

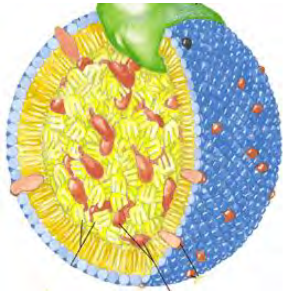


BIOCHEMISTRY REVIEW

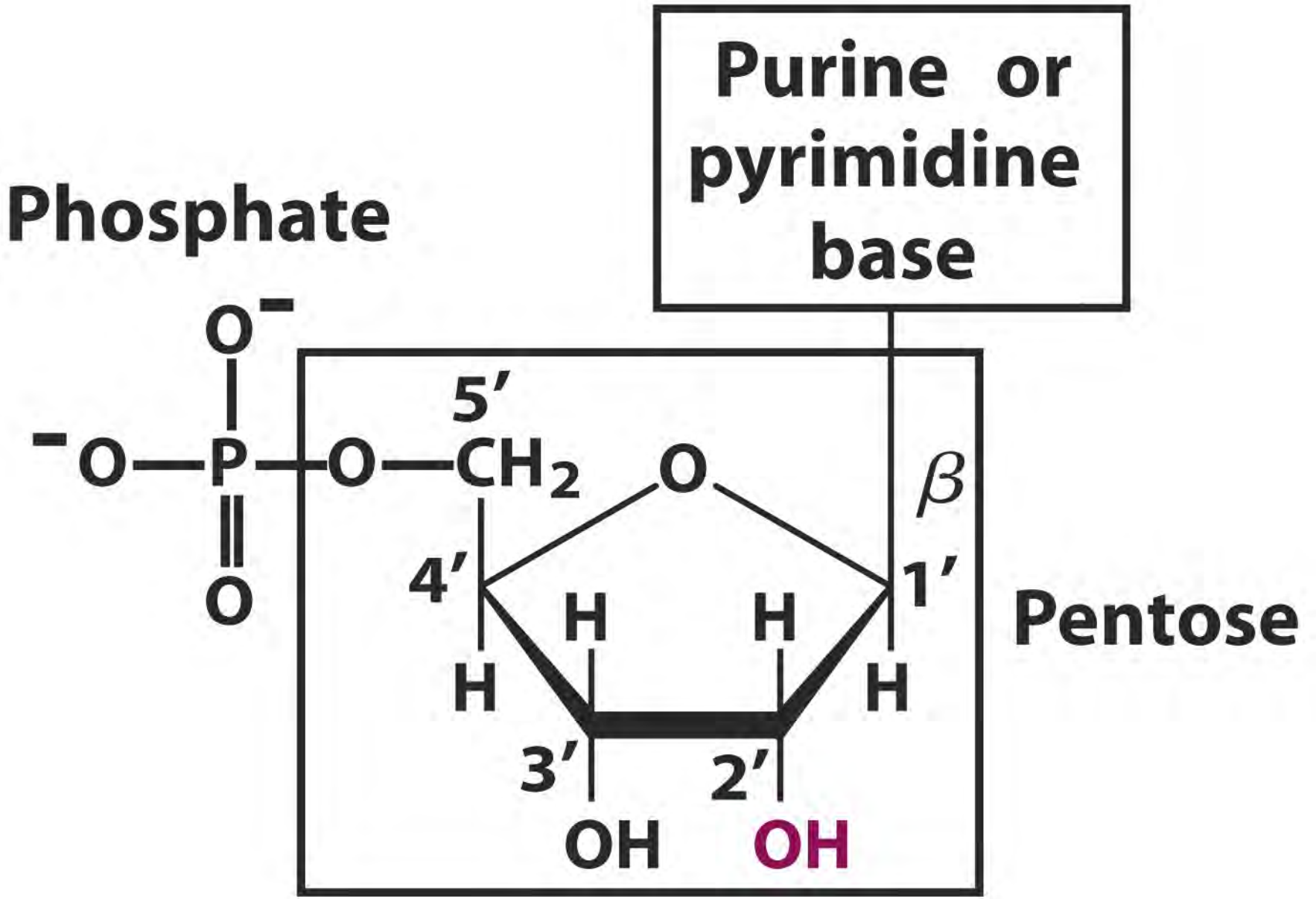
Overview of Biomolecules

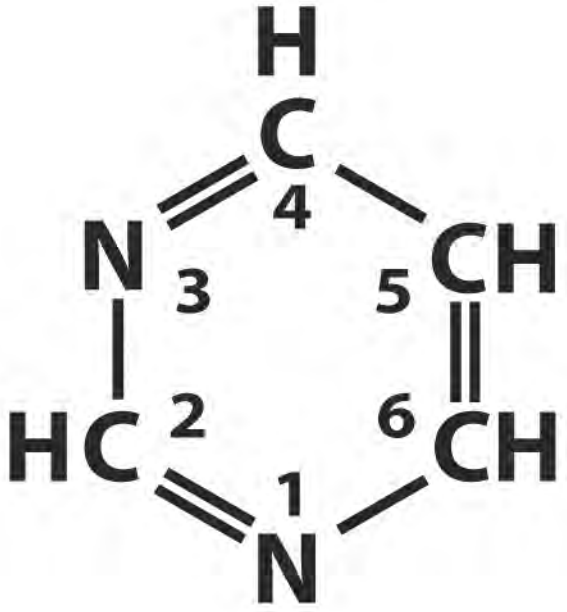
Chapter 9

Nucleotides

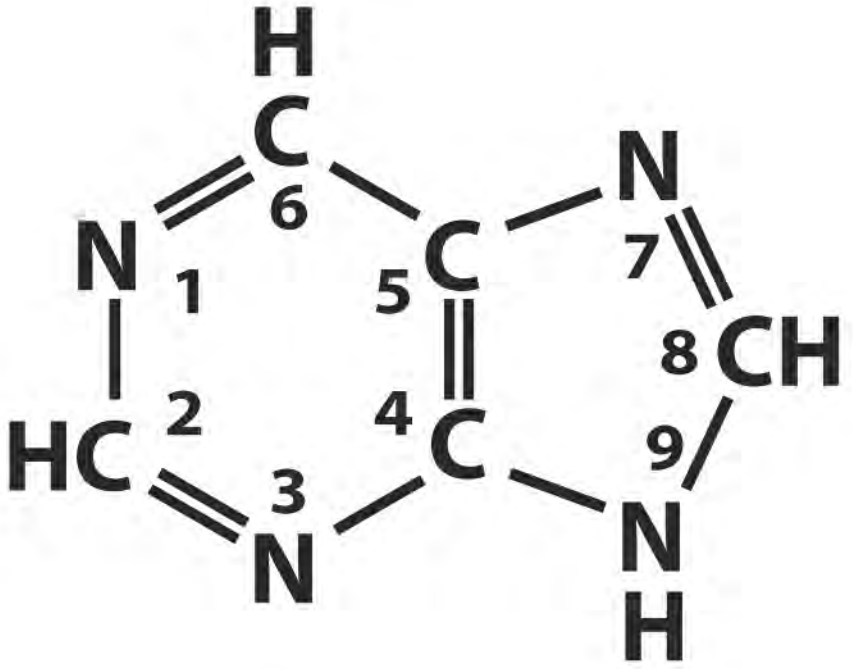




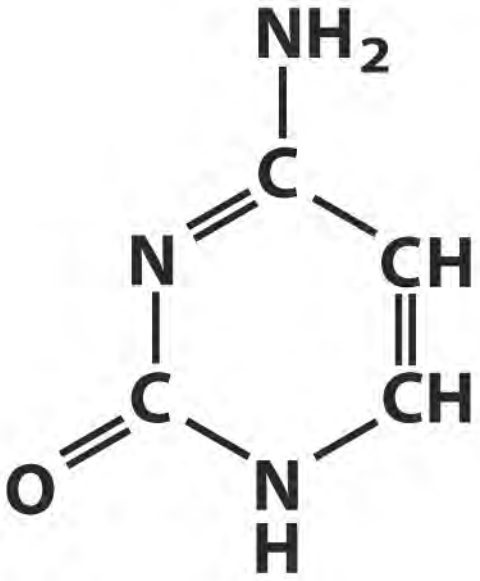

Purine or pyrimidine base
Phosphate
O⁻
⁻O—P—O—CH₂
O
O
5′
4′
1′
β
H
H
H
H
Pentose
3′
2′
OH
OH



