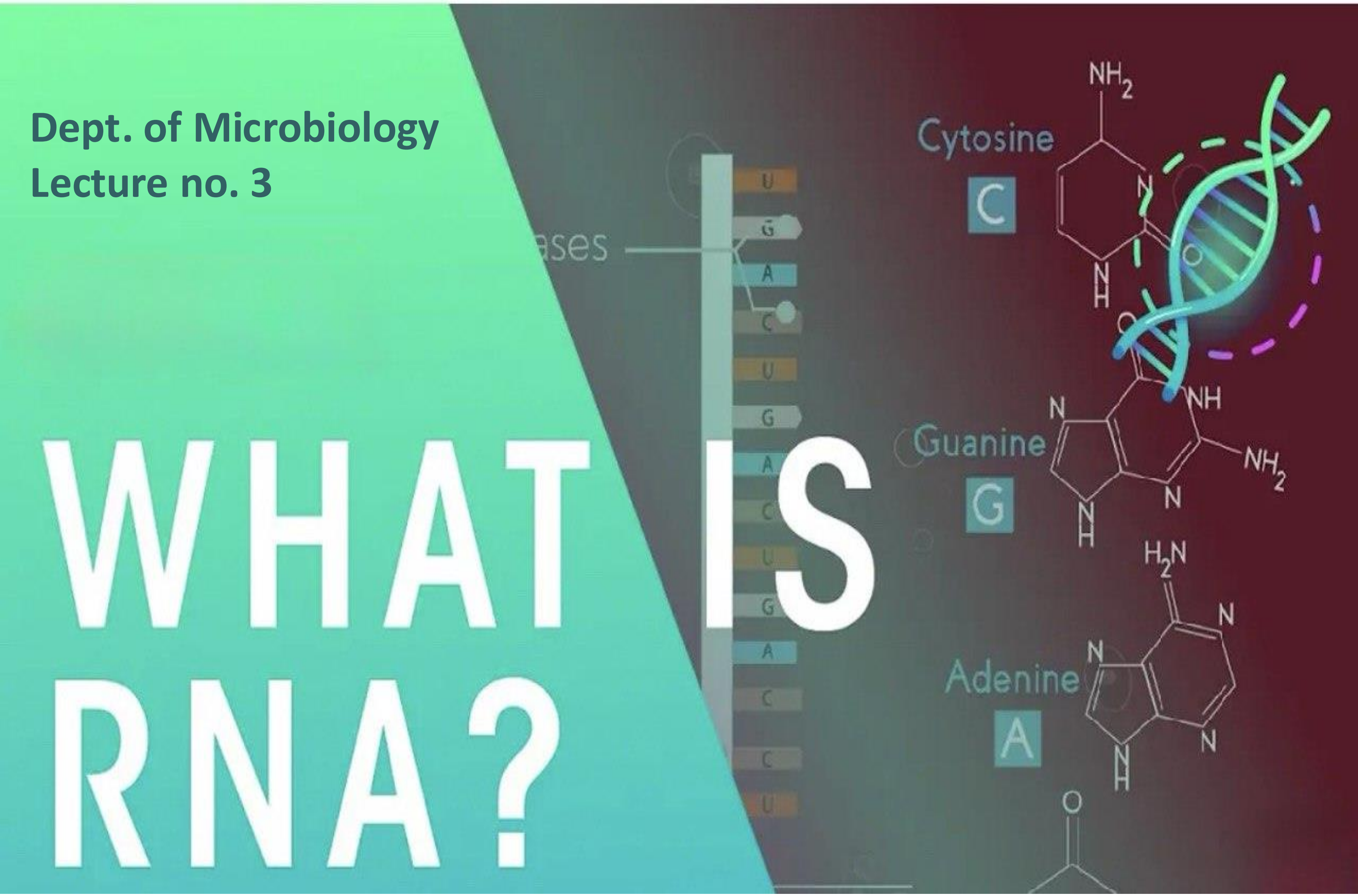
Dept. of Microbiology
Lecture no. 3



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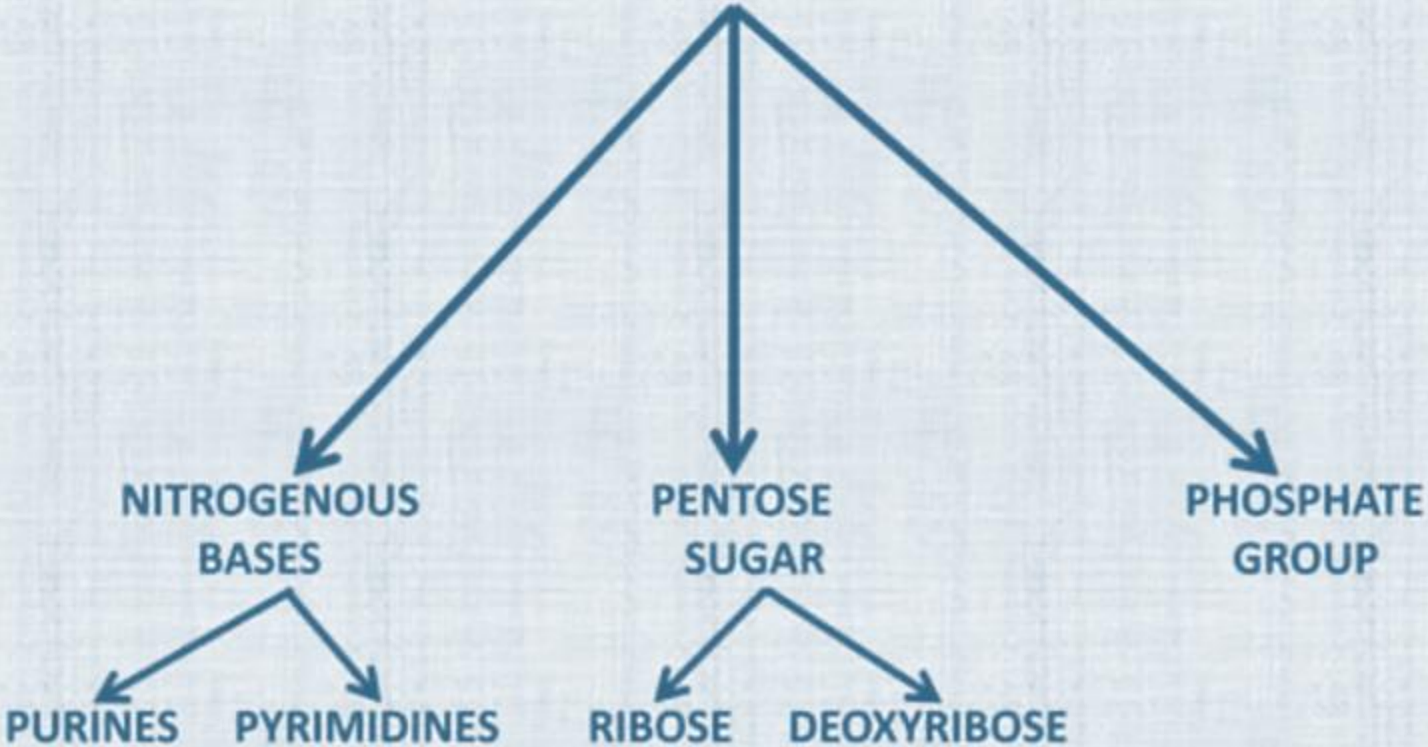
General Objectives:

1. To understand the basic structure of RNA (ribonucleotides, ribose sugar, nitrogenous bases including Uracil).
2. To compare and contrast DNA and RNA in terms of sugar, bases, structure, location, function, and stability.
3. To identify the three main types of RNA (messenger mRNA, transfer tRNA, ribosomal rRNA) and the function of each.
4. To explain the central role of RNA in protein synthesis (as a copy of genetic code and a carrier of amino acids).

