Class: M.Sc.
Semester :IV (Parasitology)
Course : XV A Physiology & Biochemistry of Parasites
Unit : 2c
Prof.H.S.Singh

NUCLEIN ACID IN PARASITES

Composition

There are two major classes of nucleic acids: DNA and RNA.

Both are composed of un-branched chains of units called nucleotides, each of which contains:

(1) A nitrogenous base (either a purine or pyrimidine),

(2) A pentose, and

(3) Phosphoric acid.

In RNA, the pentose is ribose, whereas in DNA it is 2-deoxyribose. Both DNA and RNA contain the purine nitrogenous bases adenine (abbreviated A) and guanine (G) and the pyrimidine cytosine (C), but in DNA a second pyrimidine is thymine (T), whereas in RNA it is uracil (U). A number of other nitrogenous bases have been identified in DNA and RNA, but these occur much less frequently. The phosphoric acid component of each nucleotide is, of course, chemically identical in both nucleic acids.

Nucleotides

DNA and RNA are polymers (in the case of DNA, often very long polymers), and are made up of monomers known as **nucleotides**. When these monomers combine, the resulting chain is called a **polynucleotide** (*poly*- = "many").

Each nucleotide is made up of three parts: a nitrogen-containing ring structure called a nitrogenous base, a five-carbon sugar, and at least one phosphate group. The sugar molecule has a central position in the nucleotide, with the base attached to one of its carbons and the phosphate group (or groups) attached to another. Let’s look at each part of a nucleotide in turn.