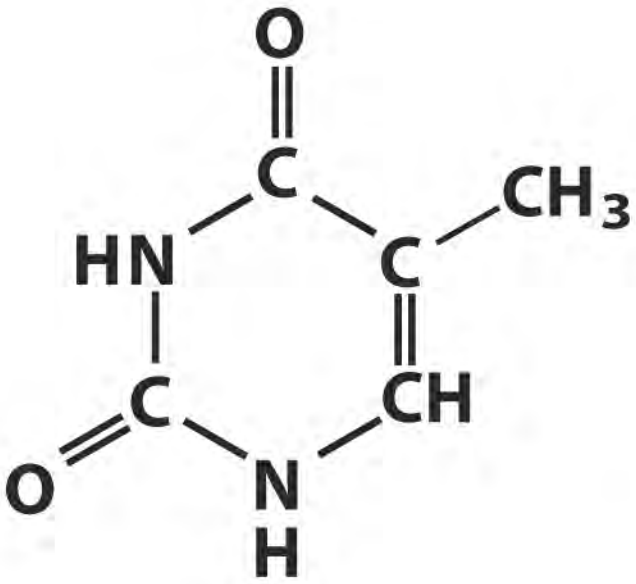
Pyrimidine



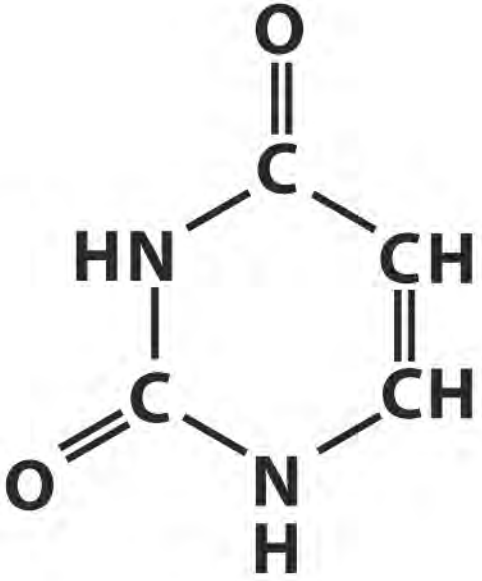
Purine



Cytosine

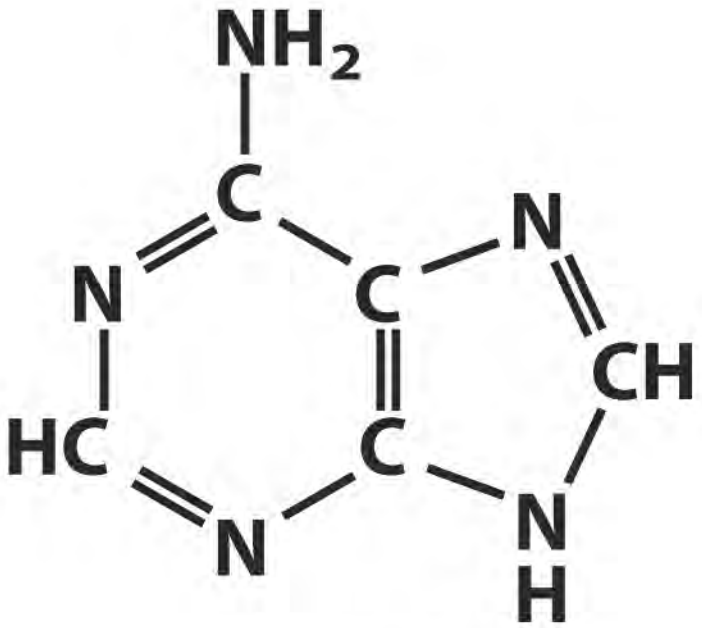


Thymine
(DNA)

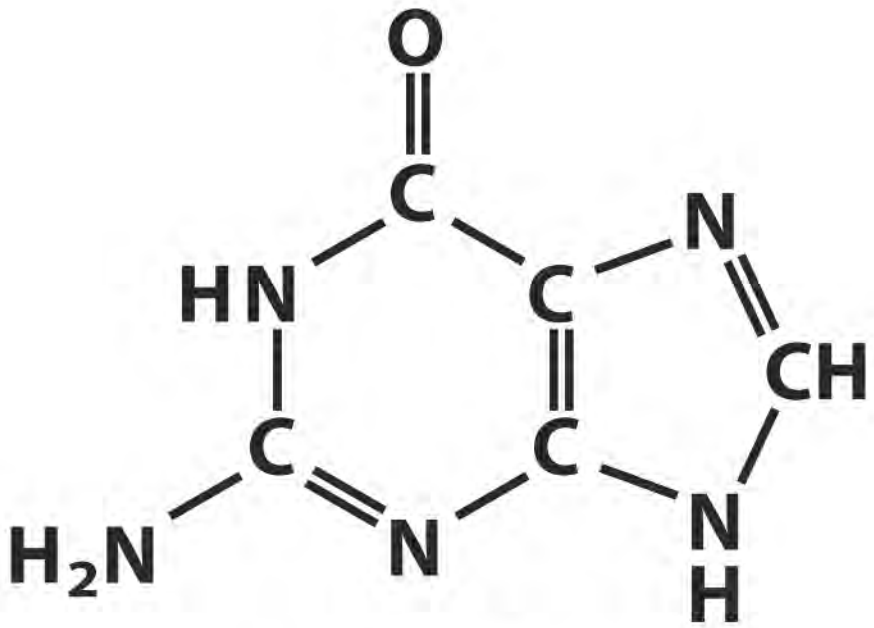


Uracil
(RNA)

Pyrimidines



Adenine

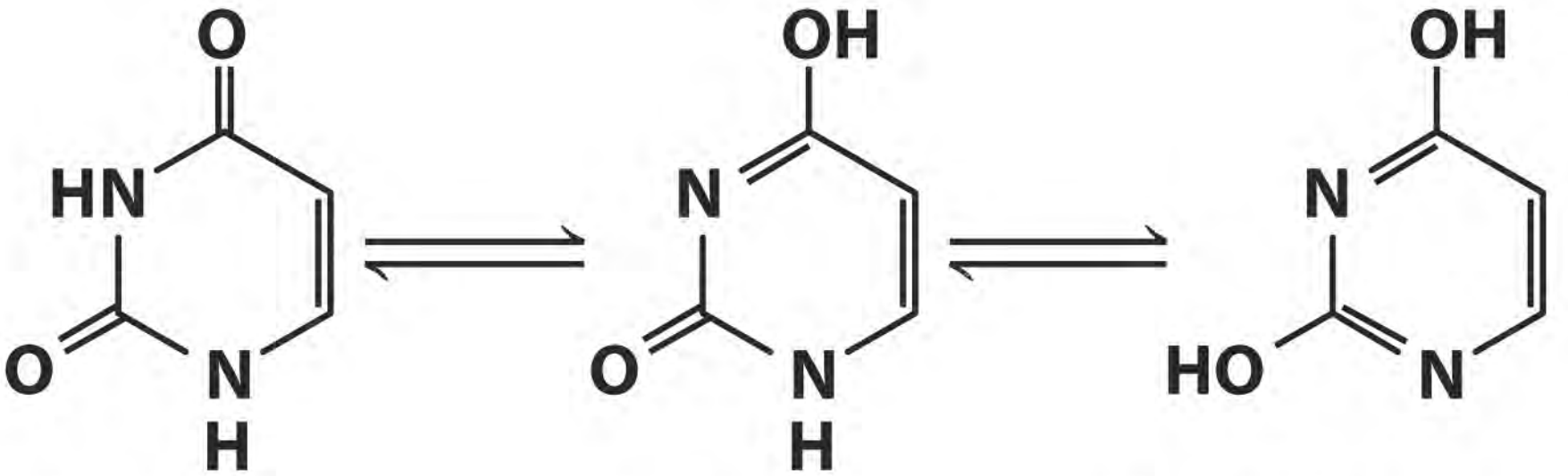


Guanine

Purines

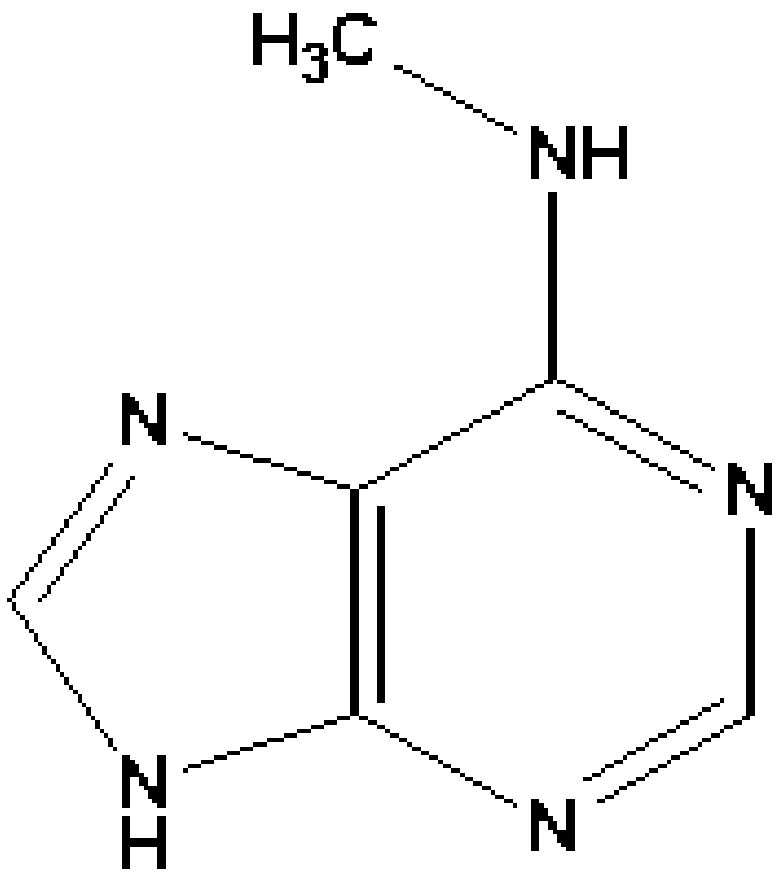
GENERAL FEATURES OF NITROGENOUS BASES

- **AROMATIC CHARACTER / STABLE RINGS**
- **UNCHARGED AT pH = 7.0**
- **PLANAR OR NEARLY PLANAR**
- **HYDROGEN BOND FORMATION**
- **TAUTOMERIC FORMS**