Nucleotide


NITROGENOUS BASES
PENTOSE SUGAR
PHOSPHATE GROUP
PURINES
PYRIMIDINES
RIBOSE
DEOXYRIBOSE

Ribonucleic acid

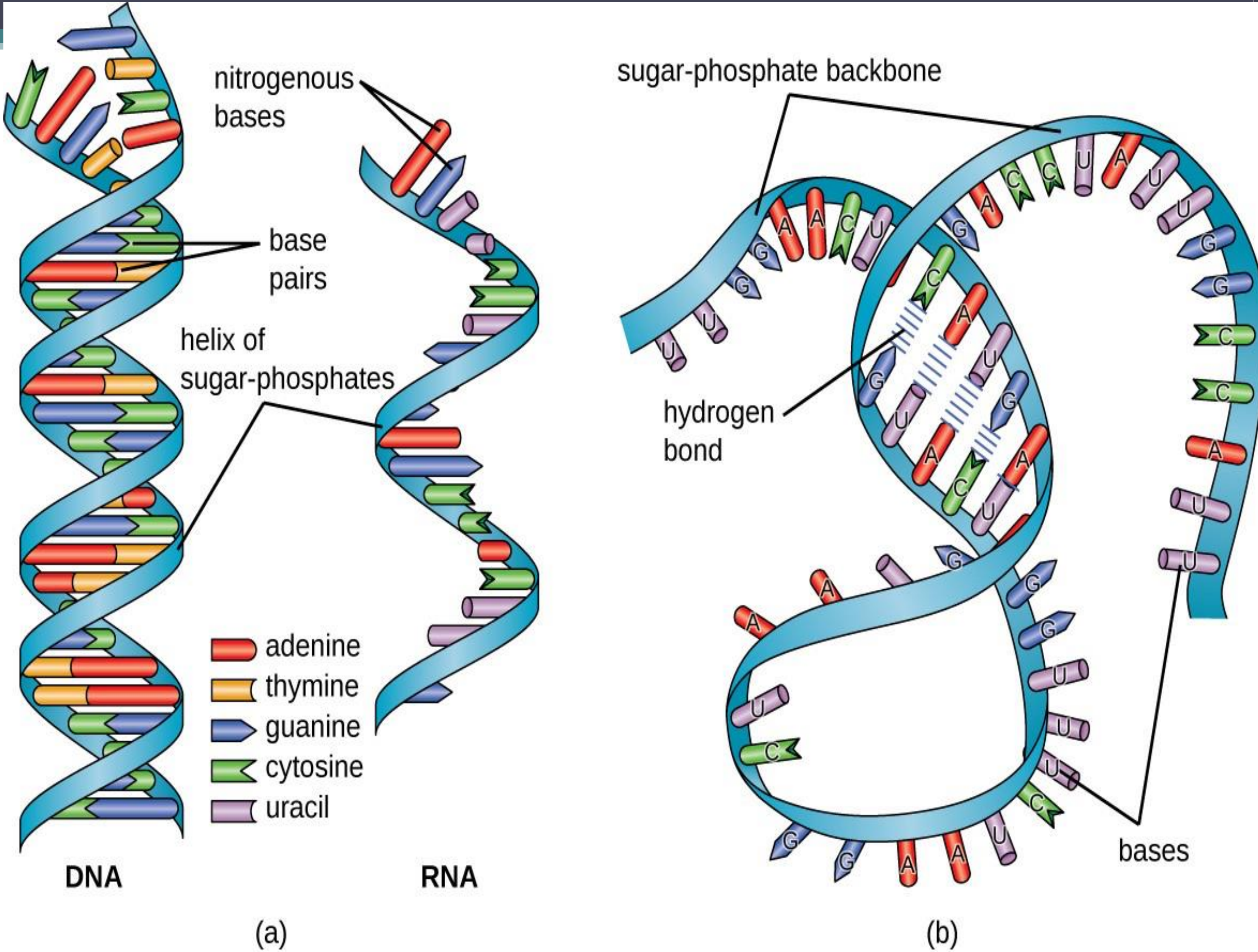
A nucleic acid present in all living cells. Its principal role is to act as a messenger carrying instructions from DNA for controlling the synthesis of proteins, although in some viruses RNA rather than DNA carries the genetic information. RNA, abbreviation of ribonucleic acid, complex compound of high molecular weight that functions in cellular protein synthesis and replaces DNA (deoxyribonucleic acid) as a carrier of genetic codes in some viruses.

