Al-Mustaqbal University

College of Engineering and Technologies

Biomedical Engineering Department

Biology

Lecture: 5

The Nucleus and Nucleic Acids

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The Nucleus

This is clearly oval or spherically shaped largest central structure surrounded by a double-layered membrane. In the nucleus, DNA directs protein synthesis and serves as a genetic blueprint during cell replication.

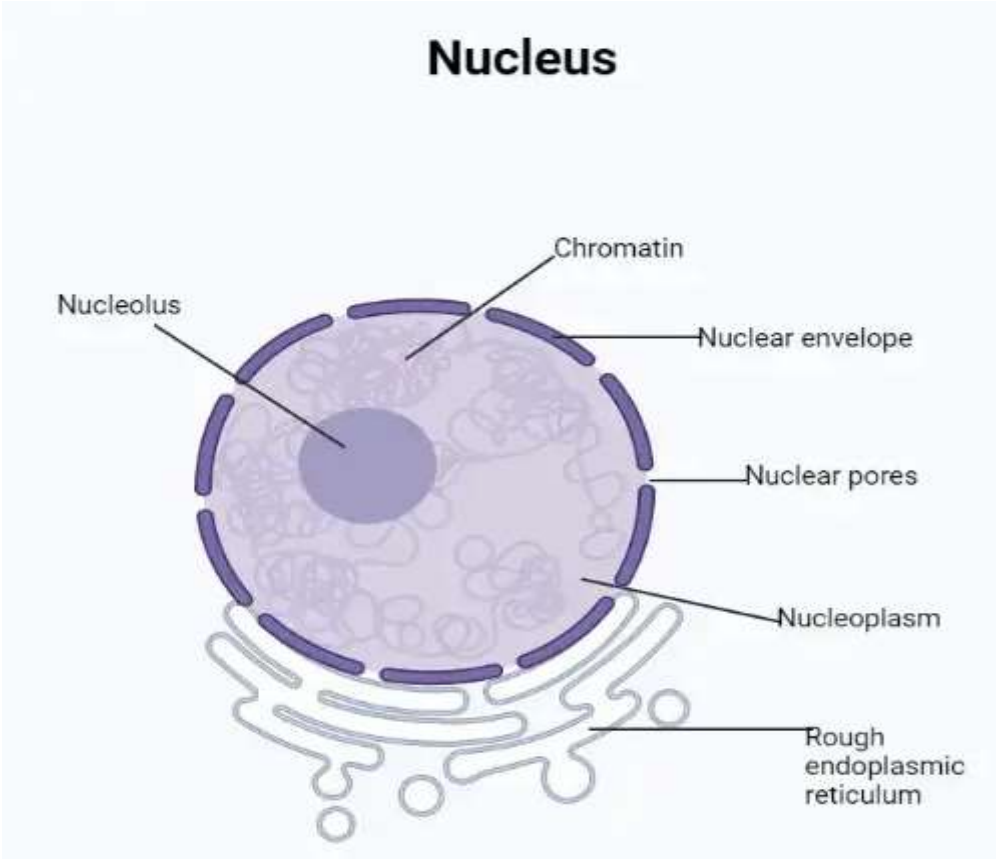


Figure 1. Structure of Nucleus.

Generally, the nucleus may be:

- rounded: e.g. in hepatocytes.
- indented (segmented): e.g. in neutrophils.
- binucleated: e.g. in parietal cells, cardiac muscle cells.
- multinucleated: e.g. in osteoclasts, skeletal muscle cells.
- very large (many DNA): e.g. in megakaryocytes.
- absent: e.g. in mature erythrocytes, blood platelets.

The nucleus is surrounded by a **nuclear envelope** and contains chromatin and one or more nucleoli.

The Nuclear envelope

- ✓ surrounds nuclear material
- ✓ consists of outer and inner membrane
- ✓ perforated at intervals by nuclear pores
- ✓ through this pores most ions and water soluble molecules to transfer between nucleus and cytoplasm.