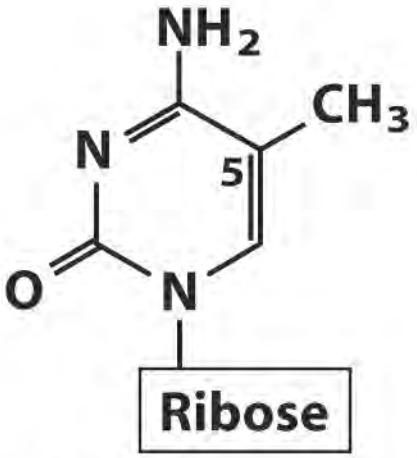


Lactam **Lactim** **Double lactim**

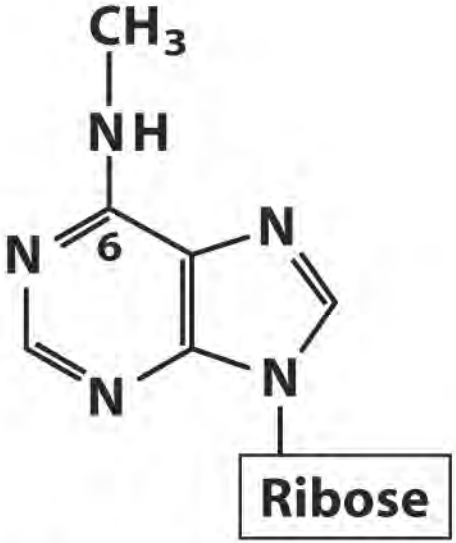
Uracil



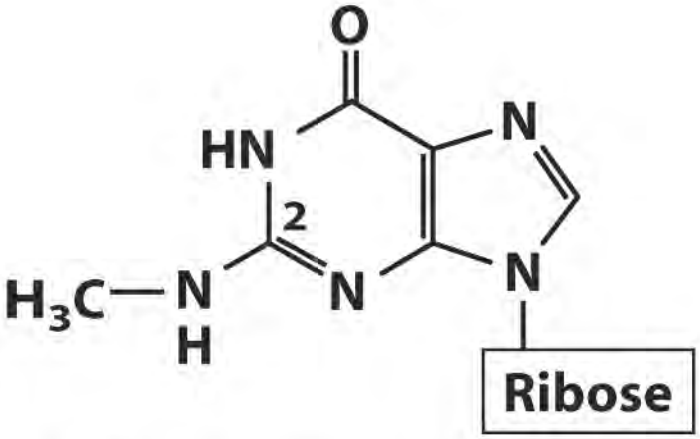
N6-methyladenine (mA)



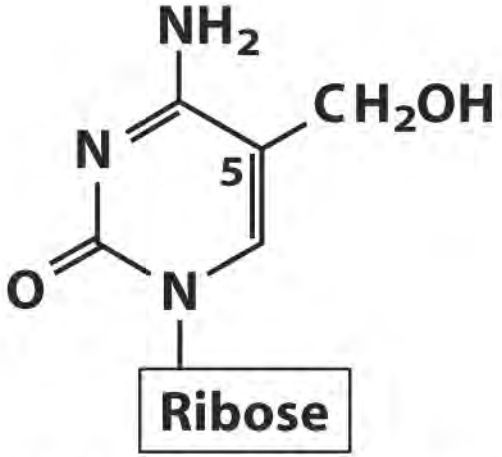
5-Methylcytidine



N^6-Methyladenosine



N^2-Methylguanosine



5-Hydroxymethylcytidine



Are You Getting It??



Which characteristics are found in both purines and pyrimidines? ***(multiple answers)***

a) They both are heterocyclic.
b) They both contain two rings.
c) They both have aromatic properties.
d) They both become protonated at pH=7.0.
e) They both contain groups that form H-bonds.



Are You Getting It??



Answer

Which characteristics are found in both purines and pyrimidines?

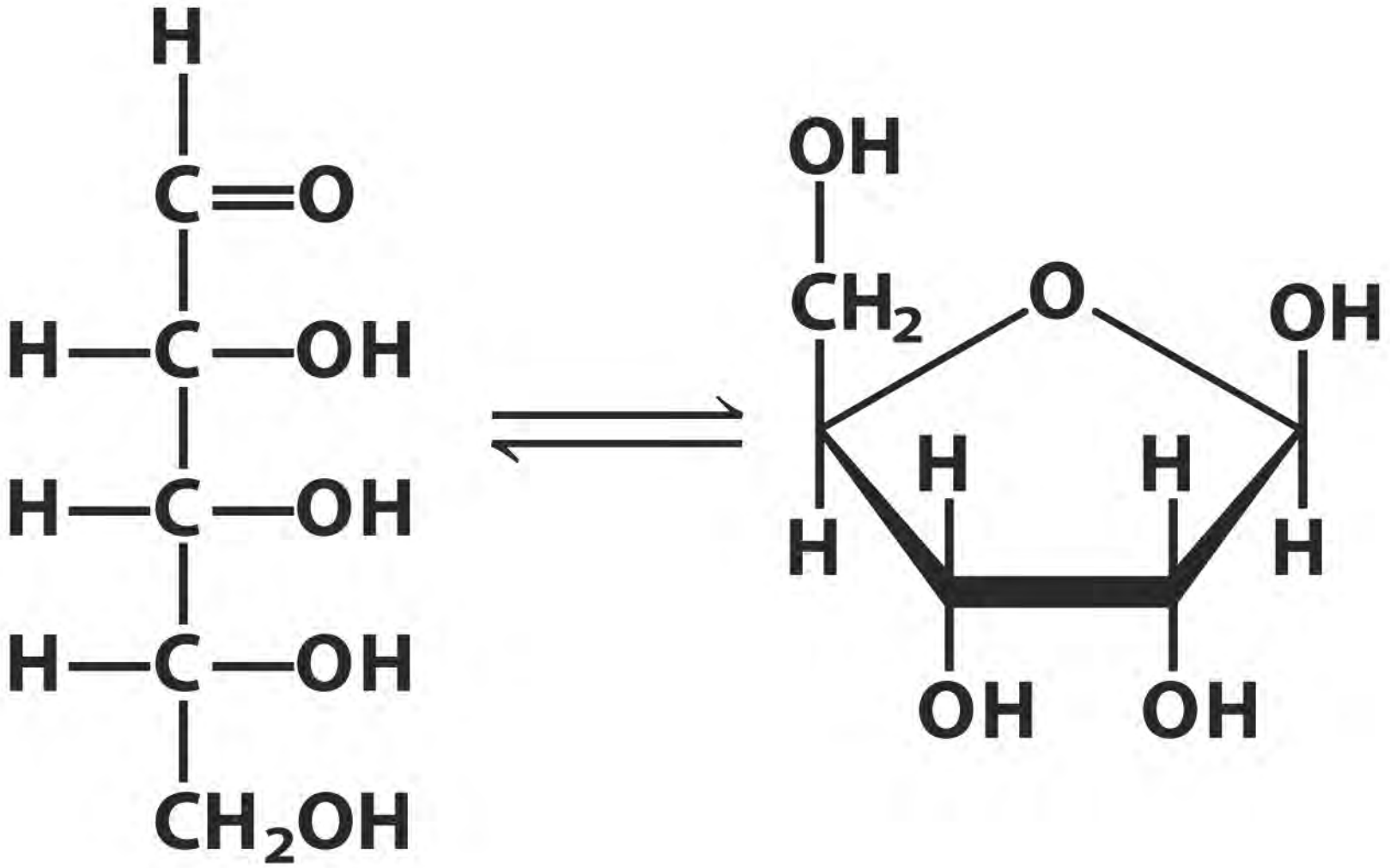
a) ***They both are heterocyclic.***

b) **They both contain two rings.**

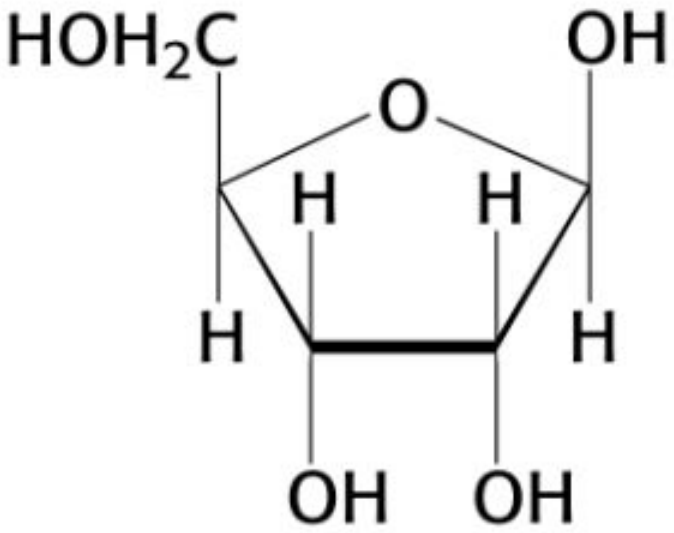
c) ***They both have aromatic properties.***