RNA consists of ribose nucleotides (nitrogenous bases appended to a ribose sugar) attached by phosphor- diester bonds, forming strands of varying lengths. The nitrogenous bases in RNA are adenine, guanine, cytosine, and uracil, which replaces thymine in DNA. The ribose sugar of RNA is a cyclical structure consisting of five carbons and one oxygen. The presence of a chemically reactive hydroxyl (−OH) group attached to the second carbon group in the ribose sugar molecule makes RNA prone to hydrolysis.

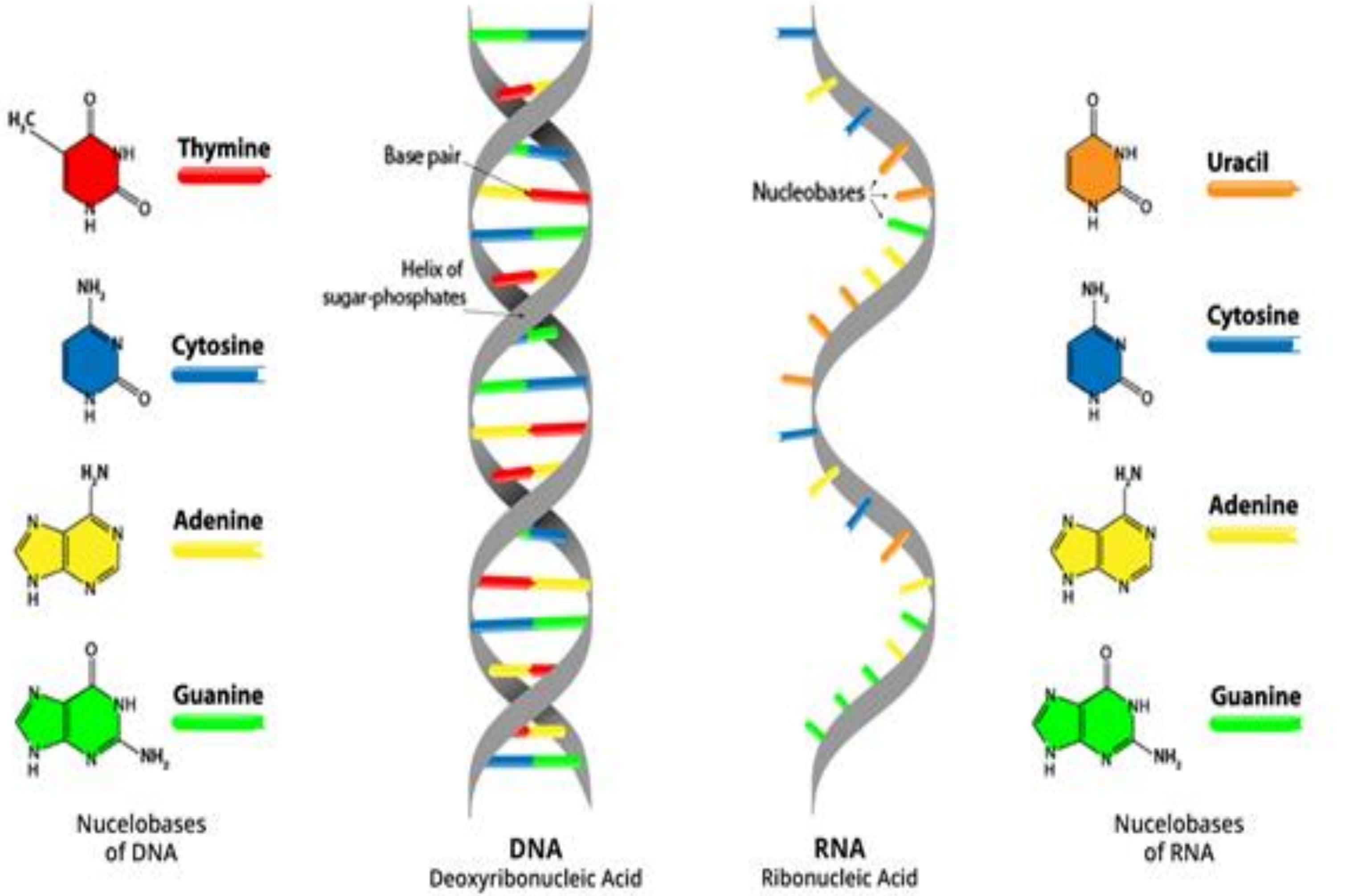
This chemical labiality of RNA, compared with DNA, which does not have a reactive −OH group in the same position on the sugar moiety (deoxyribose), is thought to be one reason why DNA evolved to be the preferred carrier of genetic information in most organisms. The structure of the RNA molecule was described by R.W. Holley in 1965.

