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Review Article

Nucleic Acid Metabolism

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Abstract

The process through which nucleic acids (DNA and RNA) are created and broken down is known as nucleic acid metabolism. Polymers of nucleotides make up nucleic acids. A typical anabolic process that involves a chemical reaction is nucleotide synthesis, composed of a nitrogenous base, pentose sugar, and phosphate (Delaimy WK et al., 2002). A catabolic process occurs when nucleic acid is destroyed. Nucleotides can also be created from fragments of other nucleotides or nucleobases. Enzymes are needed to promote synthesis and degradation processes. These enzymes can have flaws or deficits that cause a number of illnesses (Armitage A et al., 1978).

Keywords: Polymers, Nucleic acids, Nucleotides, Enzymes

INTRODUCTION

As a component of every cell, nucleic acids are necessary for all living forms. Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), the two naturally occurring forms of nucleic acids, are the two types. Biopolymers, which are naturally occurring, repeatedly set monomers (forming polymers) that then make nucleotides, which then form nucleic acids, are the building blocks of nucleic acids. Understanding the structure of the nucleotides that make up nucleic acid is crucial for comprehending the structure of nucleic acid (Armstrong DW et al., 1998).

Phosphoryl transfer processes predominate in the metabolism of nucleic acids. These include the chemical processes that DNA and RNA polymerases use to catalyse the production of DNA and RNA. In these processes, a molecule of pyrophosphate is produced when the hydroxyl group at the 3′ end of an RNA or DNA strand attacks the -phosphate of an incoming (deoxy)ribonucleotide triphosphate [d]NTP to generate a new phosphodiester bond. In DNA and RNA cleavage, a similar phosphoryl transfer takes place, with the exception that the nucleic acid backbone is being attacked, and the nucleophile is either a water molecule or a sugar hydroxyl. A 5′ phosphate and a 3′ hydroxyl are the cleavage products when a water molecule is the nucleophile. The 5′ end product is covalently connected to the ribonucleotide when the 2′ or 3′ hydroxyl group of a ribonucleotide is the nucleophile, as in RNA splicing, catalysed by the group I and group II self-splicing ribozymes. A DNA transposition or exon ligation, both of which are important in RNA splicing, may take place if the nucleophile is the terminal 3′ hydroxyl of a DNA or RNA strand (Asimus S et al., 2008).

There are three bonds between the elements that make up a nucleotide. A phosphate group, a sugar with five carbons, and a nitrogen base make up the three components.

Phosphate family

A phosphorus atom with four negatively charged oxygen atoms connected makes up the phosphate group.

Five-carbon sugar

The pentose, a sugar with five carbons, contains the nucleic acids ribose and deoxyribose. Deoxyribose and ribose both contain one oxygen atom and five carbon atoms. Hydrogen atoms and hydroxyl groups are joined to the carbon atoms (Bendayan R et al., 1990).

The second and third carbon atoms of ribose sugar are joined by hydroxyl groups. The third carbon atom in deoxyribose sugar has a hydroxyl group connected to it, whereas the second carbon atom just has a hydrogen atom (Benowitz NL 1990).

Nitric acid base

Because it has the ability to donate electrons to other

molecules and so generate new molecules, the nitrogen molecule functions as a base in nucleic acid. It may form ring structures by joining with molecules of carbon, hydrogen, and oxygen. Pyrimidines have single-ring structures, while purines have double-ring structures. Thymine, cytosine, and uracil are pyrimidines. Adenine and guanine are examples of purines. Purines and pyrimidines differ in size, and this helps to determine how they couple together in DNA strands (Benowitz NL 1996).

Bonds in nucleic acids

Glycosidic and ester linkages are what hold the phosphorus, sugar, and nitrogen molecules together. A 5-carbon sugar's initial carbon atom and a nitrogenous base's ninth nitrogen atom form glycosidic linkages. The phosphate group and the fifth carbon atom of a 5-carbon sugar form ester linkages. These bonds serve to bind together nucleotides in chains to form polynucleotides, which are then combined to produce deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). The phosphate group that is attached to the fifth carbon atom of a 5-carbon sugar will bond to the third carbon atom of the subsequent 5-carbon sugar to form these chains (Novotny TE et al., 1999). A chain with a sugar-phosphate backbone will be produced by repeating this process. A strand of RNA will be generated if the sugar in this chain is a ribose sugar. The RNA strand forms a hydrogen bond with a polynucleotide that has an antiparallel structure and a similar structure to DNA. The pyrimidines and purines in the nitrogen bases are joined by these hydrogen bonds. Guanine and cytosine link up in a process known as complementary base pairing, whereas adenine and thymine do the same. This improves the base pairs' energy efficiency, and this pattern will always be followed by them (Armstrong DW et al., 1998).

