Nucleic acid biology: essential macromolecules for life's survival

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Dumbell Y. Nucleic acid biology: essential macromolecules for life's survival. J Biomol Biochem. 2022;6(1):03.

ABSTRACT

The nucleic acids, which are macromolecules made up of nucleotide units, exist in two types: deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) (RNA). DNA is the genetic substance that can be found in all living things, from single-celled bacteria to multicellular animals like you and me. Although some viruses employ RNA rather than DNA as their genetic material, they aren't really living (since they cannot reproduce without help from a host). DNA is found in the nucleus, a specialized, membrane-bound vault in the cell, as well as in certain other types of organelles in eukaryotes, such as plants and animals (such as mitochondria and the chloroplasts of plants). Although DNA is contained in a specific cell area termed the nucleoid in prokaryotes, such as bacteria, it is not covered in a membrane envelope. DNA is often divided up into a number of very long, linear segments called chromosomes in eukaryotes, but chromosomes in prokaryotes, such as bacteria, are much smaller and often circular (ring-shaped). A chromosome can include tens of thousands of genes, each of which gives instructions on how to manufacture a specific product that the cell requires. Many genes code for protein products, which means they define the amino acid sequence utilized to make a certain protein. However, before this information can be utilized to make proteins, an RNA copy (transcript) of the gene must be created. Messenger RNA (mRNA) is a form of RNA that acts as a link between DNA and ribosomes, which are molecular engines that read mRNA sequences and use them to make proteins. The "core dogma" of molecular biology is the pathway from DNA to RNA to protein. Not all genes produce protein products, which is important to note. Some genes, for example, code for ribosomal RNAs (rRNAs), which are structural components of ribosomes, or transfer RNAs (tRNAs), which are cloverleaf-shaped RNA molecules that transport amino acids to the ribosome for protein synthesis. Other RNA molecules, such as small microRNAs (miRNAs), operate as gene regulators, and new non-protein-coding RNAs are being found all the time. DNA and RNA are polymers (sometimes very long polymers in the case of DNA) made up of monomers called nucleotides. A polynucleotide is formed when these monomers unite to form a chain. A nitrogen-containing ring structure termed a nitrogenous base, a five-carbon sugar, and at least one phosphate group make up each nucleotide. With the base connected to one of its carbons and the phosphate.

INTRODUCTION

The sugar molecule occupies a pivotal position in the nucleotide. Let's take a look at each component of a nucleotide one by one. Adenine (A), Guanine (G), Cytosine (C), and Thymine (T) are the four nitrogenous bases that may be found in DNA (T). Purines, such as adenine and guanine, have two joined carbon-nitrogen rings in their architecture. In contrast, cytosine and thymine are pyrimidines with a single carbon-nitrogen ring. Adenine, guanine, and cytosine bases can also be found in RNA nucleotides, but instead of thymine, they have uracil, a pyrimidine base (U). Each base has its own structure, as illustrated in the diagram, with its own collection of functional groups connected to the ring structure. A single phosphate group, or a chain of up to three phosphate groups, can be added to the sugar's 5' carbon in nucleotides. Although some chemical sources limit the term "nucleotide" to the single-phosphate case, the broader meaning is widely recognised in molecular biology. A nucleotide nearing the end of a polynucleotide chain in a cell will have a succession of three phosphate groups. The nucleotide loses two phosphate groups as it enters the developing DNA or RNA chain. Each nucleotide in a DNA or RNA strand has only one phosphate group. Chains of deoxyribonucleic acid, or DNA, are usually found in a double helix, which is a configuration in which two complementary (matching) chains are locked together, as seen in the diagram at left. The sugars and phosphates on the exterior of the helix make up the backbone of DNA, which is frequently referred to as the sugar-phosphate backbone. The nitrogenous bases extend into the interior in pairs, like the steps of a staircase; each pair's bases are linked by hydrogen bonds. A protein-coding gene and its protein output are separated by Messenger RNA (mRNA). When a cell needs to generate a certain protein, the gene encoding that protein is turned "on" which means an RNA-polymerizing enzyme is summoned to create an RNA copy of the gene's DNA sequence, known as a transcript. The transcript has the same information as the gene's DNA sequence. In the RNA molecule, however, the letter T is substituted with the base U. If a DNA coding strand contains the sequence 5'-AATTGCGC-3', the equivalent RNA will have the sequence 5'-AAUUGCGC-3'. Ribosomal RNA (rRNA) is a key component of ribosomes, where it assists mRNA in binding to the correct location so that its sequence information can be read. Some rRNAs also function as enzymes, which means they aid in the speeding up (catalysing) of chemical processes, such as the creation of bonds between amino acids to make proteins. Ribozymes are RNAs that function as enzymes. Non-coding RNAs (RNAs that do not code for proteins) have a role in regulating the expression of other genes. These RNAs are known as regulatory RNAs. MicroRNAs (miRNAs) and small interfering RNAs (siRNAs) are two examples. Small regulatory RNA molecules, or siRNAs, are around 22 nucleotides long. They attach to certain mRNA molecules (with partially or totally complementary sequences) and diminish their stability or interfere with translation, allowing the cell to reduce or fine-tune mRNA levels.

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Received: 20-Jan-2022, Manuscript No. PULJBB-22-4324; Editor assigned: 22-Jan-2022, PreQC No. PULJBB-22-4324 (PQ); Reviewed:15-Feb-2022, QC No. PULJBB-22-4324 (Q); Revised:28-Feb-2022, Manuscript No. PULJBB-22-4324 (R); Published:10-Mar-2022; DOI: 10.37532/puljbb.22.6(1).03