d) **They both become protonated at pH=7.0.**

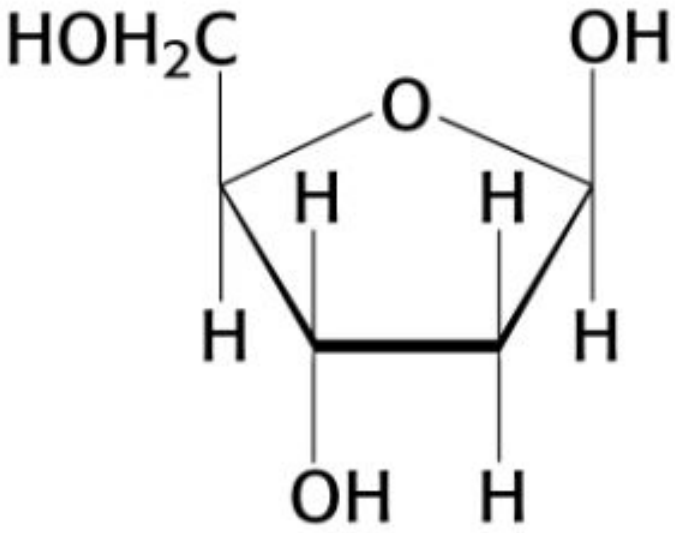
e) ***They both contain groups that form H-bonds.***



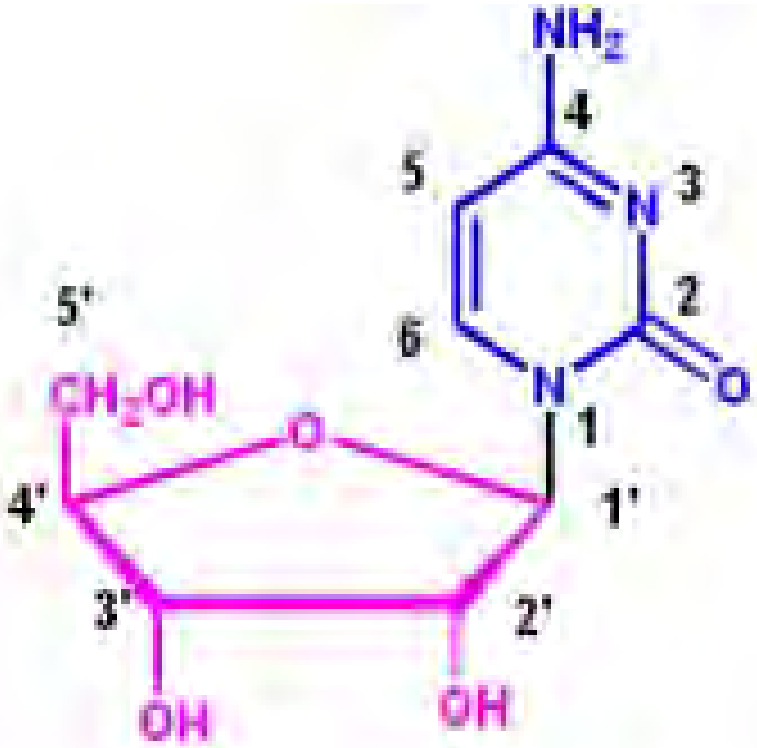
Aldehyde ⇌ **β-Furanose**



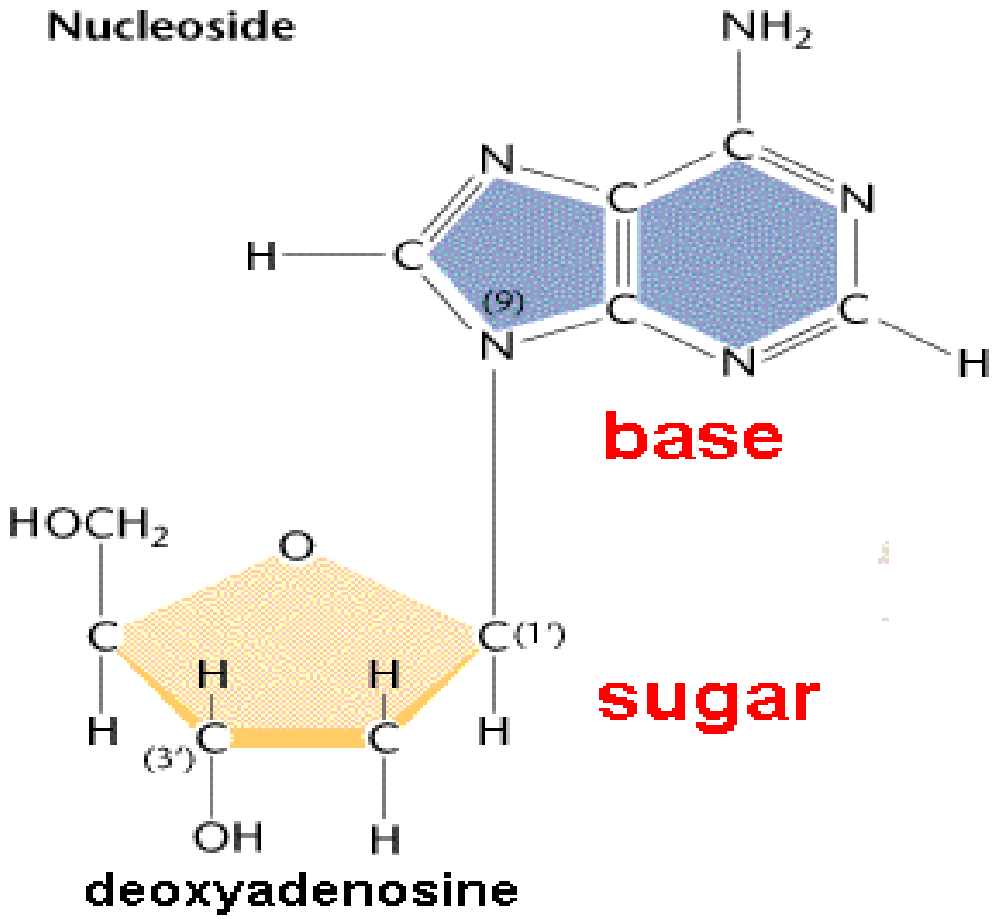
D-Ribose



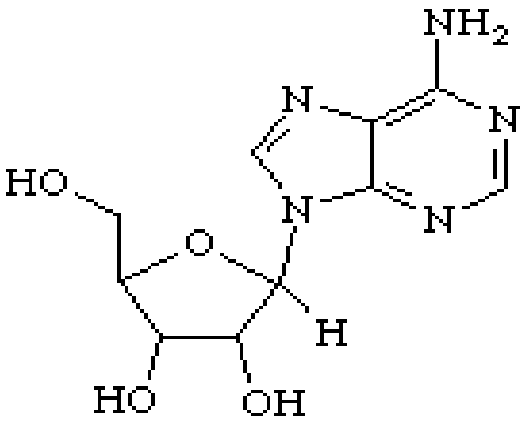
2-Deoxy-D-ribose



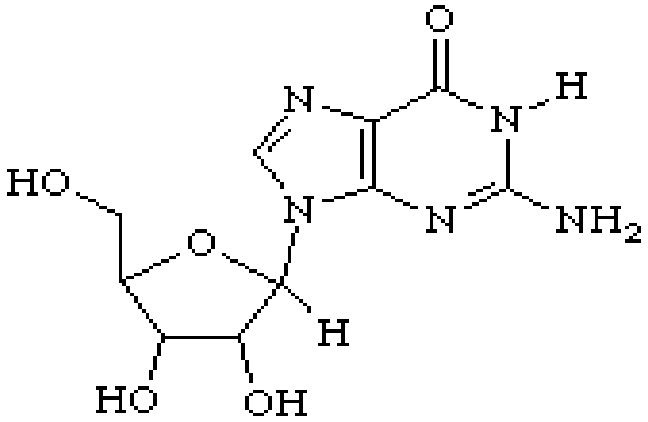
A nucleoside:
β-glycosidic bond between D-ribose and cytosine nitrogenouos base