Chromatin: The term chromatin means "colored material" and refers to the fact that this material is easily stained for viewing with microscope, and it is composed mainly of coils DNA bound to basic protein called **histones**.

Nucleoli: The nuclei of most cells contain one or more lightly stained structures called **nucleoli** that actively engage in synthesizing of ribosomes. The nucleolus, unlike most of the organelles, does not have a limiting membrane. Instead, it is simply a structure that contains large amounts of RNA and protein of the type found in ribosomes. The nucleolus becomes considerably enlarged when a cell is actively synthesizing proteins.

Nucleic Acids

Nucleic acids are bio-macromolecules composed of nucleotide subunits linked by **phosphodiester bonds**. DNA and RNA are **polynucleotides**. There are two types of nucleic acids: deoxyribonucleic acid (DNA) and

ribonucleic acid (RNA). DNA encodes the hereditary details and controls the growth and division of the cells. The genetic information stored in DNA is then transcribed into RNA, and the details in RNA are then translated for the synthesis of the proteins.

Nucleotide structure

Each nucleotide is composed of three main components:

1. Nitrogen base

- **DNA** has four bases: adenine, guanine, cytosine and thymine.

- **RNA** also contains four bases. Three-adenine, guanine and cytosine- are same as those in DNA. But the fourth base in RNA is **uracil** instead of **thymine**.

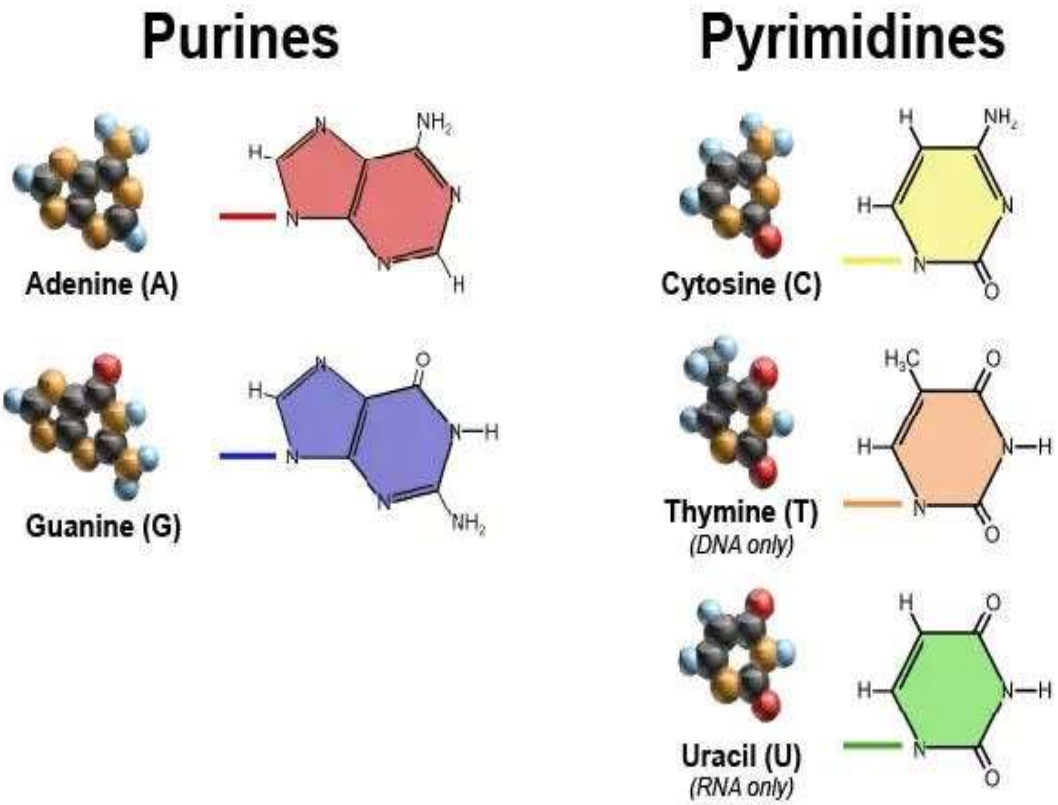


Figure 2. Nitrogen base groups

2. Ribose sugar

- **In DNA**: the five membered sugar is **2'deoxy-D-ribose**.

