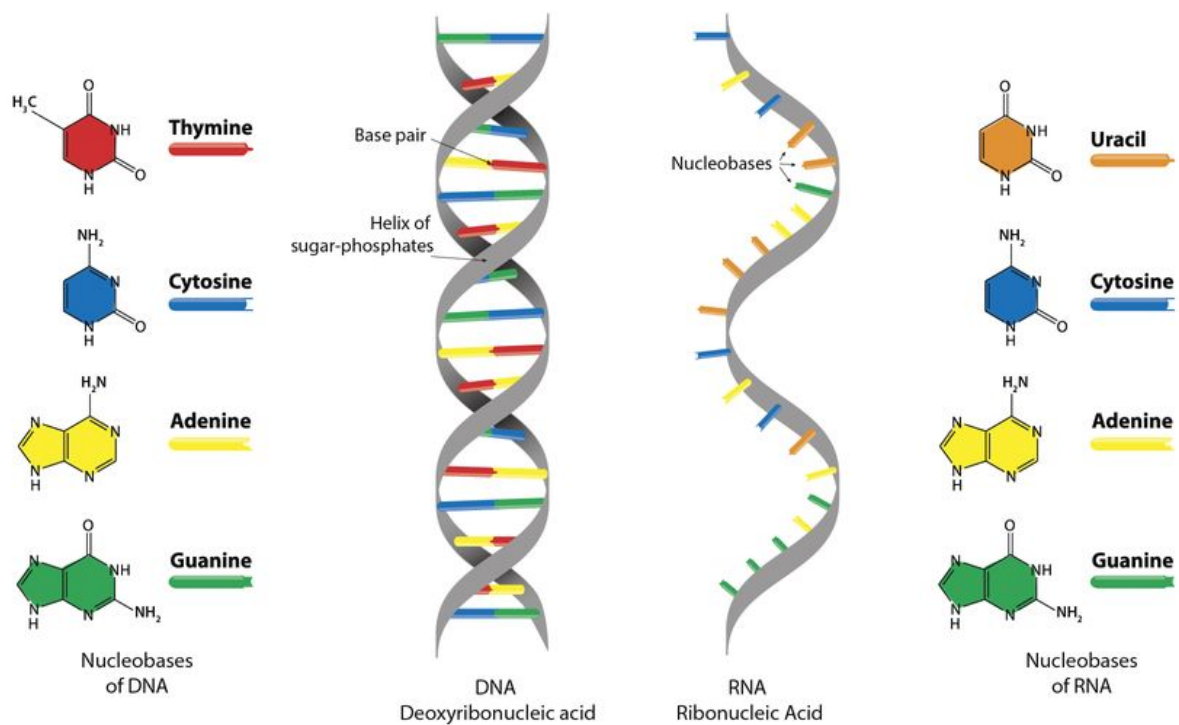


DNA vs. RNA – 5 Key Differences and Comparison

Article Published: December 18, 2020 | [RJ Mackenzie](#)



Credit: Technology Networks

DNA vs. RNA: The Key Differences. *Credit: Technology Networks via YouTube*

Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are perhaps the most important molecules in cell biology, responsible for the storage and reading of genetic information that underpins all life. They are both linear polymers, consisting of sugars, phosphates and bases, but there are some key differences which separate the two¹. These distinctions enable the two molecules to work together and fulfil their essential roles. Here, we look at 5 key differences between DNA and RNA. Before we delve into the differences, we take a look at these two

nucleic acids side-by-side.

Contents

[DNA vs. RNA – A comparison chart](#)

[What are the key differences between DNA and RNA?](#)

- Function
- Sugar
- Bases
- Structure
- Location

[Unusual types of DNA and RNA](#)

- Z-DNA
- A-DNA
- Triplex DNA
- dsRNA

[References](#)