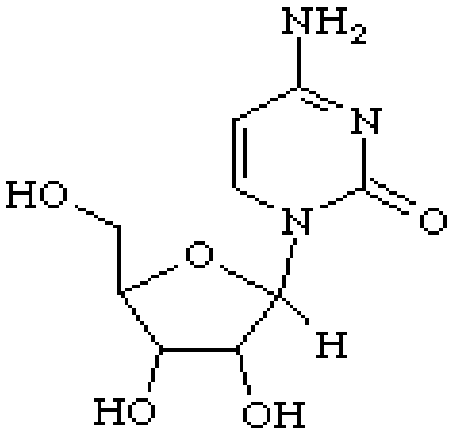
(after Klug & Cummings 1997)



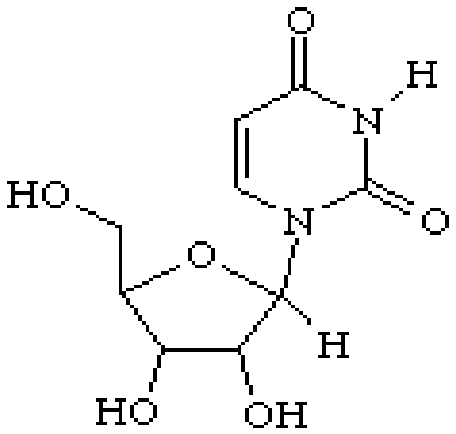
Adenosine



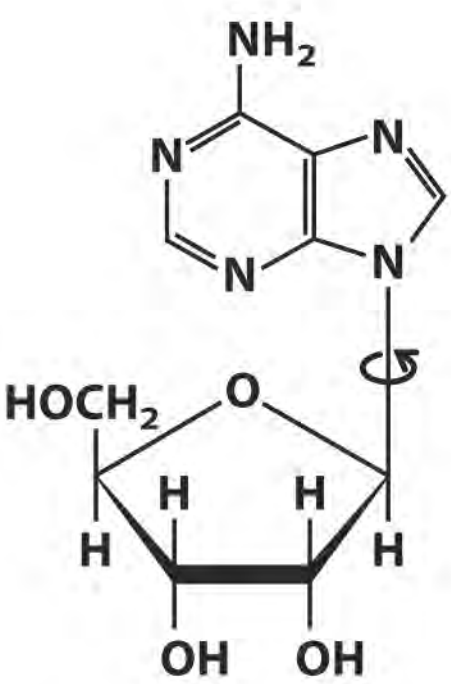
Guanosine



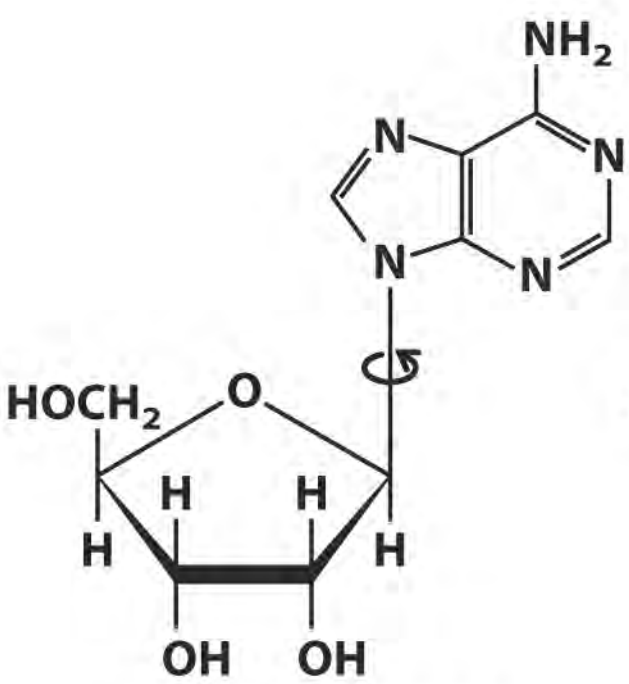
Cytidine



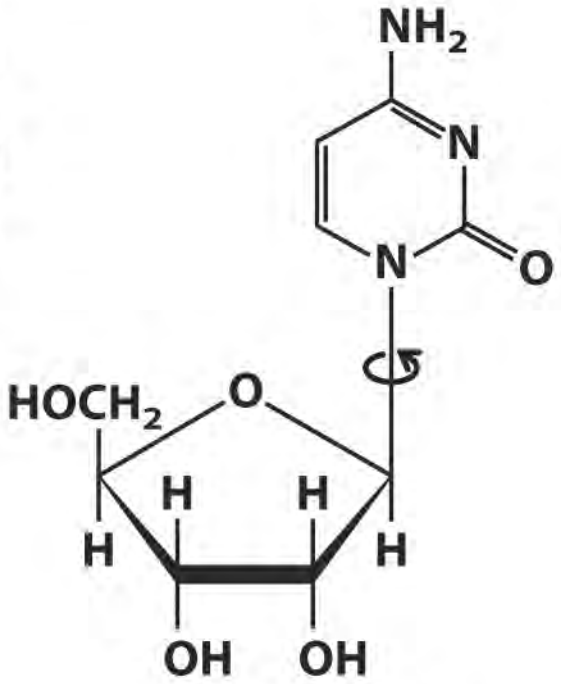
Uridine



syn-Adenosine



anti-Adenosine



anti-Cytidine



Are You Getting It??



Which characteristics will uridine have?

(multiple answers)

a) It contains a pyrimidine.
b) It contains deoxyribose.
c) It contains a hemiacetal bond.
d) It is stable in base.
e) It contains a pyranose.
f) It contains a 1,1'-N-glycosidic bond.



Are You Getting It??



Answer

Which characteristics will uridine have?