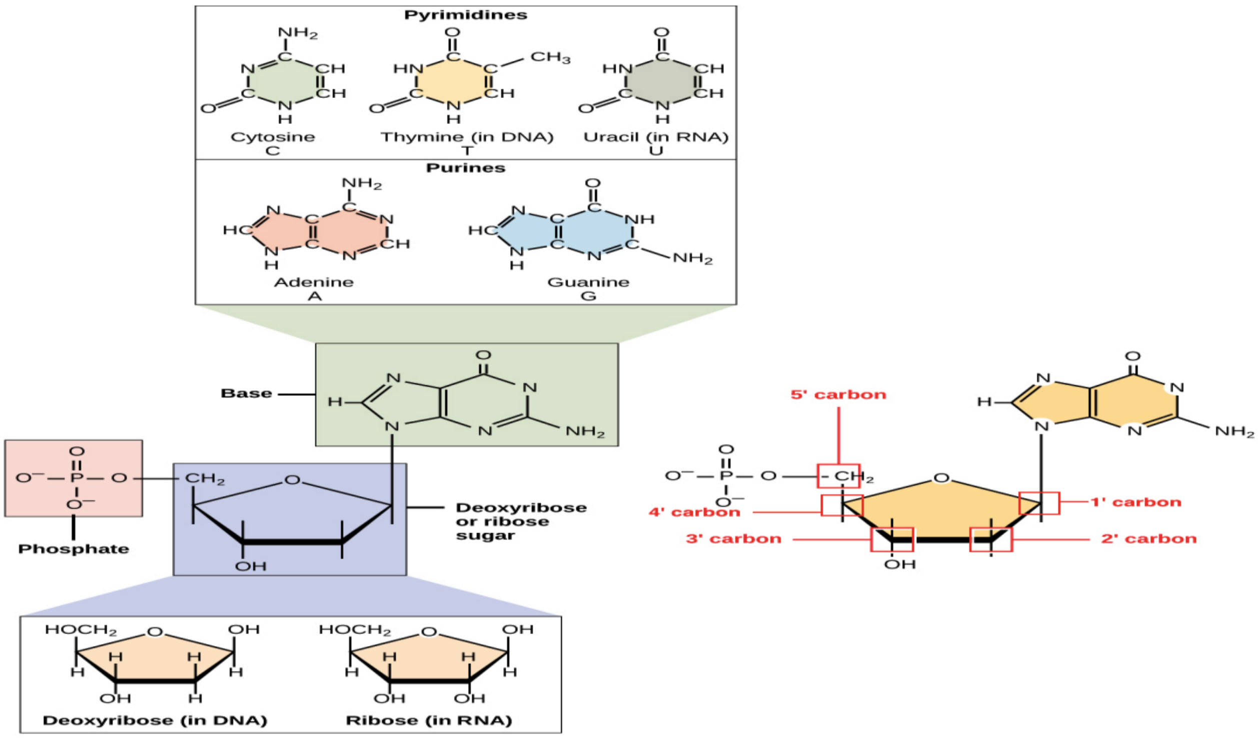


Fig. components of DNA and RNA, including the sugar (deoxyribose or ribose), phosphate group, and nitrogenous base. Bases include the pyrimidine bases (cytosine, thymine in DNA, and uracil in RNA, one ring) and the purine bases (adenine and guanine, two rings). The phosphate group is attached to the 5' carbon. The 2' carbon bears a hydroxyl group in ribose, but no hydroxyl (just hydrogen) in deoxyribose.

(Image modified from ," by OpenStax College, Biology)

Nitrogenous bases

The nitrogenous bases of nucleotides are organic (carbon-based) molecules made up of nitrogen-containing ring structures.

Each nucleotide in DNA contains one of four possible nitrogenous bases: adenine (A), guanine (G) cytosine (C), and thymine (T). Adenine and guanine are **purines**, meaning that their structures contain two fused carbon-nitrogen rings. Cytosine and thymine, in contrast, are **pyrimidines** and have a single carbon-nitrogen ring. RNA nucleotides may also bear adenine, guanine and cytosine bases, but instead of thymine they have another pyrimidine base called uracil (U). As shown in the figure above, each base has a unique structure, with its own set of functional groups attached to the ring structure.

In molecular biology shorthand, the nitrogenous bases are often just referred to by their one-letter symbols, A, T, G, C, and U. DNA contains A, T, G, and C, while RNA contains A, U, G, and C (that is, U is swapped in for T).

Sugars

In addition to having slightly different sets of bases, DNA and RNA nucleotides also have slightly different sugars. The five-carbon sugar in DNA is called **deoxyribose**, while in RNA, the sugar is **ribose**. These two are very similar in structure, with just one difference: the second carbon of ribose bears a hydroxyl group, while the equivalent carbon of deoxyribose has a hydrogen instead. The carbon atoms of a nucleotide's sugar molecule are numbered as 1′, 2′, 3′, 4′, and 5′ (1′ is read as "one prime"), as shown in the figure above. In a nucleotide, the sugar occupies a central position, with the base attached to its 1′ carbon and the phosphate group (or groups) attached to its 5′ carbon.

Phosphate

Nucleotides may have a single phosphate group, or a chain of up to three phosphate groups, attached to the 5’ carbon of the sugar. Some chemistry sources use the term “nucleotide” only for the single-phosphate case, but in molecular biology, the broader definition is generally accepted^11start superscript, 1, end superscript

In a cell, a nucleotide about to be added to the end of a polynucleotide chain will bear a series of three phosphate groups. When the nucleotide joins the growing DNA or RNA chain, it loses two phosphate groups. So, in a chain of DNA or RNA, each nucleotide has just one phosphate group.

Polynucleotide chains

A consequence of the structure of nucleotides is that a polynucleotide chain has **directionality** – that is, it has two ends that are different from each other. At the **5’ end**, or beginning, of the chain, the 5’ phosphate group of the first nucleotide in the chain sticks out. At the other end, called the **3’ end**, the 3’ hydroxyl of the last nucleotide added to the chain is exposed. DNA sequences are usually written in the 5' to 3' direction, meaning that the nucleotide at the 5' end comes first and the nucleotide at the 3' end comes last.

As new nucleotides are added to a strand of DNA or RNA, the strand grows at its 3’ end, with the 5′ phosphate of an incoming nucleotide attaching to the hydroxyl group at the 3’ end of the chain. This makes a chain with each sugar joined to its neighbors by a set of bonds called a phosphodiester linkage.

Parasitic organisms are not exception to this. In case of them too most of the DNA is found in the nucleus which constitutes the basic genetic information or genome. Small quantities of DNA is also found out side the nucleus often associated with mitochondria called mt DNA In case of parasitic protozoan a special kind of DNA is known as kinetoplast DNA (k DNA). There is no reason to believe that parasite DNA has some unusual base pair.

