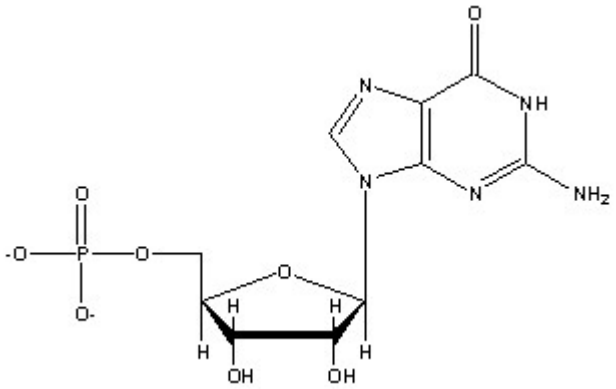
Nucleic Acids (Structure)

Nucleic acids determine and control the functioning of cells.

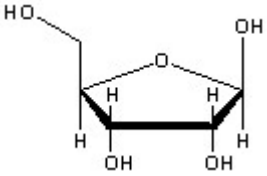
DNA – deoxyribonucleic acid and RNA – ribonucleic acid.

Both nucleic acids are polymers of **<u>nucleotides</u>**. Nucleotides contain a phosphate group, a sugar and a nitrogen base.

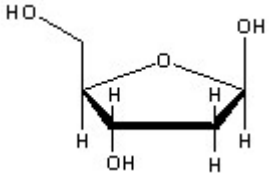


You already know the structure of the phosphate group.

Notice that in this nucleotide the sugar (β-D-ribose, found in RNA) is an aldopentose. If you wanted to draw the sugar found in DNA, then you have to remove the Oxygen atom from C-2' (keep in mind that the C atoms in the sugar are numbered in a clockwise direction).



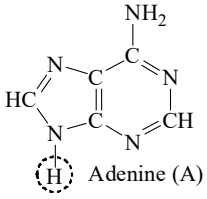
β-D-ribose
(ribose)



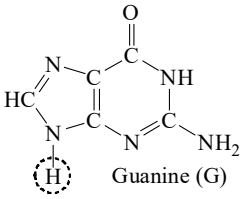
2-deoxy -D-ribose
(deoxyribose)

The nitrogen bases, which are heterocyclic rings containing nitrogen, can be divided in two classes according to the number of rings they have. They are:

PURINES

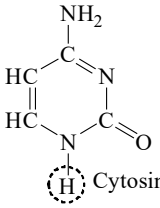


Adenine (A)

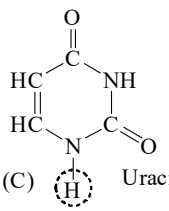


Guanine (G)

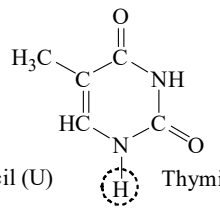
PYRIMIDINES



Cytosine (C)



Uracil (U)

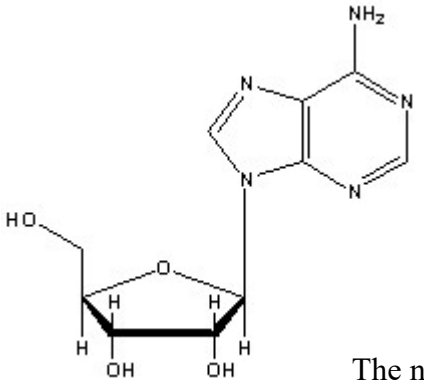


Thymine (T)

Both nucleic acids contain the nitrogen bases: Adenine, Guanine and Cytosine, but Thymine appears only in DNA, whereas Uracil in RNA.

(Don't need to memorize them!)

If the structure contains just the carbohydrate and the nitrogen base, it is known as a **<u>nucleoside</u>**.



The names of nucleosides are given according to the type of N-base.