a) ***It contains a pyrimidine.***

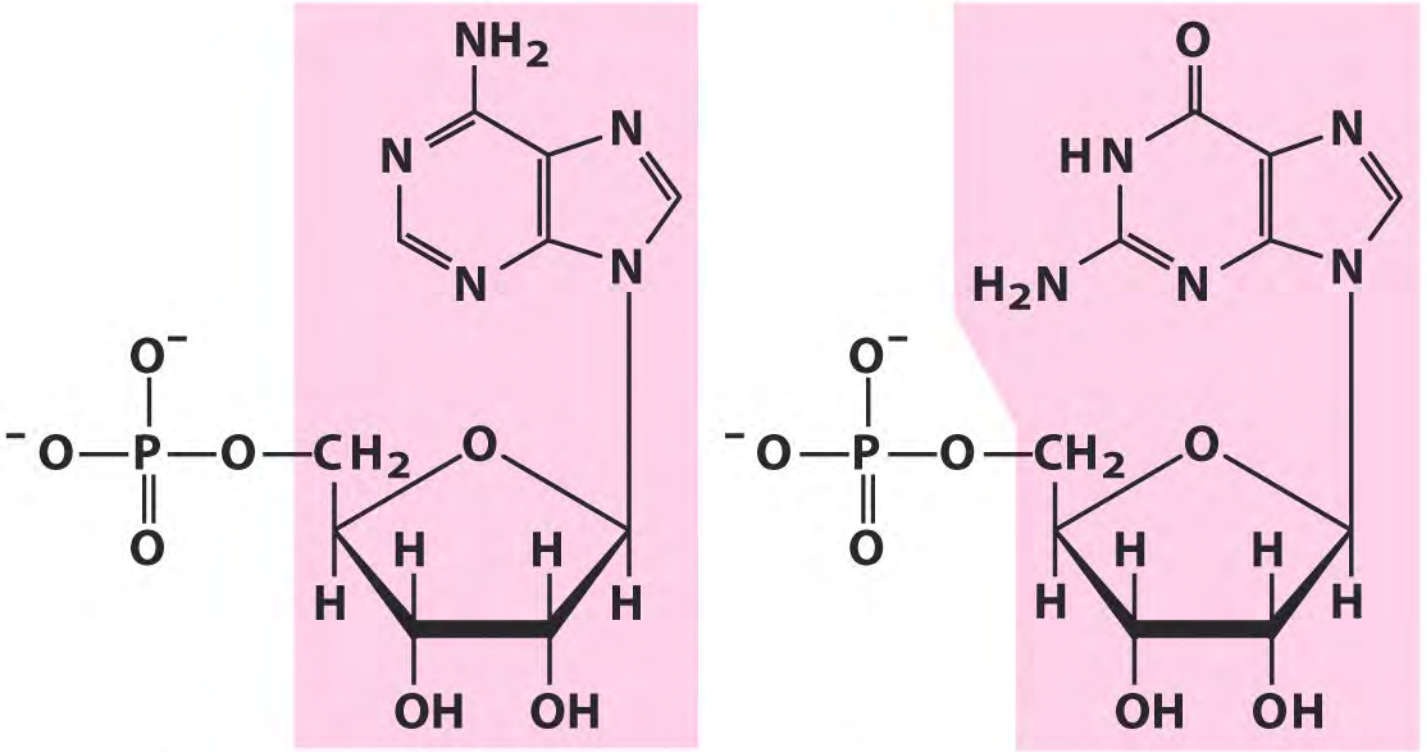
b) **It contains deoxyribose.**

c) **It contains a hemiacetal bond.**

d) ***It is stable in base.***

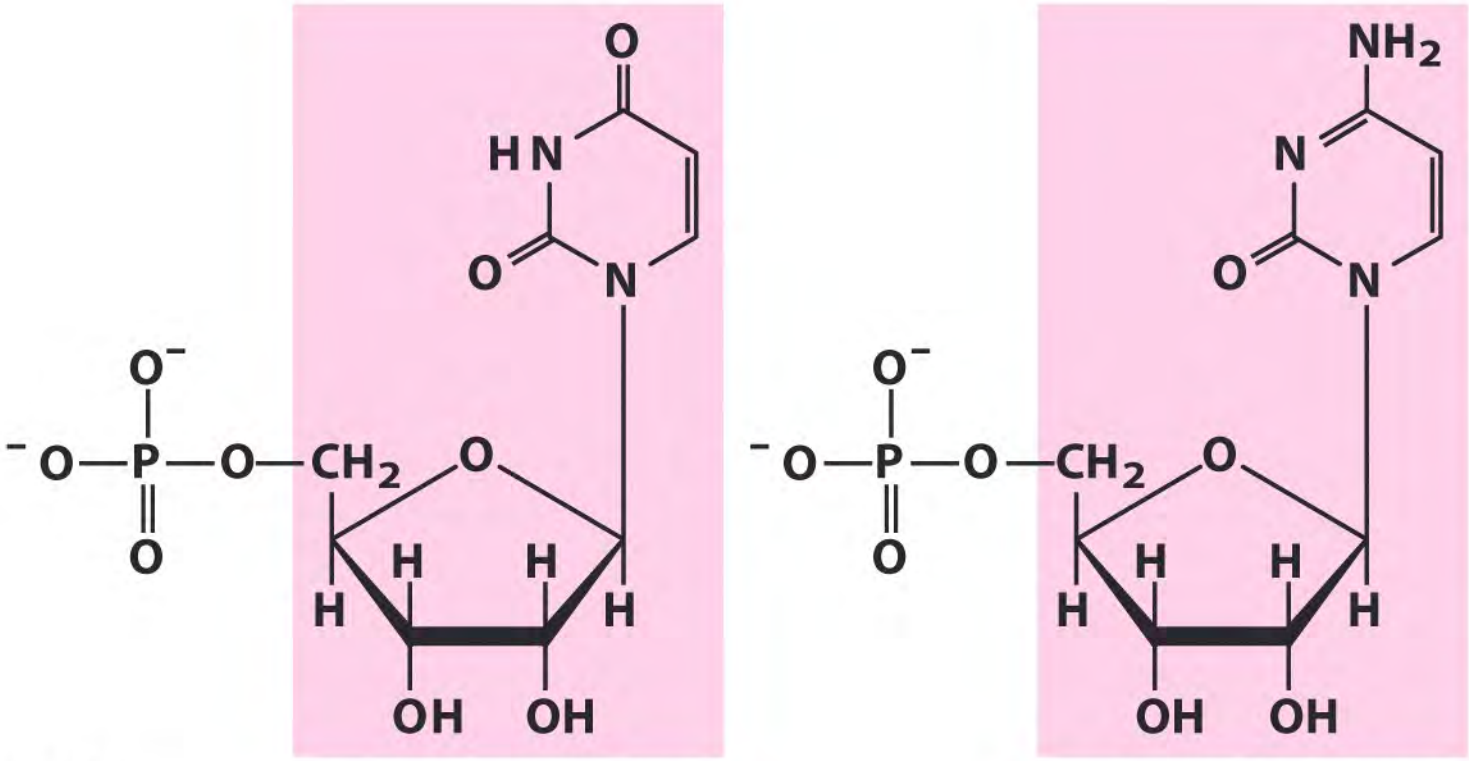
e) **It contains a pyranose.**

f) ***It contains a 1,1'-N-glycosidic bond.***

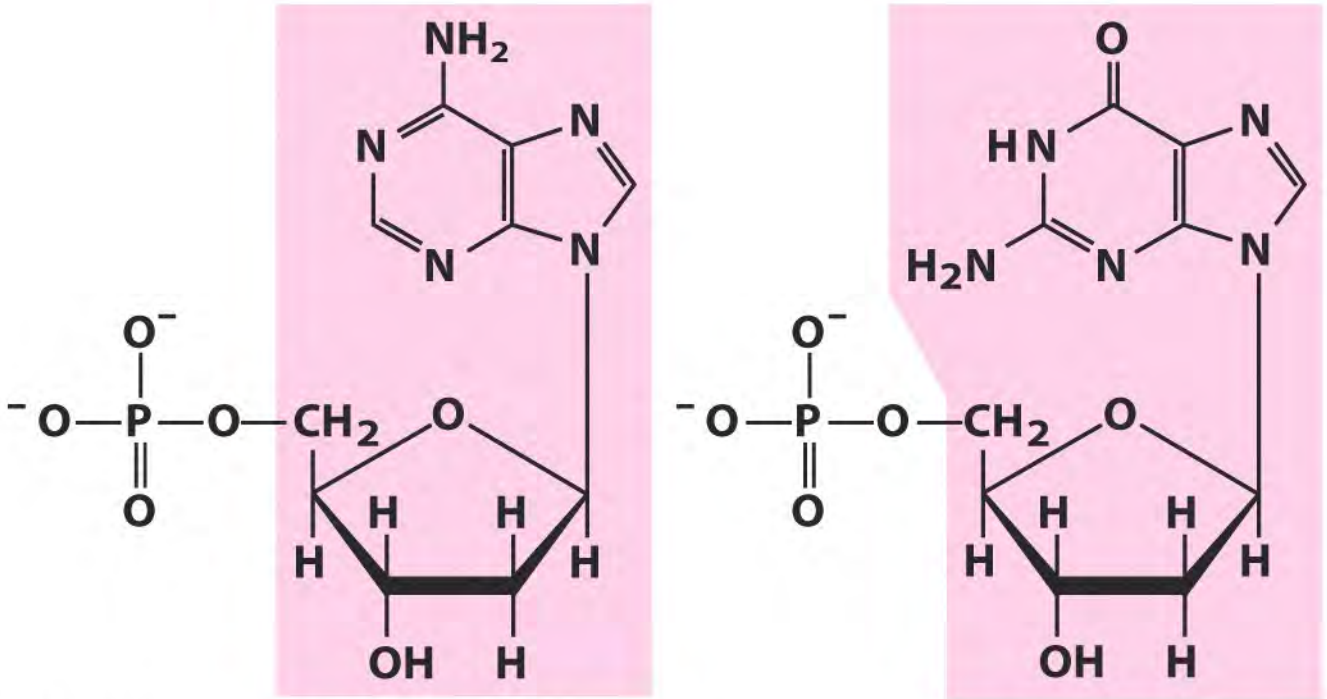


Nucleotide:	**Adenylate (adenosine 5′-monophosphate)**	**Guanylate (guanosine 5′-monophosphate)**
Symbols:	**A, AMP**	**G, GMP**
Nucleoside:	**Adenosine**	**Guanosine**