- **In RNA**, the five membered sugar is **D-ribose**.

3. Phosphate group.

- A compound with a **<u>nitrogen base</u>** bonded to **<u>sugar</u>** (D-ribose or 2'-deoxy-D-ribose) is called **<u>nucleoside</u>**.

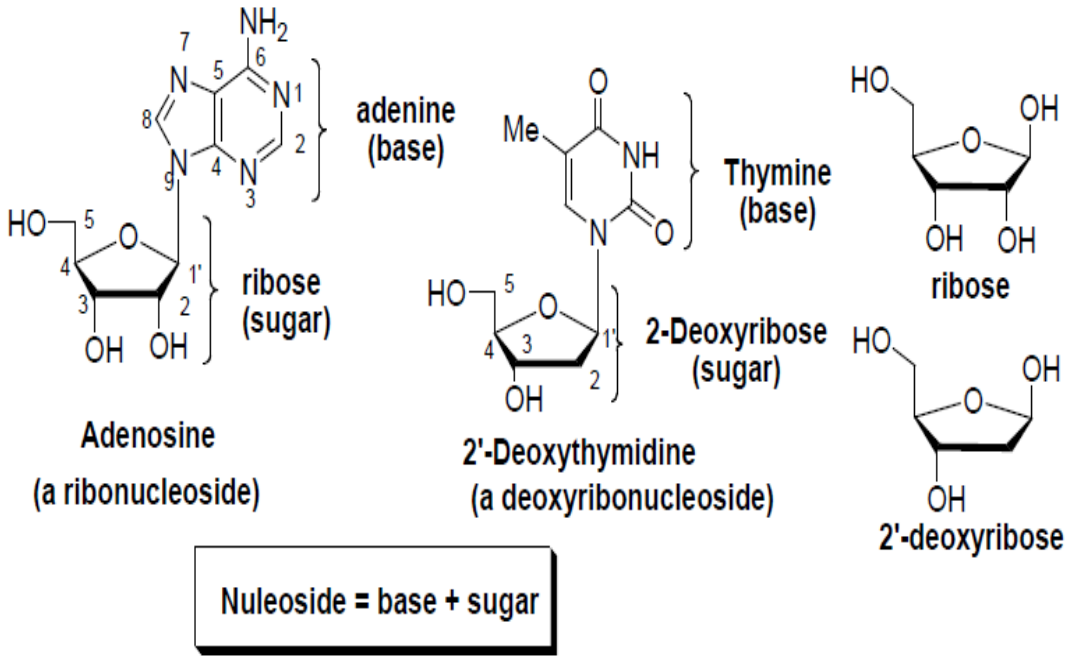


Figure 3. Nucleoside structure.

- The nucleotide where the sugar is D-ribose is called **<u>ribonuleotide</u>**, whereas the nucleotide with 2'-deoxy-D-ribose is called **<u>deoxyribonuleotide</u>** (Figure 4).