RNA Structure

RNA typically is a single-stranded biopolymer. However, the presence of selfcomplementary sequences in the RNA strand leads to intra-chain base-pairing and folding of the ribonucleotide chain into complex structural forms consisting of bulges and helices. The three-dimensional structure of RNA is critical to its stability and function, allowing the ribose sugar and the nitrogenous bases to be modified in numerous different ways by cellular enzymes that attach chemical groups to the chain. Such modifications enable the formation of chemical bonds between distant regions in the RNA strand, leading to complex contortions in the RNA chain, which further stabilizes the RNA structure. Molecules with weak structural modifications and stabilization may be readily destroyed.


nitrogenous bases
base pairs
helix of sugar-phosphates
adenine
thymine
guanine
cytosine
uracil
DNA
RNA
(a)
sugar-phosphate backbone
hydrogen bond
bases
(b)

DNA vs. RNA – 5 Key Differences and Comparison



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 blueprint for all genetic information contained within an organism	RNA converts the genetic information contained within 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 unravelled.	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 deoxyribose, which contains one less hydroxyl group than RNA's ribose.	RNA contains ribose sugar 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 specialised regions of the cytoplasm depending on the type of RNA formed.
Reactivity	Due to its deoxyribose sugar, which contains one less 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.	RNA, containing a ribose sugar, is more reactive than DNA and 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.

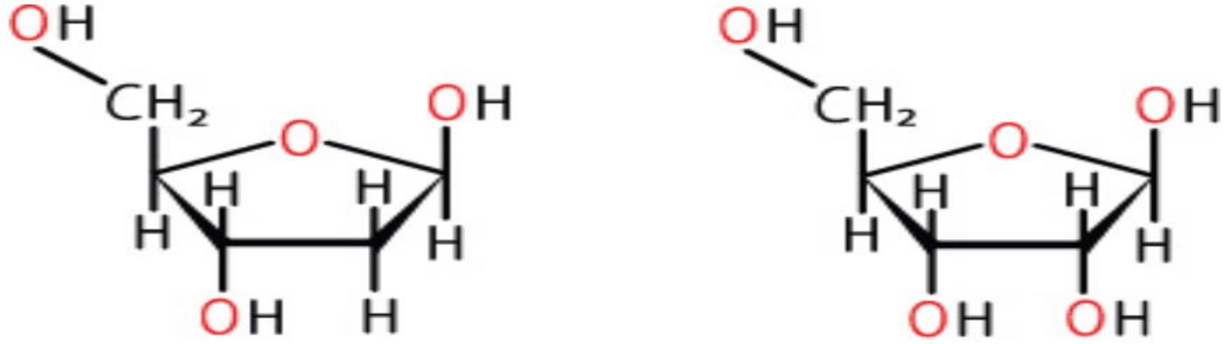
What are the key differences between DNA and RNA?