(b) Ribonucleotides

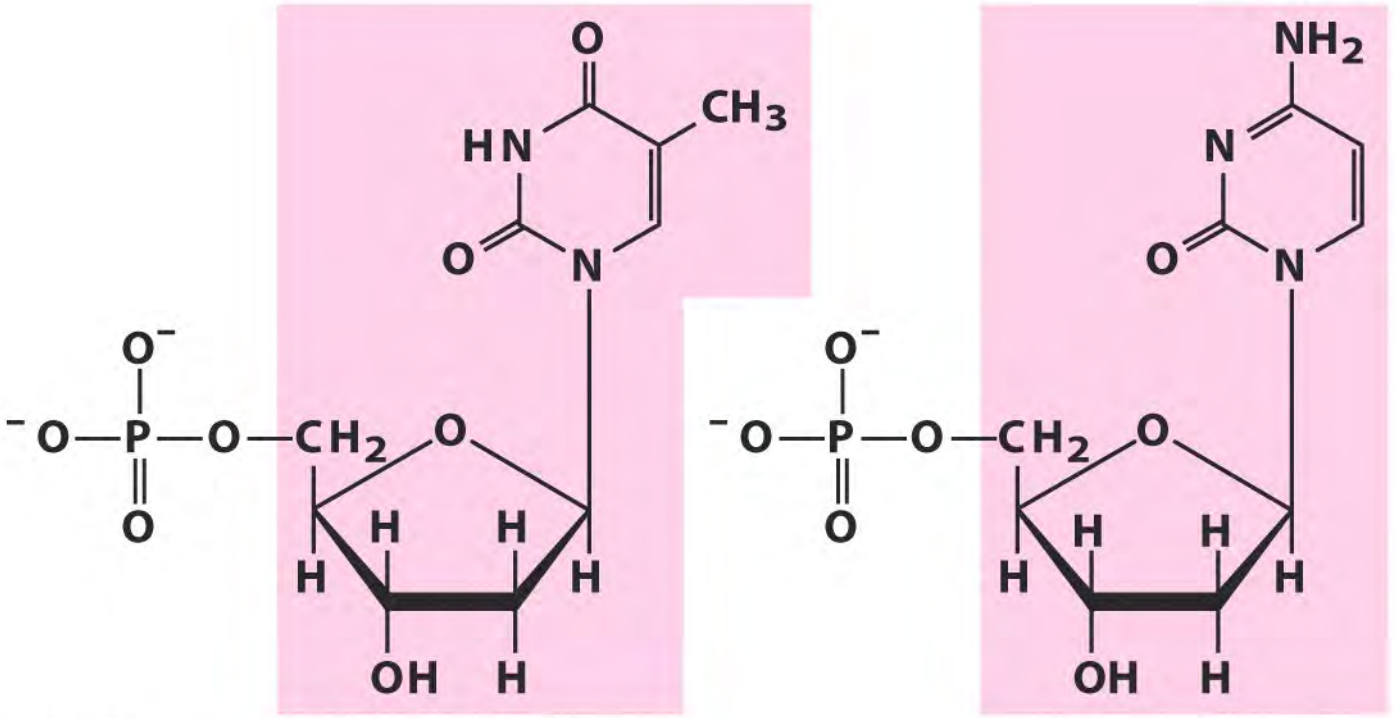


(b) Ribonucleotides

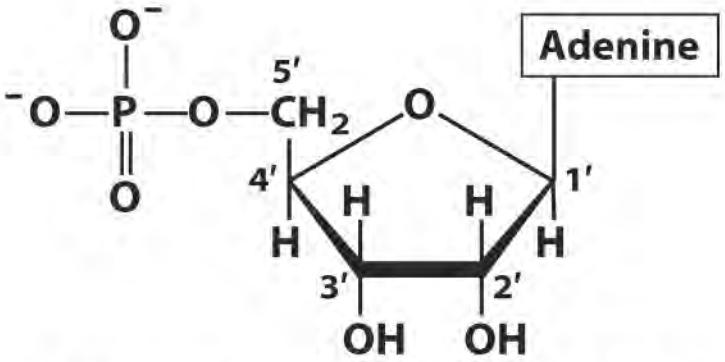


Nucleotide:	**Deoxyadenylate (deoxyadenosine 5′-monophosphate)**	**Deoxyguanylate (deoxyguanosine 5′-monophosphate)**
Symbols:	**A, dA, dAMP**	**G, dG, dGMP**
Nucleoside:	**Deoxyadenosine**	**Deoxyguanosine**

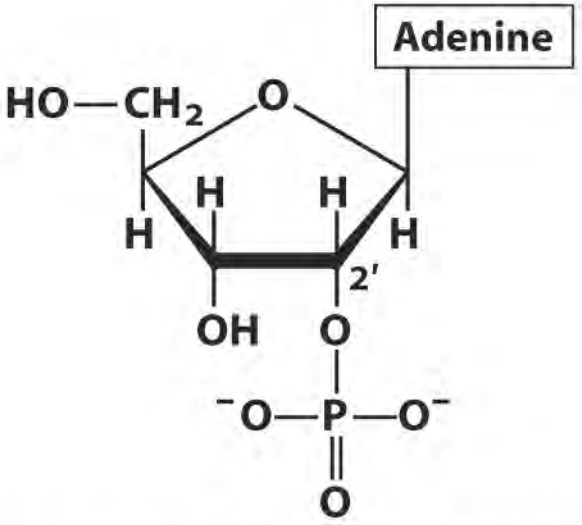
(a) Deoxyribonucleotides



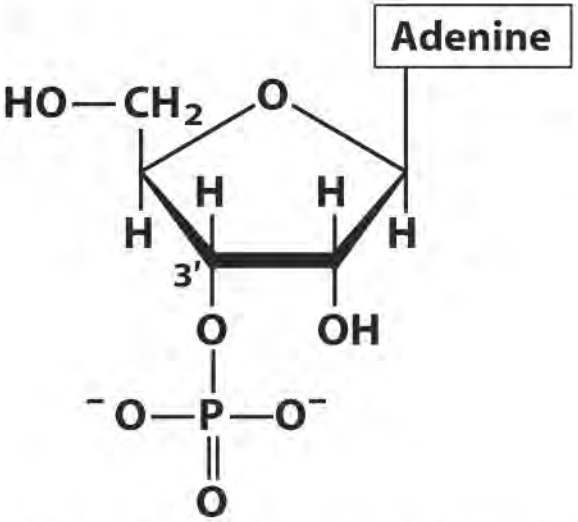
(a) Deoxyribonucleotides



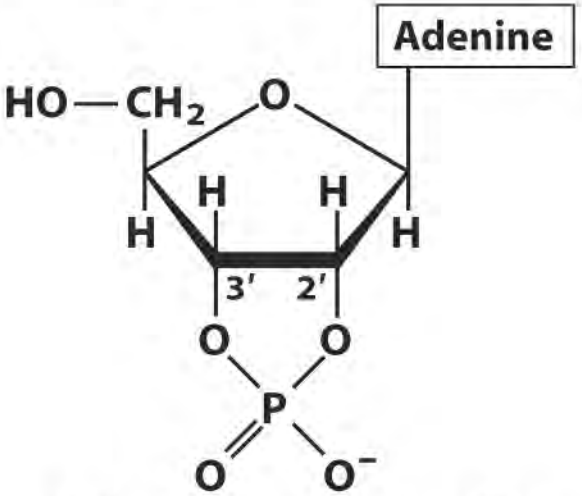
Adenosine 5′-monophosphate



Adenosine 2′-monophosphate



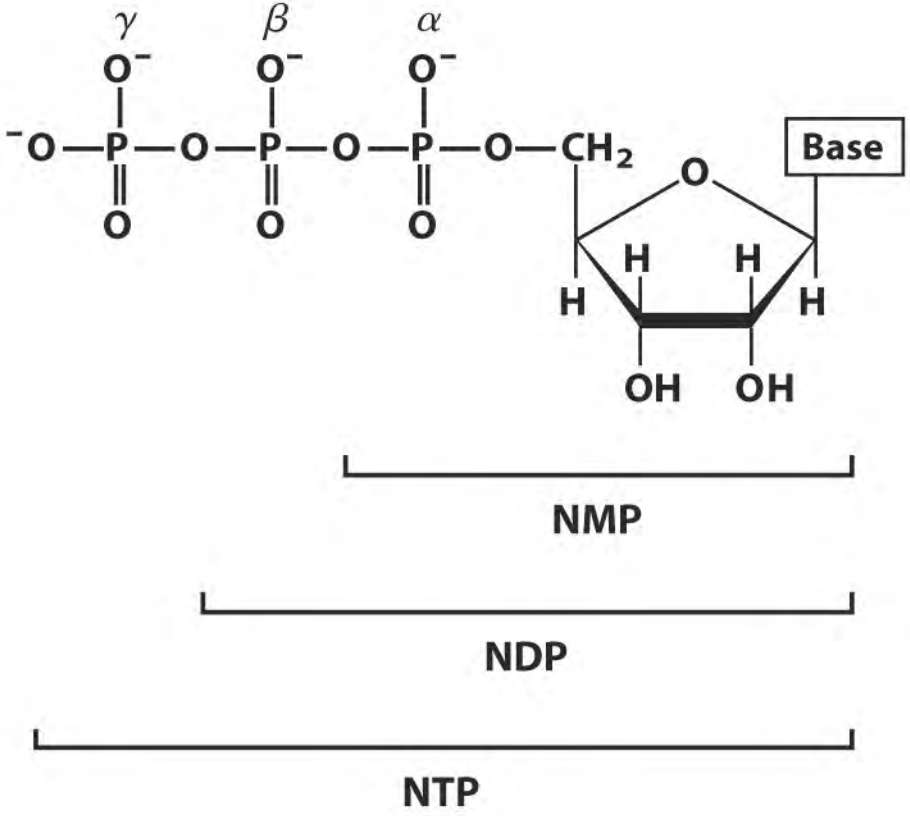
Adenosine 3′-monophosphate



Adenosine 2′,3′-cyclic monophosphate

TABLE 8–1 Nucleotide and Nucleic Acid Nomenclature

Base	*Nucleoside*	*Nucleotide*	*Nucleic acid*
Purines			
Adenine	Adenosine	Adenylate	RNA
	Deoxyadenosine	Deoxyadenylate	DNA
Guanine	Guanosine	Guanylate	RNA
	Deoxyguanosine	Deoxyguanylate	DNA
Pyrimidines			
Cytosine	Cytidine	Cytidylate	RNA
	Deoxycytidine	Deoxycytidylate	DNA
Thymine	Thymidine or deoxythymidine	Thymidylate or deoxythymidylate	DNA
Uracil	Uridine	Uridylate	RNA



Abbreviations of ribonucleoside 5′-phosphates			
Base	**Mono-**	**Di-**	**Tri-**
Adenine	AMP	ADP	ATP
Guanine	GMP	GDP	GTP
Cytosine	CMP	CDP	CTP
Uracil	UMP	UDP	UTP

Abbreviations of deoxyribonucleoside 5′-phosphates			
Base	**Mono-**	**Di-**	**Tri-**
Adenine	dAMP	dADP	dATP
Guanine	dGMP	dGDP	dGTP
Cytosine	dCMP	dCDP	dCTP
Thymine	dTMP	dTDP	dTTP



Are You Getting It??