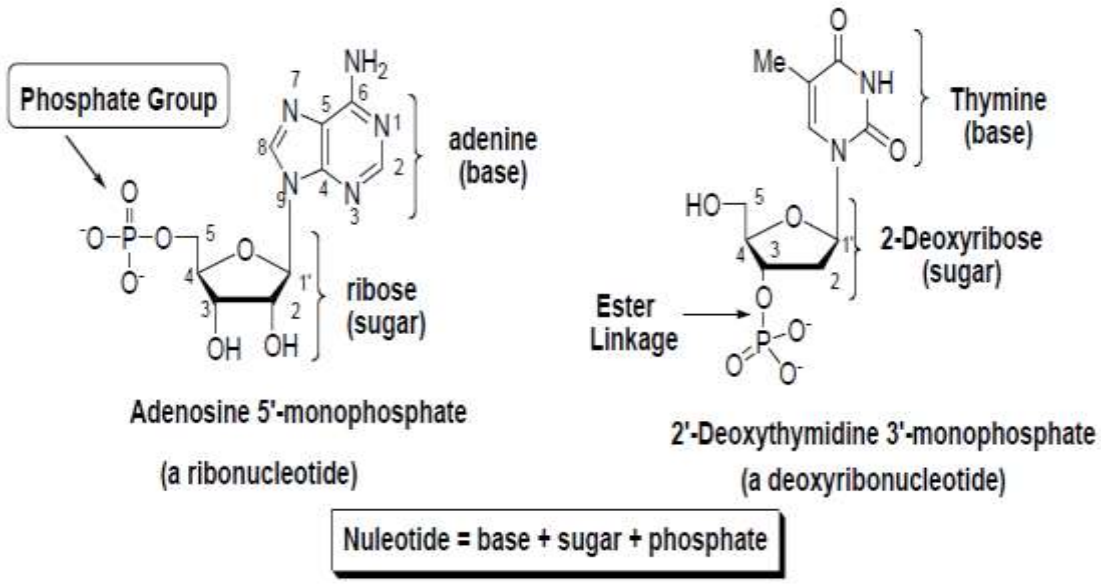
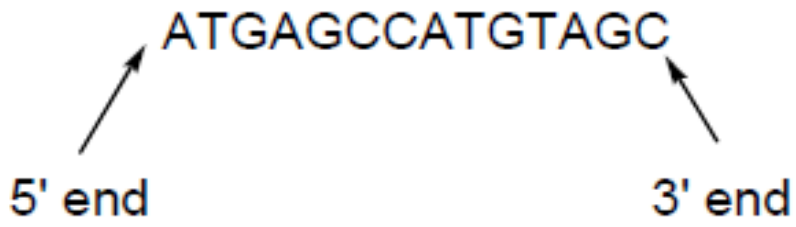


Figure 4. Nucleotide structure.

Primary Structure of Nucleic acid

It describes the sequence of bases in the strand. By convention, the sequence of bases is written in the 5' to 3' direction.



Secondary Structure of Nucleic acid

DNA consists of two strands of nucleic acids with the **sugar-phosphate backbone outside** and **the base inside**. The chains are held together by **H-bonding** between the base of one strand with the base of another strand. Adenine pairs with thymine by **two H-bonds**, while guanine pairs with cytosine through **three H-bonds**. This means if we know the sequences bases in one strand, we will be able to sequence the bases in

the other strand (Figure 5a). If the two strands run in opposite directions, the strands are not linear. Instead they are twisted into a helix around common axis, which is known as **double helix** (Figure 5b).

