Nucleic Acid

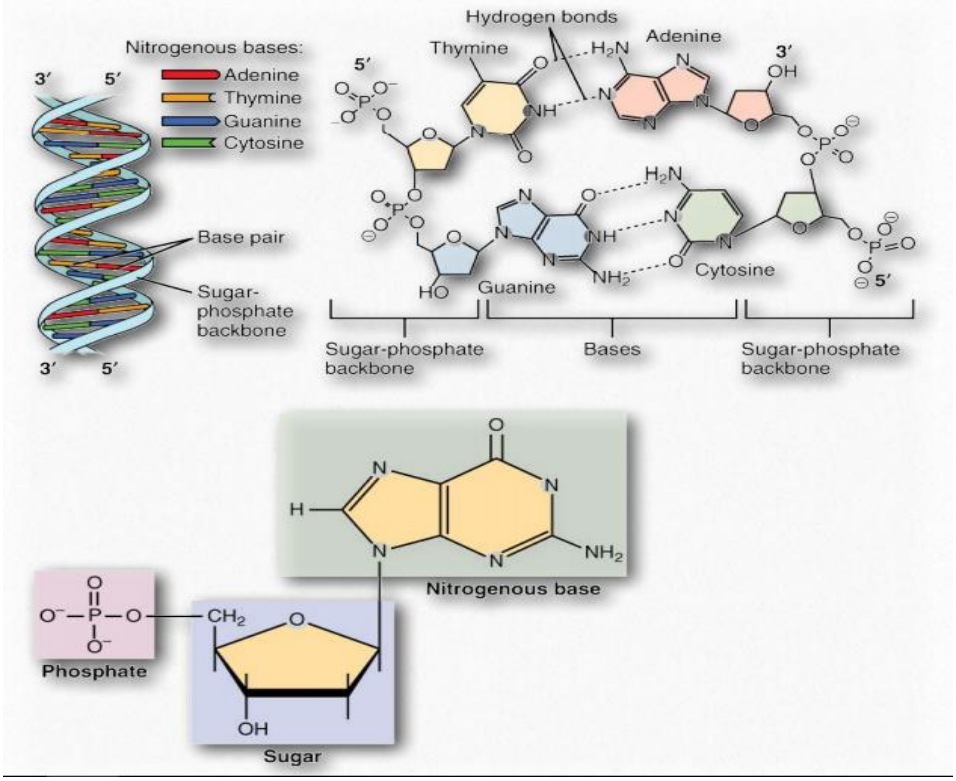
Introduction

The nucleic acids, DNA and RNA, may be thought of as the information molecules of the cell. In this section, we will examine the structures of DNA and RNA, and how these structures are related to the functions these molecules perform.

We will begin with DNA, which is the hereditary information in every cell, that is copied and passed on from generation to generation. The race to elucidate the structure of DNA was one of the greatest stories of 20th century science.

Discovered in 1869 by Friedrich Miescher, DNA was identified as the genetic material in experiments in the 1940s led by Oswald Avery, Colin MacLeod, and Maclyn McCarty. X-ray diffraction work of Rosalind Franklin and the observations of Erwin Chargaff were combined by James Watson and Francis Crick to form a model of DNA that we are familiar with today.

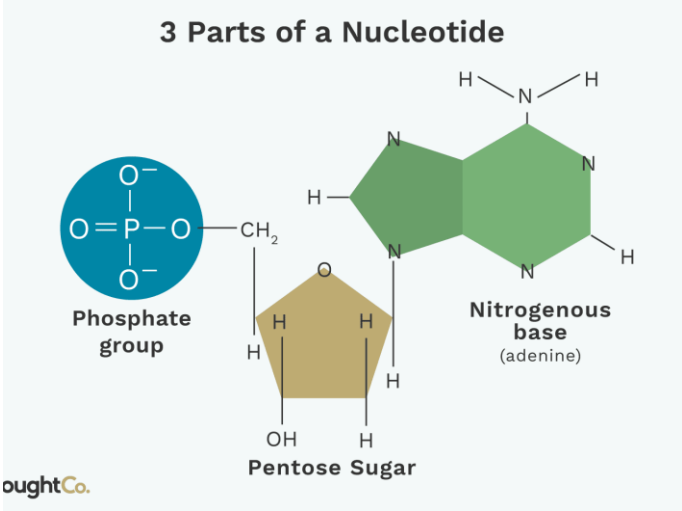
Their famous paper, in the April 25, 1953 issue of Nature, opened the modern era of molecular biology. The double helix, made up of a pair of DNA strands, has at its core, bases joined by hydrogen bonds to form base pairs - adenine always paired with thymine, and guanine invariably paired with cytosine. Two hydrogen bonds are formed between adenine and thymine, but three hydrogen bonds hold together guanine and cytosine



Structure

A DNA strand is a polymer of nucleoside monophosphates held together by phosphodiester bonds. Two such paired strands make up the DNA molecule, which is then twisted into a helix. In the most common Bform, the DNA helix has a repeat of 10.5 base pairs per turn, with sugars and phosphate forming the covalent phosphodiester "backbone" of the molecule and the adenine, guanine, cytosine, and thymine bases oriented in the middle where they form the now familiar base pairs that look like the rungs of a ladder.