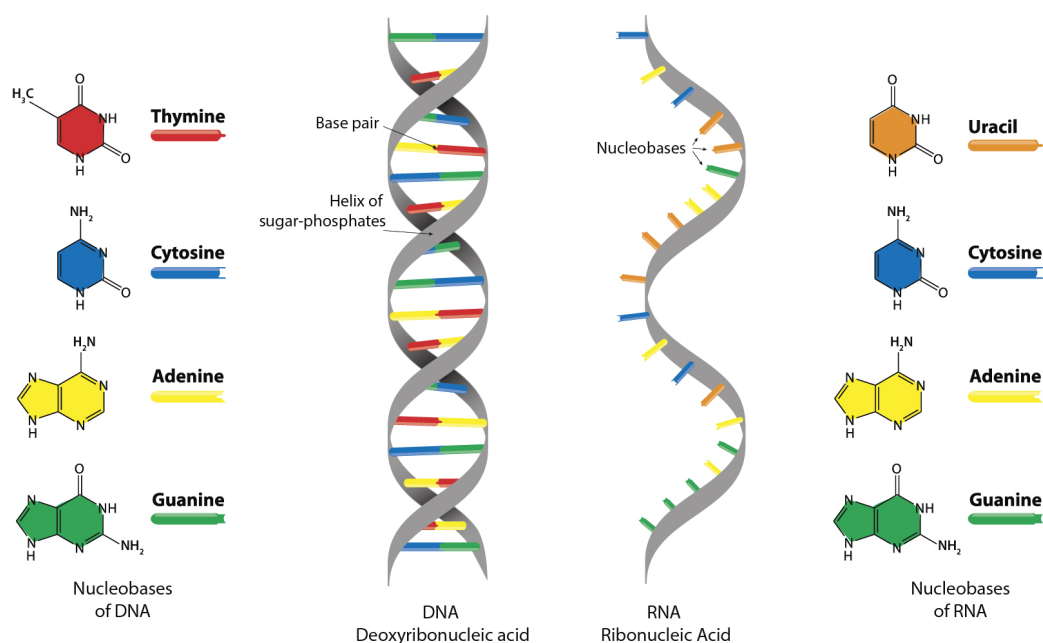


Figure 1: A comparison of the helix and base structure of RNA and DNA. *Credit: Technology Networks.*

DNA vs. RNA – A comparison chart

Comparison	DNA	RNA
Full Name	Deoxyribonucleic Acid	Ribonucleic Acid
Function	DNA replicates and stores genetic information. It is a	RNA converts the genetic information contained within

	blueprint for all genetic information contained within an organism.	DNA to a format used to build proteins, and then moves it to ribosomal protein factories.
Structure	DNA consists of two strands, arranged in a double helix. These strands are made up of subunits called nucleotides. Each nucleotide contains a phosphate, a 5-carbon sugar molecule and a nitrogenous base.	RNA only has one strand, but like DNA, is made up of nucleotides. RNA strands are shorter than DNA strands. RNA sometimes forms a secondary double helix structure, but only intermittently.
Length	DNA is a much longer polymer than RNA. A chromosome, for example, is a single, long DNA molecule, which would be several centimetres in length when unraveled.	RNA molecules are variable in length, but much shorter than long DNA polymers. A large RNA molecule might only be a few thousand base pairs long.
Sugar	The sugar in DNA is	RNA contains ribose sugar

	deoxyribose, which contains one less hydroxyl group than RNA's ribose.	molecules, without the hydroxyl modifications of deoxyribose.
Bases	The bases in DNA are Adenine ('A'), Thymine ('T'), Guanine ('G') and Cytosine ('C').	RNA shares Adenine ('A'), Guanine ('G') and Cytosine ('C') with DNA, but contains Uracil ('U') rather than Thymine.
Base Pairs	Adenine and Thymine pair (A-T) Cytosine and Guanine pair (C-G)	Adenine and Uracil pair (A-U) Cytosine and Guanine pair (C-G)
Location	DNA is found in the nucleus, with a small amount of DNA also present in mitochondria.	RNA forms in the nucleolus, and then moves to specialized regions of the cytoplasm depending on the type of RNA formed.
Reactivity	Due to its deoxyribose sugar, which contains one less	RNA, containing a ribose sugar, is more reactive than DNA and

	oxygen-containing hydroxyl group, DNA is a more stable molecule than RNA, which is useful for a molecule which has the task of keeping genetic information safe.	is not stable in alkaline conditions. RNA's larger helical grooves mean it is more easily subject to attack by enzymes.
Ultraviolet (UV) Sensitivity	DNA is vulnerable to damage by ultraviolet light.	RNA is more resistant to damage from UV light than DNA.

What are the key differences between DNA and RNA?

We can identify five key categories where DNA and RNA differ:

- Function
- Sugar
- Bases
- Structure
- Location

Function

DNA encodes all genetic information, and is the blueprint from which all biological life is created. And that's only in the short-term. In the long-term, [DNA is a storage device, a biological flash drive that allows the blueprint of life to be passed between generations](#)². RNA functions as the reader that decodes this flash drive. This reading process is multi-step and there are specialized RNAs for each of these steps. Below, we look in more detail at the three most important types of RNA.



Article

RNA-Seq: Basics, Applications and Protocol

[READ MORE](#)

What are the three types of RNA?