➢ ***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. 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.

➢ *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 stability.



The Chemical Structures of Deoxyribose (left) and Ribose (right) Sugars

➢ *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 adenine.

➢ *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 chromosome. 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.

➢ *STRUCTURE*

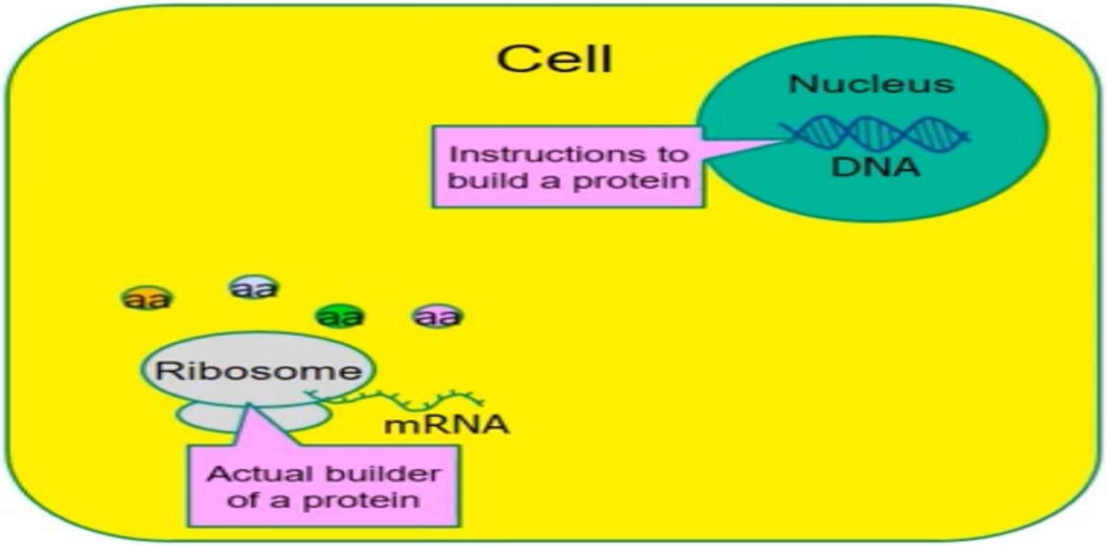
Whilst the ubiquity of Francis Crick and James Watson's DNA double helix means that the two-stranded structure of DNA structure is common knowledge, RNA's single stranded format is not as well known. RNA can form into double-stranded structures, such as during translation, when mRNA and tRNA molecules 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 shorter.

What are the three types of RNA?

