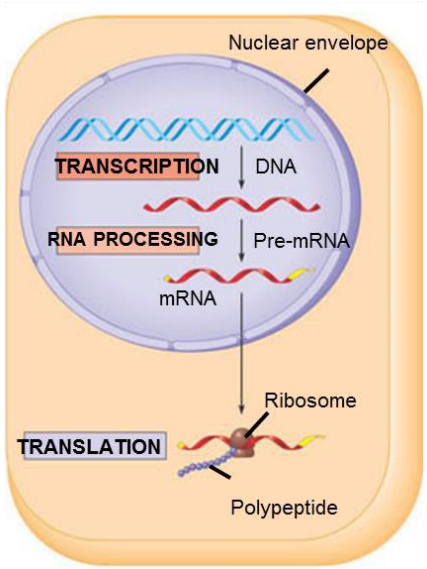
Transcription and Translation in Prokaryotes and Eukaryotes

- **In prokaryotes:**
  - Transcription and translation occur together.



(a) **Prokaryotic cell.** In a cell lacking a nucleus, mRNA produced by transcription is immediately translated without additional processing.

- **In eukaryotes:**
  - RNA transcripts are modified before becoming true mRNA



(b) **Eukaryotic cell.** The nucleus provides a separate compartment for transcription. The original RNA transcript, called pre-mRNA, is processed in various ways before leaving the nucleus as mRNA.

REFERENCES

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- 2- Mitosis https://youtu.be/7NM-UWFHG18
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