- Messenger RNA (**mRNA**) copies portions of genetic code, a process called [transcription](#), and transports these copies to ribosomes, which are the cellular factories that facilitate the production of proteins from this code.
- Transfer RNA (**tRNA**) is responsible for bringing amino acids, basic protein building blocks, to these protein factories, in response to the coded instructions introduced by the mRNA. This protein-building process is called translation.
- Finally, Ribosomal RNA (**rRNA**) is a component of the ribosome factory itself without which protein production would not occur¹.

Sugar

Both DNA and RNA are built with a sugar backbone, but whereas the sugar in DNA is called deoxyribose (left in image), the sugar in RNA is called simply ribose (right in image). The 'deoxy' prefix denotes that, whilst RNA has two hydroxyl (-OH) groups attached to its carbon backbone, DNA has only one, and has a lone hydrogen atom attached instead. RNA's extra hydroxyl group proves useful in the process of converting genetic code into mRNAs that can be made into proteins, whilst the deoxyribose sugar gives DNA more stability³.

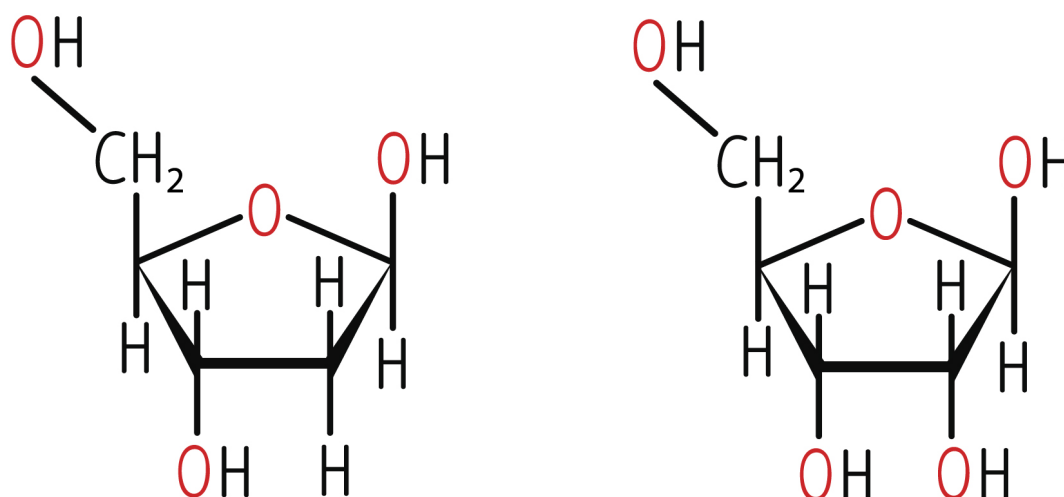


Figure 2: The chemical structures of deoxyribose (left) and ribose (right) sugars. *Credit: Technology Networks.*

Bases

The nitrogen bases in DNA are the basic units of genetic code, and their correct ordering and pairing is essential to biological function. The four bases that make up this code are adenine (A), thymine (T), guanine (G) and cytosine (C). Bases pair off together in a double helix structure, these pairs being A and T, and C and G. RNA doesn't contain thymine bases, replacing them with uracil bases (U), which

pair to adenine¹.

Structure

While the ubiquity of Francis Crick and James Watson's (or should that be [Rosalind Franklin's](#)?) DNA double helix means that the two-stranded structure of DNA structure is common knowledge, RNA's single-stranded format is not as well known.

RNA can form into double-stranded structures, such as during translation, when mRNA and tRNA molecules pair. DNA polymers are also much longer than RNA polymers; the 2.3m long human genome consists of 46 chromosomes, each of which is a single, long DNA molecule. RNA molecules, by comparison, are much shorter³.

Location

Eukaryotic cells, including all animal and plant cells, house the great majority of their DNA in the nucleus, where it exists in a tightly compressed form, called a chromosome⁴. This squeezed format means the DNA can be easily stored and transferred. In addition to nuclear DNA, some DNA is present in energy-producing mitochondria, small organelles found free-floating in the cytoplasm, the area of the cell outside the nucleus.

The three types of RNA are found in different locations. mRNA is made in the nucleus, with each mRNA fragment copied from its relative piece of DNA, before leaving the nucleus and entering the cytoplasm. The fragments are then shuttled around the cell as needed, moved along by the cell's internal transport system, the cytoskeleton. tRNA, like mRNA, is a free-roaming molecule that moves around the cytoplasm. If it receives the correct signal from the ribosome, it will then hunt down amino acid subunits in the cytoplasm and bring them to the ribosome to be built into proteins⁵. rRNA, as previously mentioned, is found as part of ribosomes. Ribosomes are formed in an area of the nucleus called the nucleolus, before being exported to the cytoplasm, where some ribosomes float freely. Other cytoplasmic ribosomes are bound to the endoplasmic reticulum, a membranous structure that

helps process proteins and export them from the cell⁵.