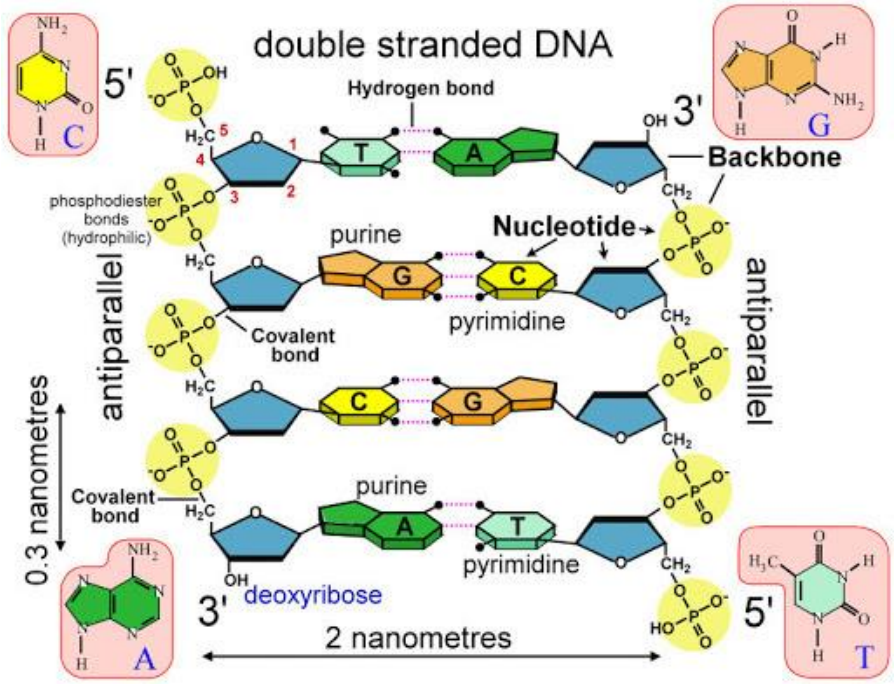
Nucleic acids are composed of **nucleotide monomers** linked together. Nucleotides have three parts:



- **A Nitrogenous Base**
- **A Five-Carbon (Pentose) Sugar**
- **A Phosphate Group**
- Nitrogenous bases include purine molecules (adenine and guanine) and pyrimidine molecules (cytosine, thymine, and uracil.) In DNA, the five-carbon sugar is deoxyribose, while ribose is the pentose sugar in RNA. Nucleotides are linked together to form polynucleotide chains.
- They are joined to one another by covalent bonds between the phosphate of one and the sugar of another. These linkages are called phosphodiester linkages. Phosphodiester linkages form the sugar-phosphate backbone of both DNA and RNA.
- Similar to what happens with protein and carbohydrate monomers, nucleotides are linked together through dehydration synthesis. In nucleic acid dehydration synthesis, nitrogenous bases are joined together and a water molecule is lost in the process.

- Interestingly, some nucleotides perform important cellular functions as "individual" molecules, the most common example being adenosine triphosphate or ATP, which provides energy for many cell functions.