Synthesis

The monomers that polymerize into nucleic acids are called nucleotides. All nucleotides include a nitrogenous base, a phosphate, and a sugar. Either purines or pyrimidines serve as the bases in nucleic acids. They are both largely created in the liver of more complex multicellular creatures, although the two distinct groups are synthesised in various ways. However, phosphoribosyl pyrophosphate (PRPP), which provides the phosphate and ribose needed to make a nucleotide, is required for all nucleotide synthesis (Thorgeirsson TE et al., 2008).

The two nucleotides categorised as purines are adenine and guanine. PRPP is converted into inosine monophosphate, or IMP, during the production of purines. Among other things, glutamine, glycine, aspartate, and 6 ATP are needed for the production of IMP from PRPP. AMP (adenosine monophosphate) is then produced from IMP by utilising GTP and aspartate, which is changed into fumarate. The creation of GMP (guanosine monophosphate) involves an intermediary step in which NAD+ is utilised to create the intermediate xanthosine monophosphate, or XMP, whereas IMP may be immediately converted to AMP (Hawkins BT et al., 2004). The hydrolysis of 1 ATP and the conversion of glutamine to glutamate are then used to turn XMP into GMP. Kinases that include extra phosphates can then convert AMP and GMP into ATP and GTP, respectively. GTP encourages the synthesis of ATP, whereas ATP stimulates the synthesis of GTP. Because of this cross control, the proportions of ATP and GTP remain constant. The chance of DNA mutations, when the incorrect purine nucleotide is introduced, may rise if either nucleotide is present in excess. Hypoxanthine-guanine phosphoribosyltransferase, or HGPRT, is an enzyme that catalyses the reversible process of guanine synthesis from GMP, and its absence results in Lesch-Nyhan syndrome. This sex-related congenital abnormality results in an excessive production of uric acid, as well as mental impairment, spasticity, and a desire to harm oneself (Cogo K et al., 2008).

Cytidine, uridine, and thymidine are examples of pyrimidine nucleosides. Any pyrimidine nucleotide's synthesis starts with the synthesis of uridine. Aspartate, glutamine, bicarbonate, two ATP molecules (to supply energy), and PRPP, which supplies ribose-monophosphate, are all needed for this process. The sugar/phosphate group from PRPP is introduced to the nitrogenous base later in the process than it is in purine synthesis (Yildiz D 2004). Uridine-monophosphate can be created and then react with two ATP molecules to create uridine-triphosphate, or UTP. CTP synthetase can catalyse the conversion of UTP to CTP (cytidine-triphosphate). Prior to the base being methylated to form thymidine, the uridine must first be reduced to deoxyuridine. The production of pyrimidines is activated by the purine nucleotide ATP and inhibited by the pyrimidine nucleotide CTP. Because equal levels of purines and pyrimidines are needed for DNA synthesis, this control helps to maintain the purine/pyrimidine proportions in a comparable range. Deficiencies of enzymes involved in pyrimidine synthesis can lead to the genetic disease Orotic acid excretion in the urine is considerable in those with orotic aciduria (Brunnemann KD et al., 1996).

CONCLUSION

Polymers of nucleotides make up nucleic acids. Both a nitrogen base (purine or pyrimidine) and a phosphate group are connected to a five-carbon sugar (D-ribose or D-deoxyribose) in the latter. Nucleosides are nucleotides without the phosphate group. The purine and pyrimidine nucleotides those are most common in cellular nucleic acids. They exist as the monophosphate forms shown as well as the nucleoside diphosphates (NDP) and triphosphates (NTP) in their unpolymerized condition. The bases of nucleic acids are projected from the backbone of alternating sugar and phosphate residues in polymerized states because the phosphate on the 5'-OH of the sugar is connected to the 3'-OH of the nearby sugar residue (Campain JA 2004). There are two different kinds of nucleic acids: ribonucleic acid (RNA) and deoxyribonucleic acid (DNA), both of which are polymers of ribonucleotides. Purine and pyrimidine

nucleotide production and breakdown, their use in DNA and RNA synthesis, and the structure, localization, and function of these nucleic acids are all aspects of nucleic acid metabolism.

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