If the nucleoside contains a *purine* (two rings), the name of the structure will end with "_____*osine*". (Adeno*sine*, Guano*sine*)

On the other hand, if the N-base is a *pyrimidine* (one ring), the name will end with "_____*idine*". (Cyt*idine*, Thym*idine*, Ur*idine*)

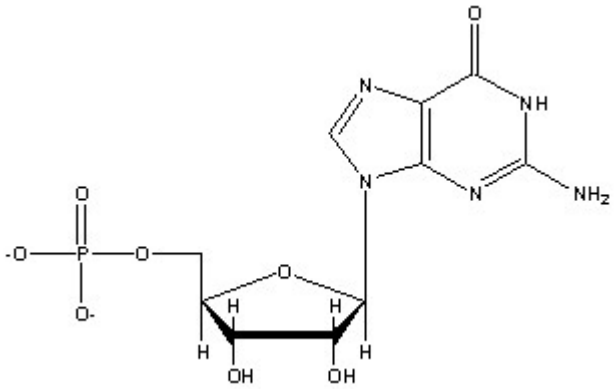
The name of this nucleoside is: "Adeno*sine*", but if we change the carbohydrate for deoxyribose, then the name would be "*<u>Deoxy</u>*adeno*sine*".

The following table (next page) summarizes the composition of the nucleosides, and the way in which the names are abbreviated.

Nucleosides

Name	Composition	Abbreviation
Adenosine	Adenine-ribose	A
Deoxyadenosine	Adenine-deoxyribose	dA
Guanosine	Guanine-ribose	G
Deoxyguanosine	Guanine-deoxyribose	dG
Cytidine	Cytosine-ribose	C
Deoxycytidine	Cytosine-deoxyribose	dC
Thymidine	Thymine-ribose	T
Deoxythimidine	Thymine-deoxyribose	dT
Uridine	Uracil-ribose	U
Deoxyuridine	Uracil-deoxyribose	dU

Nucleotides have a phosphate group on C-5'.



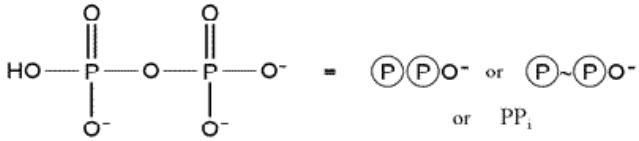
To give the name to the nucleotide we simply need to consider the new structure added, which is one phosphate group on C-5'.

The name of this nucleotide would be:

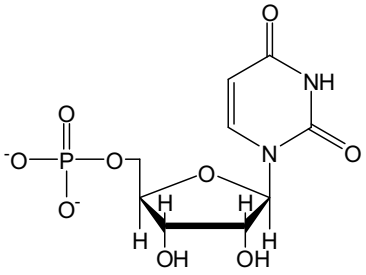
Guanosine 5'-monophosphate or GMP

(Notice that we use the nucleoside name.)

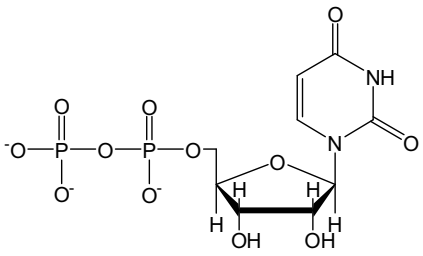
Any nucleotide can bond to additional phosphate groups:



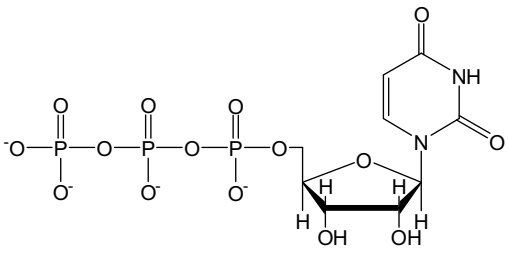
Look at the following examples with ribose and deoxyribose respectively:



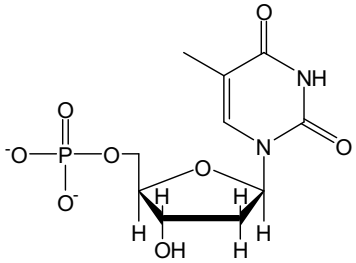
Uridine 5'-monophosphate, UMP



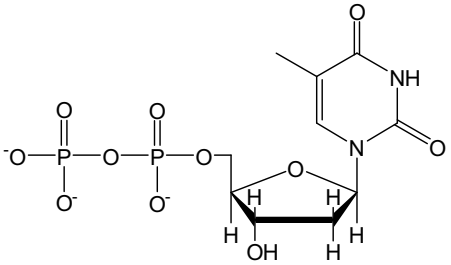
Uridine 5'-diphosphate, UDP



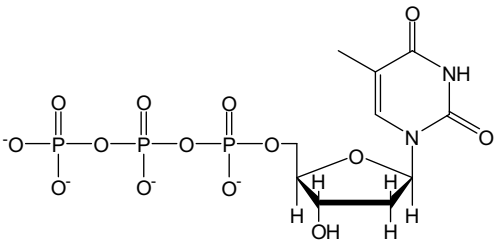
Uridine 5'-triphosphate, UTP



Deoxythymidine 5'-monophosphate, dTMP



Deoxythymidine 5'-diphosphate, dTDP

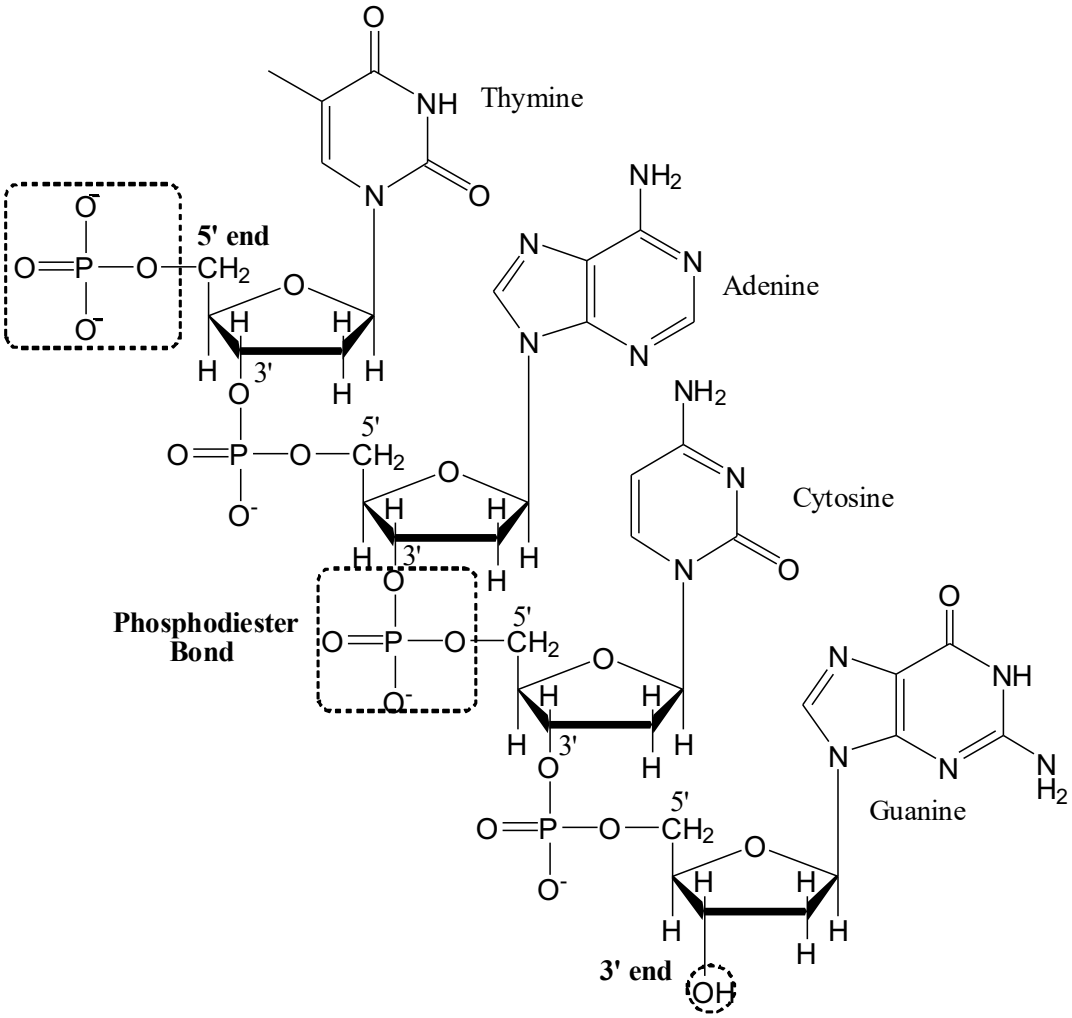


Deoxythymidine 5'-triphosphate, dTTP

Note: *You must be able to draw any nucleotide given the name or abbreviation*. (E.g. Guanosine 5'-monophosphate, dCDP, ATP, etc.)

Primary structure of DNA

As we mentioned before, nucleic acids (DNA, RNA) are polymers of these nucleotides. The sequence of nucleotides forms the primary structure of DNA.