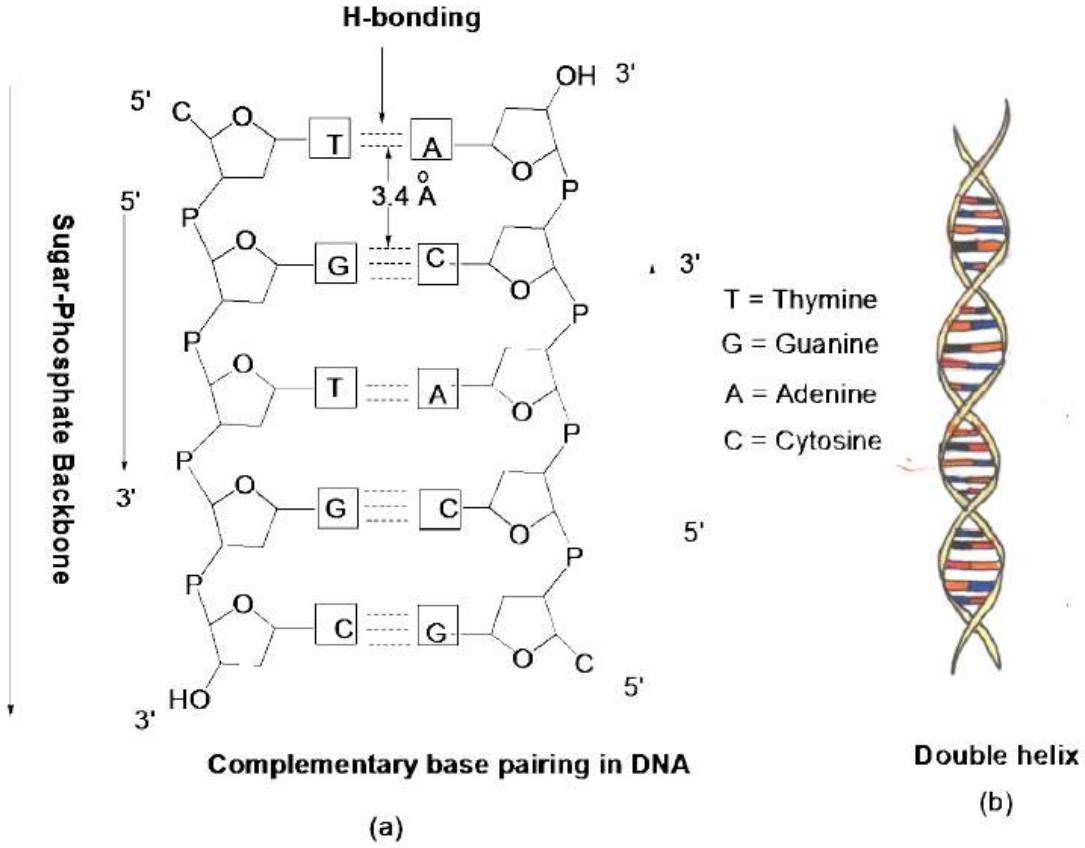


Figure 5. Double helix structure.

Stability of DNA and RNA

In RNA, the 2'-OH of ribose attacks the adjacent phosphodiester group that leads to the cleavage of the strand (Figure 6). This reaction does not take place in DNA, because it does not have the 2'-OH group. Thus, DNA remain intact throughout the life span of cells.

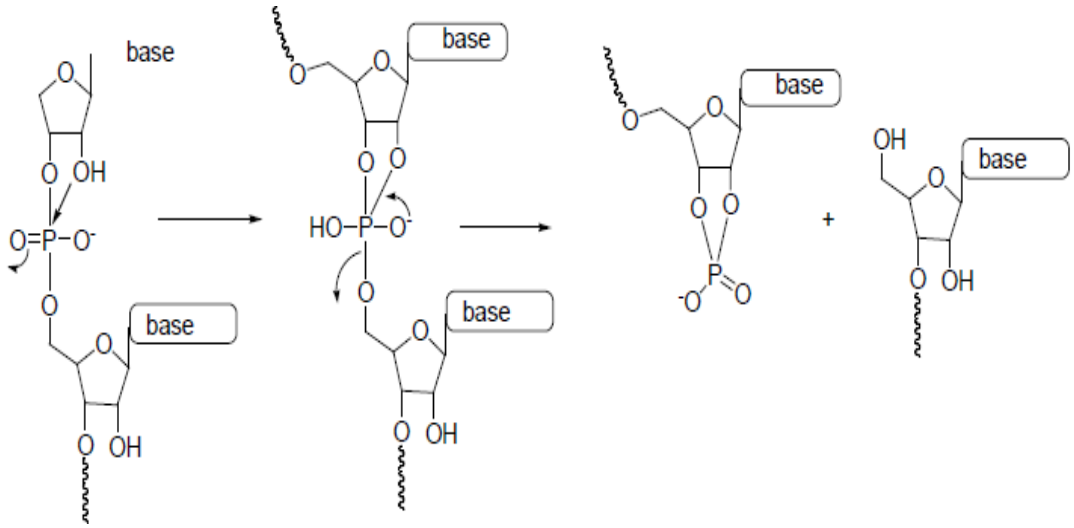


Figure 6. Nucleic acid stability.