DNA Structure



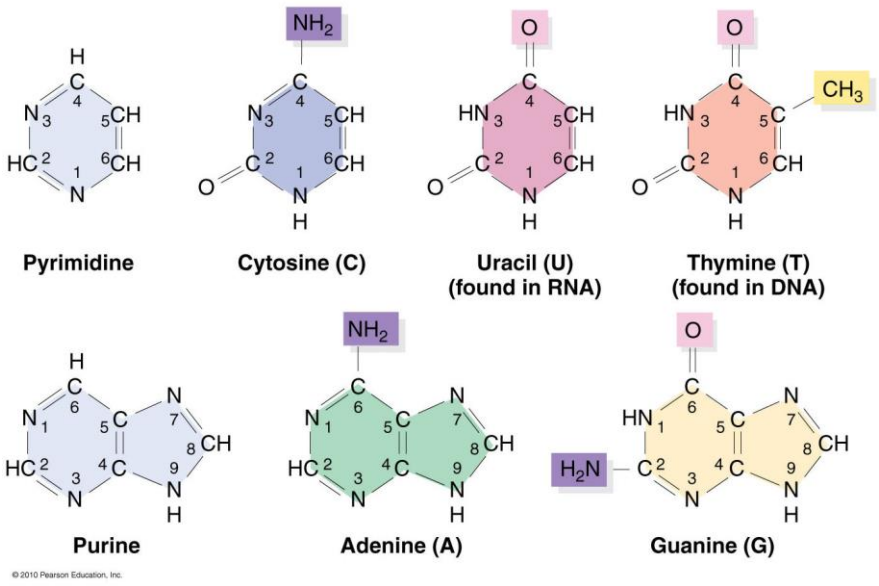
DNA is the cellular molecule that contains instructions for the performance of all cell functions. When a cell divides, its DNA is copied and passed from one cell generation to the next.

DNA is organized into chromosomes and found within the nucleus of our cells. It contains the "programmatic instructions" for cellular activities. When organisms produce offspring, these instructions are passed down through DNA.

DNA commonly exists as a double-stranded molecule with a twisted double-helix shape. DNA is composed of a phosphate-deoxyribose sugar backbone and the four nitrogenous bases:

- adenine (A)
- guanine (G)
- cytosine (C)
- thymine (T)

In double-stranded DNA, adenine pairs with thymine (A-T) and guanine pairs with cytosine (G-C).

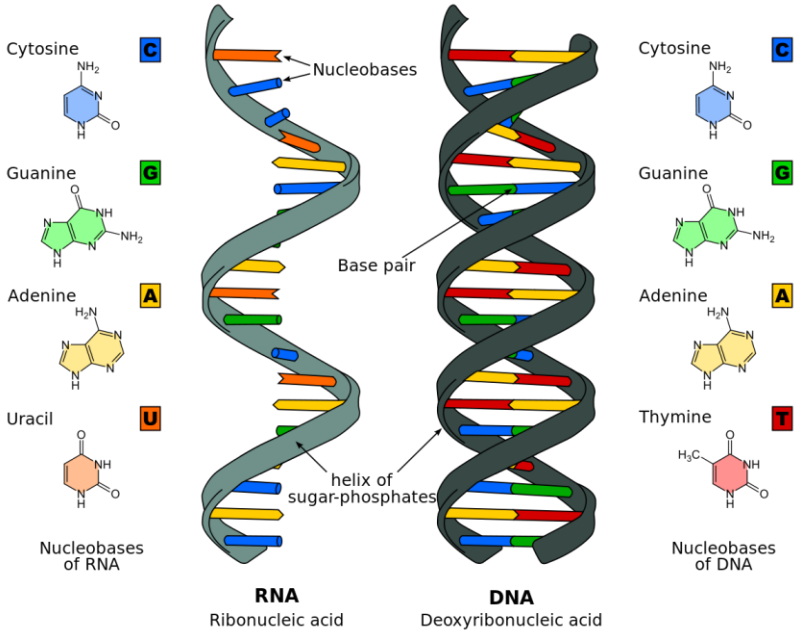


RNA Structure

RNA is essential for the synthesis of proteins. Information contained within the genetic code is typically passed from DNA to RNA to the resulting proteins. There are several types of RNA.

- **Messenger RNA (mRNA)** is the RNA transcript or RNA copy of the DNA message produced during DNA transcription. Messenger RNA is translated to form proteins.
- **Transfer RNA (tRNA)** has a three-dimensional shape and is necessary for the translation of mRNA in protein synthesis.
- **Ribosomal RNA (rRNA**) is a component of ribosomes and is also involved in protein synthesis.
- **MicroRNAs (miRNAs**) are small RNAs that help to regulate gene expression.

RNA most commonly exists as a single-stranded molecule composed of a phosphate-ribose sugar backbone and the nitrogenous bases adenine, guanine, cytosine and uracil (U). When DNA is transcribed into an RNA transcript during DNA transcription, guanine pairs with cytosine (G-C) and adenine pairs with uracil (A-U).


Cytosine
C
Guanine
G
Adenine
A
Uracil
U
Nucleobases of RNA
Nucleobases
Base pair
helix of sugar-phosphates
RNA
Ribonucleic acid
DNA
Deoxyribonucleic acid
Cytosine
C
Guanine
G
Adenine
A
Thymine
T
Nucleobases of DNA