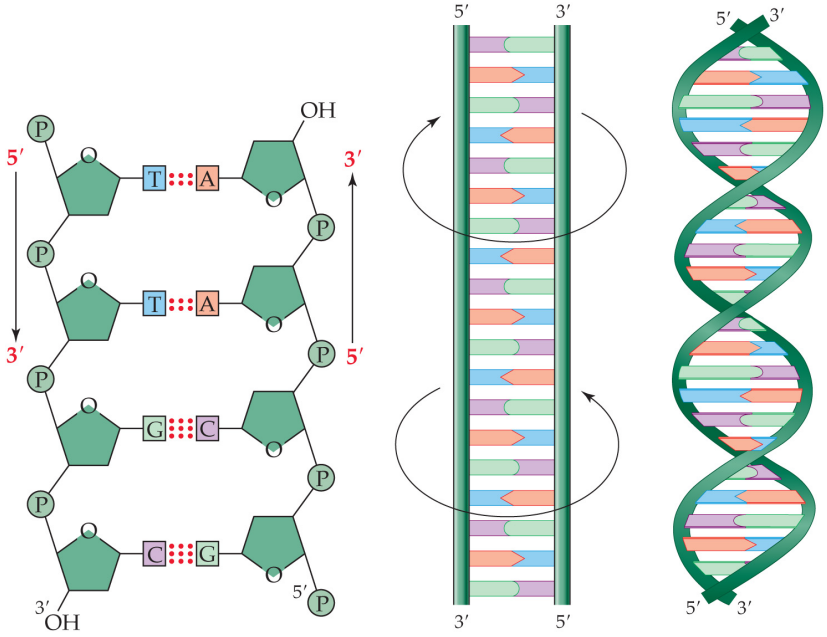
Notice three points:
1) The phosphate and the carbohydrate form a backbone.

2) The chain has a 'free' phosphate group at the 5' end and a 'free' hydroxide group at the 3' end.

3) The nucleotides are bonded together by a phosphodiester group.

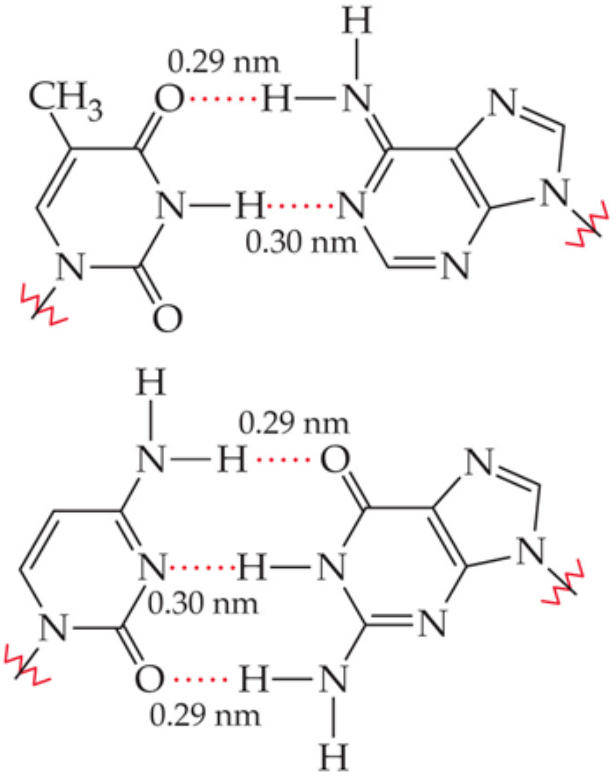
Secondary structure of DNA – The double helix

Double helix – two strands twisted together ("Twisted ladder") [Watson & Crick 1953]



The two chains are oriented in opposite directions, and held in place by means of H-bonds between Nitrogen bases.