What is DNA and RNA differences??

DNA is a double-stranded molecule that has a long chain of nucleotides. RNA is a single-stranded molecule which has a shorter chain of nucleotides. DNA replicates on its own, it is self-replicating. RNA does not replicate on its own.

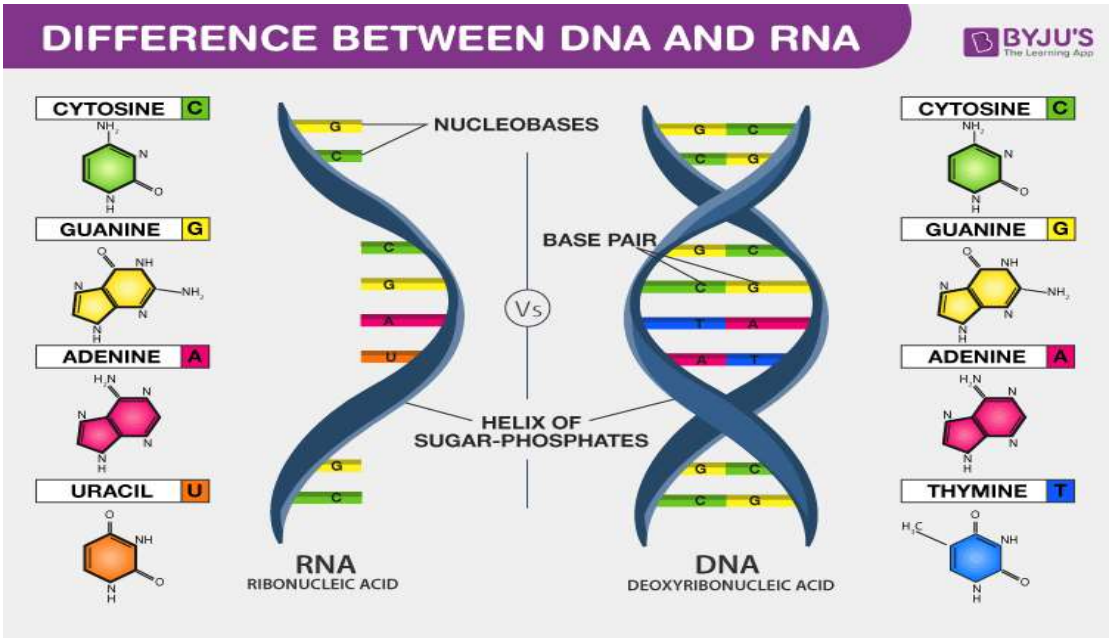


Figure (2). DNA and RNA differences.

References

1. INTRODUCTION: THE NATURE OF SCIENCE AND BIOLOGY. (2019). Retrieved September 12, 2019, from Estrellamountain.edu website:http://www2.estrellamountain.edu/faculty/farabee/biobk/biobookintro.html.

2.Theories of Evolution. (2010). Retrieved from BIOLOGY4ISC website: https://biology4isc.weebly.com/3-theories-of-evolution.html.

3. https://bio.libretexts.org/Courses/Lumen_Learning/Biology_for_Non-Majors_I_(Lumen)/01%3A_Introduction_to_Biology/1.03%3A_Taxonmy.

4. Textbook of Module for General Biology (Biol. 1012). file:///C:/Users/user/Downloads/GENERAL%20BIOLOGY%20module.pdf.

5. A brief history of evolution. (2019). Retrieved from OpenLearn website: https://www.open.edu/openlearn/history-the-arts/history/history-science-technology-and-medicine/history-science/brief-history-evolution.