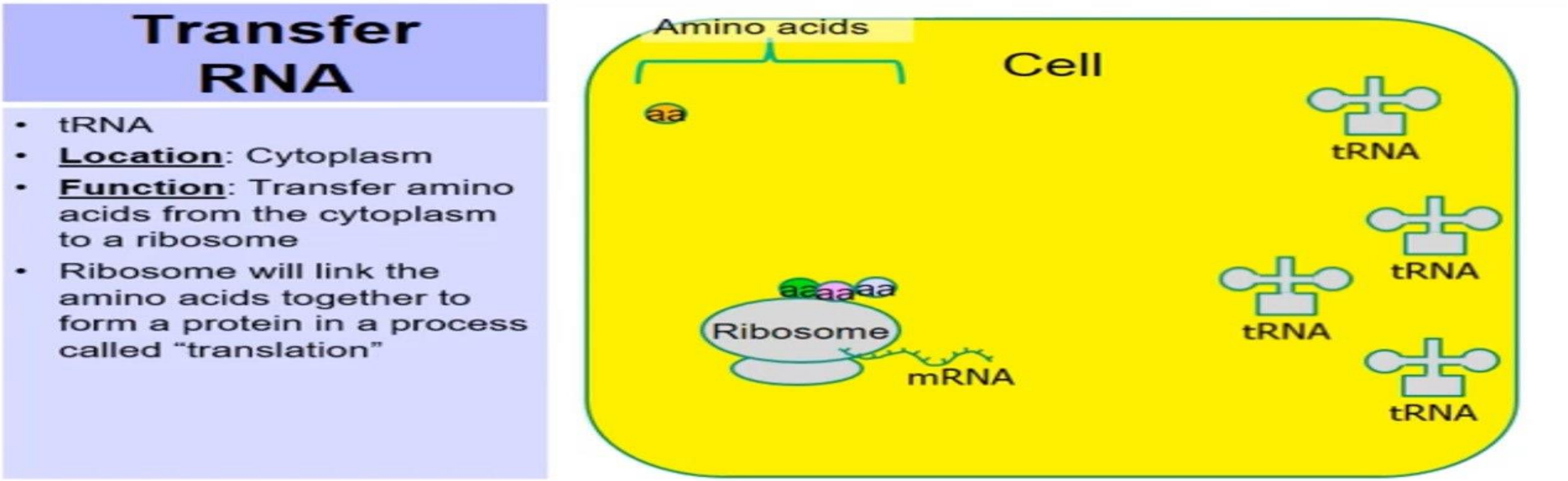
A. Messenger RNA (mRNA): copies portions of genetic code, a process called transcription, and transports these copies to ribosomes, which are the cellular factories that facilitate the production of proteins from this code.

Messenger RNA

- mRNA
- **Location**: Starts in nucleus… moves to ribosome
- **Function**: Delivers a copy of the DNA code to a ribosome
- Once the ribosome has the mRNA instructions, it can then build a protein in the process called "translation"



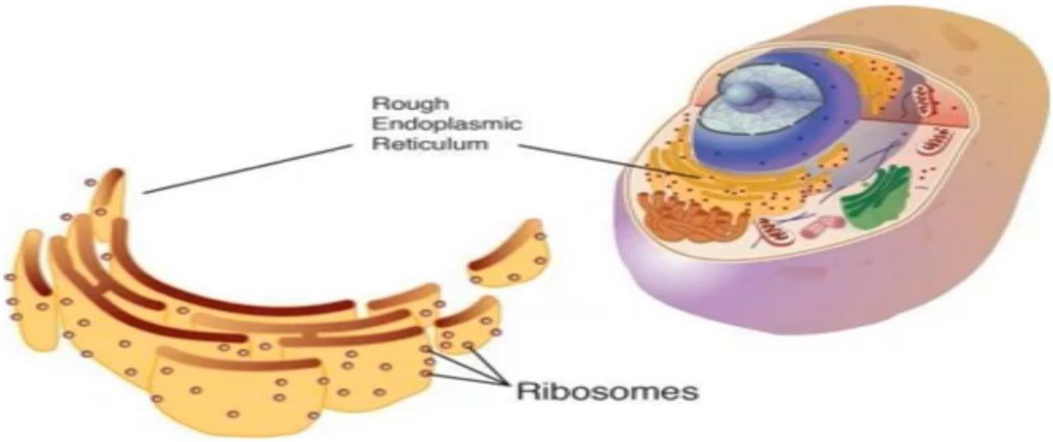
B. Transfer RNA (tRNA) : responsible for bringing amino acids, basic protein building blocks, to these protein factories, in response to the coded instructions introduced by the mRNA. This protein-building process is called translation.