Hydrogen bonds between N-bases:

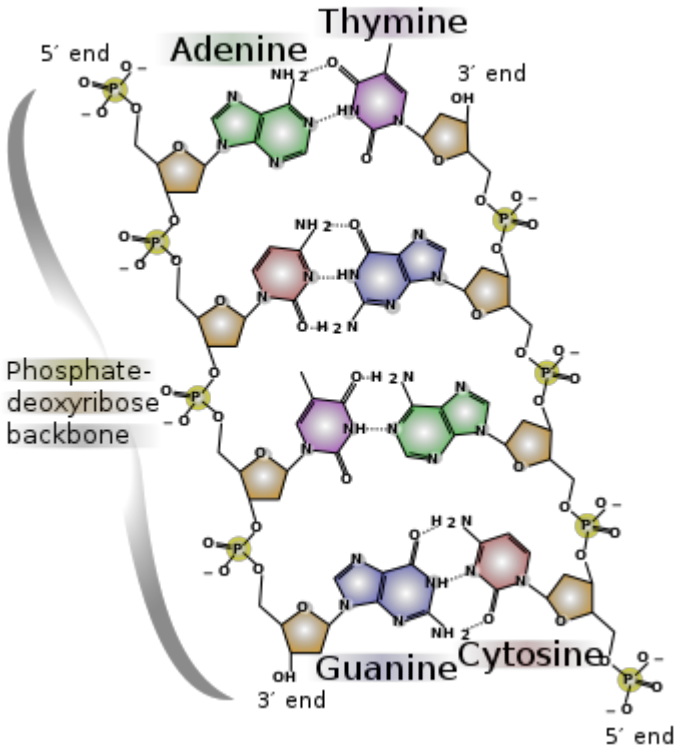


A=T (2 H-bonds)
G≡C (3-H bonds)

As we can see, a purine will H-bond to a pyrimidine. This situation results in a constant width for the ladder and it is known as “complementary base pairing”.

‘A’ can not pair with ‘G or ‘C’,
‘G’ can not pair with ‘A’ or ‘T’.

If one strand is: 5’—A-T-G-T-C-C-A—3’
The other strand would be: 3’—T-A-C-A-G-G-T—5’



Types of RNA

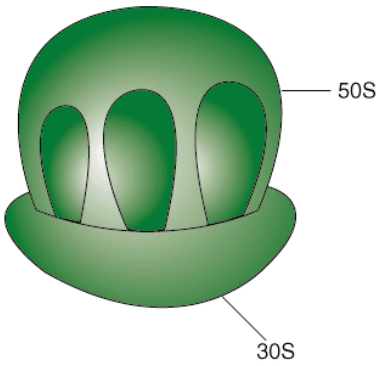
Differences between DNA and RNA:

- The Carbohydrate: RNA uses ribose instead of deoxyribose.
- Nitrogen base: Uracil instead of Thymine.
- RNA is single stranded.
- RNA is not as long as DNA.

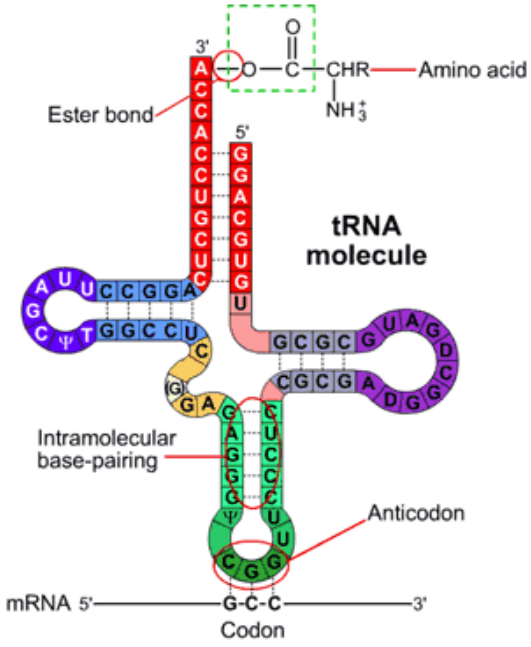
There are three main types of RNA:

Messenger RNA (mRNA) – carries the genetic information from DNA in the nucleus to the ribosomes where protein synthesis occurs.

Ribosomal RNA (rRNA) – is present in the ribosomes (cellular organelles made of RNA and proteins), which in turn are made of two subunits (one small and one large).



Transfer RNA (tRNA) – "interprets" the genetic code and delivers amino acids to the ribosome.



Acknowledgments:

"Twisted ladder" [Watson & Crick 1953]
Fundamentals of General, Organic and Biologival Chemistry. McMurry, et Al., Sixth Edition, page. 817.

H-bonds formed by nitrogen bases
Fundamentals of General, Organic and Biologival Chemistry. McMurry, et Al., Sixth Edition, page. 818.

Base pairing:
http://en.wikipedia.org/wiki/DNA

Transfer RNA
http://www.tutorvista.com/biology/types-of-dna-and-rna