Base composition of DNA is expressed as the percentage of Guanine and Cytosine relative to total base contents (G+C content). Estimation of G+C contents of about 40 different species of parasites has been made. Chappel (1999) made a comprehensive review of these studies and reported that-

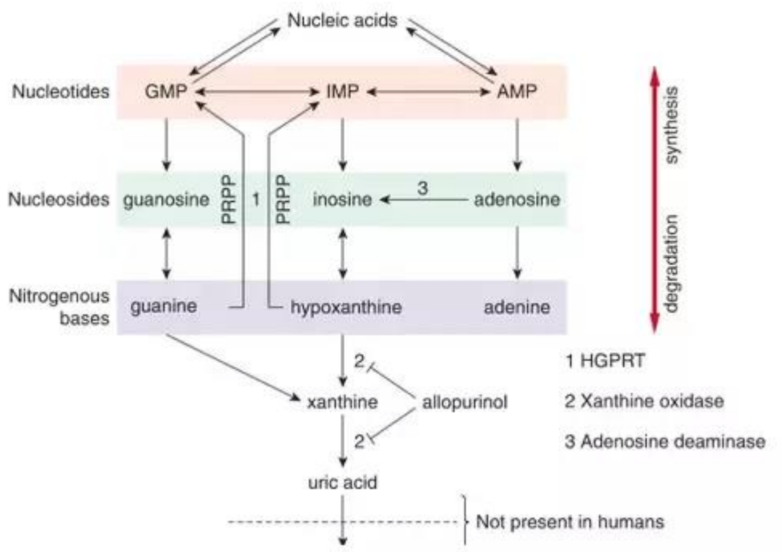
G+ C contents of Nuclear DNA in Parasites ranges from 18-61%

G+C contents of Extra nuclear DANA in Parasites ranges from 18-41%

Very little is known about the RNA of parasites. They are made of 30S and 50 S subunits. They are highly conserved and these days are used as Taxonomic tools.

Synthesis

Mammals synthesize the purine ring either de novo or from Salvage pathways involving pre formed bases or nucleosides. Most of the parasites rely almost exclusively on dietary source of salavage pathway. They are altogether incapable of performing de novo synthesis of purine.



Purine salvage pathway and deficiencies. HGPRT = hypoxanthine phos phoribosyltransferase.

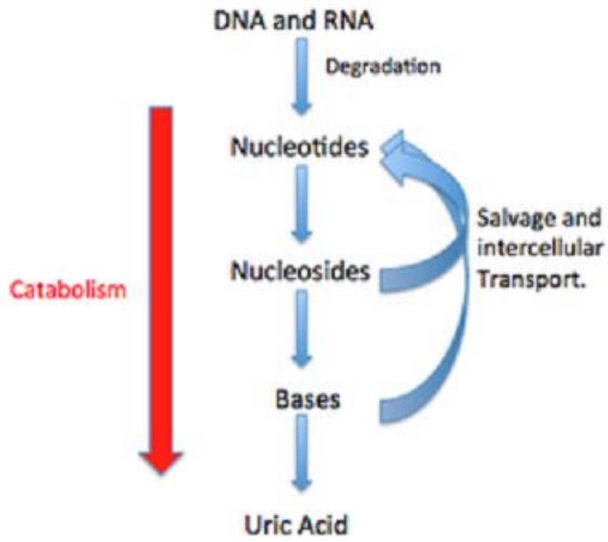
Recently two protozoan parasites Viz., *Crithidia oncopelti* and *Trypanosoma lewisi* are known to synthesize purines from glycine and serine.

In contrast to purine, pyrimidines are synthesise de novo by many parasites. The precursor molecules used for this synthesis are aspartate,bicarbonate and glutamine.

The final synthesis of nucleic acid in general requires series of enzymes collectively called polymerases about which nothing is known as far as parasites are concerned.

Catabolism

Nucleases (DNA-ase and RNA-ase) are responsible for breakdown of nucleic acids into nucleotides and phosphorylases,phosphatises and hudrolases catabolise these nucleotides into nucleosides and free bases. Variety of these enzymes, intermediates and end product of this catabolism, Uric acid as been reported from large number of parasites including helminth and acanthocephalan, implying that parasites have active nucleic acid catabolism.



Extranuclear DNA of Trypanosome

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