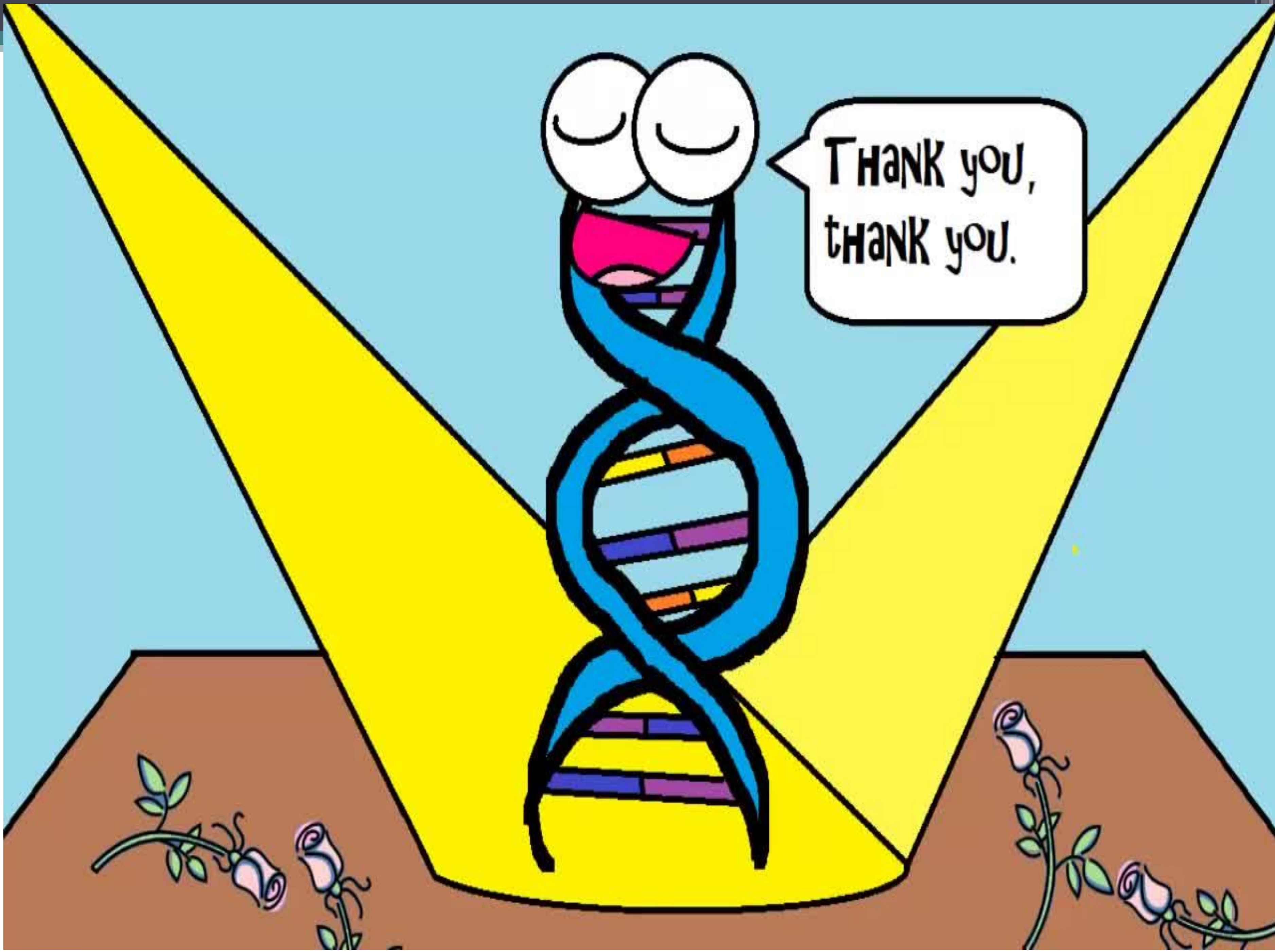


C. Ribosomal RNA (rRNA) **:** a component of the ribosome factory itself without which protein production would not occur.

Ribosomal RNA

- rRNA
- **Function**: main component of ribosomes
  - rRNA bonds with special proteins to form a ribosome
  - Ribosome = organelle that builds proteins

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