Unusual types of DNA and RNA

The structure we have described in this article is certainly the most common form of DNA, but it isn't the whole story. Other forms of both DNA and RNA exist that subvert the classical structures of these nucleic acids.

Z-DNA

While the structure of DNA you will see above – and in any biology textbook you might care to open – has a right-handed helix, DNA molecules with left-handed helices also exist. These are known as Z-DNA. Canonical, “classic” DNA is called B-DNA.

Z-DNA [molecules](#) are:

- Thinner (18 Å wide as opposed to 20 Å wide B-DNA)
- Have a different repeating unit (two base pairs as opposed to one)
- Have different twist angles between bases

Z-DNA is thought to play a role in [regulating](#) gene expression and may be [produced](#) in the wake of DNA processing enzymes, like DNA polymerase.

A-DNA

Identified at the same time as B-DNA by Rosalind Franklin, A-DNA is an alternative DNA [structure](#) that often appears when the molecule is dehydrated. Many crystal structures of DNA are in an A-DNA form. It has a shorter structure, with different numbers of base pairs per turn and tilt than B-DNA. A-DNA's biological relevance has been greatly expanded on in recent years, and it is now recognized that A-DNA is [involved in](#) many roles, such as:

- Binding to DNA enzymes, such as polymerases – this transition may enable specific atoms to be exposed for enzymatic action.
- Protection from damage – A-DNA is far less susceptible to ultraviolet ray damage, and spore-forming bacteria have been shown to adopt an A-DNA conformation, which may be a protective change.

Triplex DNA

A triple-helix DNA structure can form when certain nucleobases – pyrimidine or purine – occupy the major grooves in conventional B-DNA. This can happen naturally or as part of intentional DNA-modifying strategies for research purposes.

Triplex-forming oligonucleotides (TFOs) can [bind](#) conventional two-stranded DNA, which can help guide agents that are used to [modify](#) DNA to specific genomic locations. [H-DNA](#) is an endogenous, triple-stranded DNA molecule that encourages mutation of the genome.

dsRNA

[Double-stranded RNA \(dsRNA\)](#) is most commonly found as the genomic basis of many plant, animal and human viruses. These include *Reoviridae* and the rotaviruses, which are responsible for diseases like gastroenteritis. dsRNA molecules are potent immunogens – they activate the immune system, which then cuts the dsDNA as a protective mechanism. The discovery of the protein machinery that permits this reaction led to the development of gene-silencing RNAi technology, which won the [2006 Nobel Prize for Physiology or Medicine](#).

References *(Click to expand)*

+

References

1. Berg JM, Tymoczko JL, Stryer L, Berg JM, Tymoczko JL, Stryer L. *Biochemistry*. 5th ed. W H Freeman; 2002. https://www.ncbi.nlm.nih.gov/books/NBK21154/?utm_source=296719&utm_medium=pdf&utm_campaign=pdf_lead_conversion?utm_source=296719&utm_medium=pdf&utm_campaign=pdf_lead_conversion?utm_source=296719&utm_medium=pdf&utm_campaign=pdf_lead_conversion?utm_source=296719&utm_medium=pdf&utm_campaign=pdf_lead_conversion
2. Watson JD, Crick FHC. The Structure of Dna. *Cold Spring Harb Symp Quant Biol*. 1953;18:123-131. doi:[10.1101/SQB.1953.018.01.020](https://doi.org/10.1101/SQB.1953.018.01.020)
3. Holbrook SR. RNA structure: the long and the short of it. *Current Opinion in Structural Biology*. 2005;15(3):302-308. doi:[10.1016/j.sbi.2005.04.005](https://doi.org/10.1016/j.sbi.2005.04.005)
4. Nicodemi M, Pombo A. Models of chromosome structure. *Current Opinion in Cell Biology*. 2014;28:90-95. doi:[10.1016/j.ceb.2014.04.004](https://doi.org/10.1016/j.ceb.2014.04.004)
5. Thomson E, Ferreira-Cerca S, Hurt E. Eukaryotic ribosome biogenesis at a glance. *Journal of Cell Science*. 2013;126(21):4815-4821. doi:[10.1242/jcs.111948](https://doi.org/10.1242/jcs.111948)