Which characteristics do nucleotides have?
(multiple answers)

a) They all contain a nitrogenous base.
b) They all contain D-ribose.
c) They all contain one phosphate group.
d) They all will be negatively charged at pH=7.0
e) They all will be broken down in acid.
f) They all are found in DNA.



Are You Getting It??



Answer

Which characteristics do nucleotides have?

a) ***They all contain a nitrogenous base.***

b) **They all contain D-ribose.**

c) **They all contain one phosphate group.**

d) ***They all will be negatively charged at pH=7.0***

e) ***They all will be broken down in acid.***

f) **They all are found in DNA.**



Are You Getting It??



Which characteristics does ADP have?

(multiple answers)

a) It contains deoxyribose.
b) It contains two phosphate groups.
c) It has a charge of -3 at cellular pH.
d) It contains a purine.
e) It contains a furanose.
f) It is the same compound as adenosine.



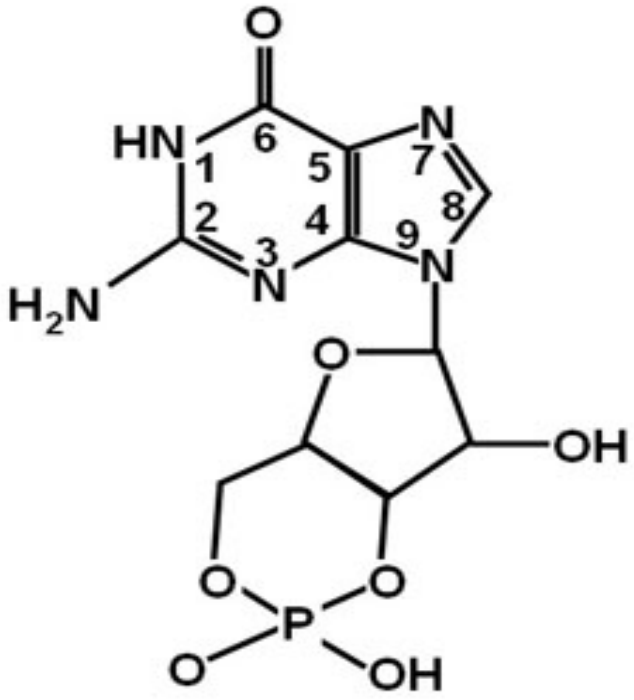
Are You Getting It??



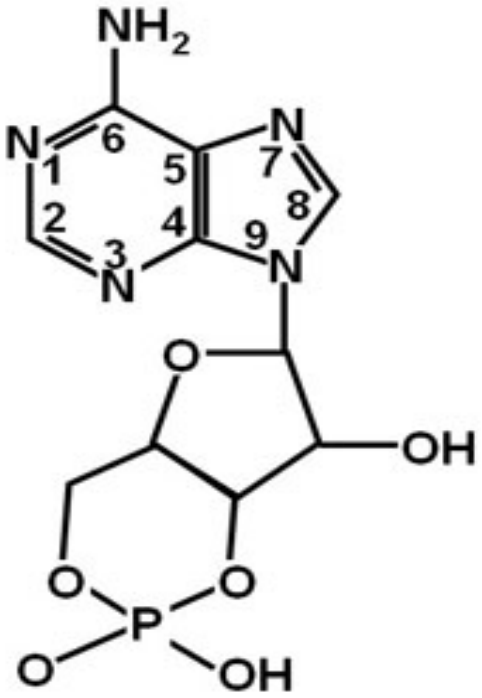
Answer

Which characteristics does ADP have?

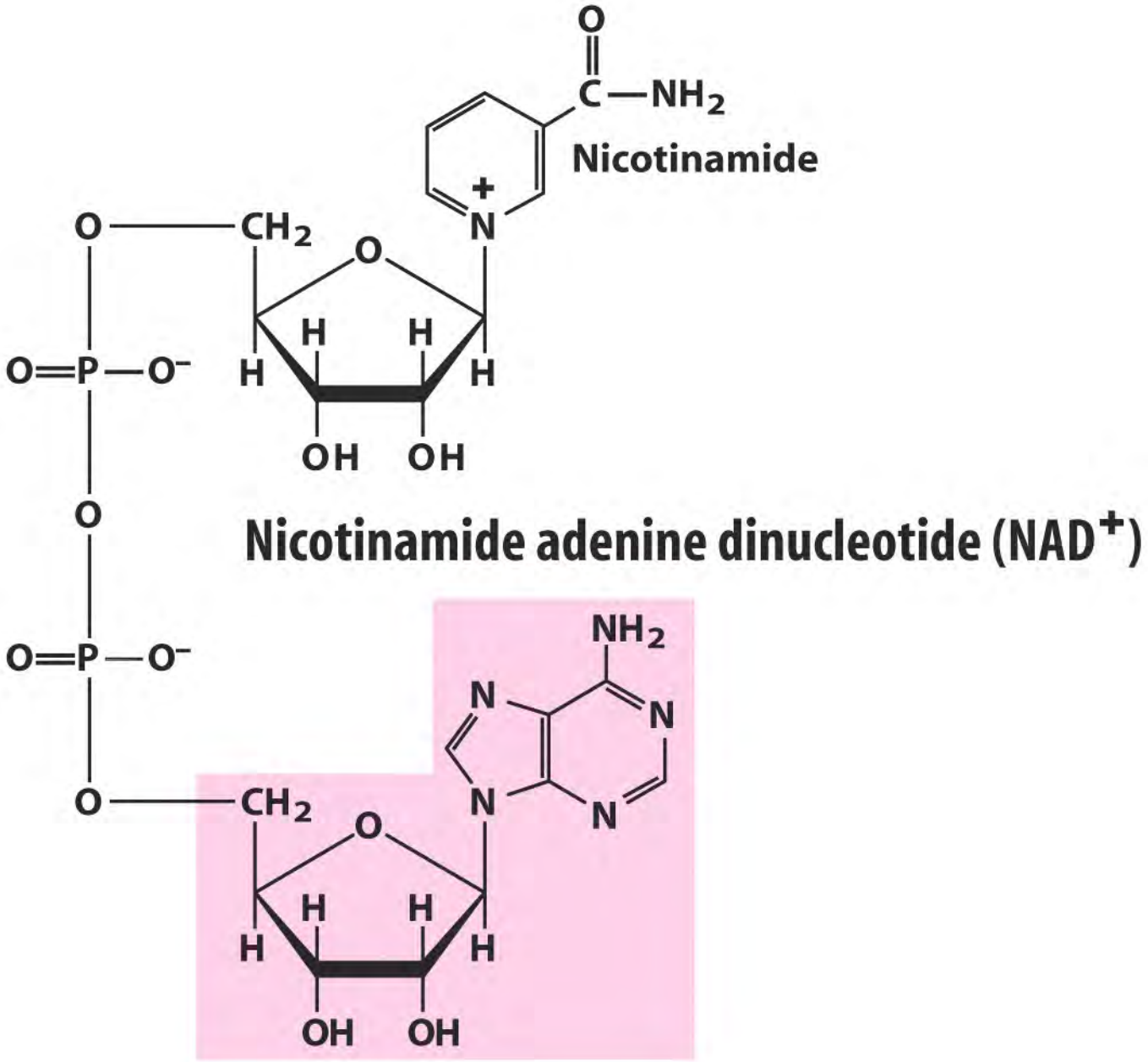
a) **It contains deoxyribose.**
b) ***It contains two phosphate groups.***
c) ***It has a charge of -3 at cellular pH.***
d) ***It contains a purine.***
e) ***It contains a furanose.***
f) **It is the same compound as adenosine.**


O
HN
1
6
5
N
7
8
2
4
3
9
N
N
H_2N
O
OH
O
O
P
O
OH

cGMP


NH_2
N
1
6
5
N
7
8
2
4
3
9
N
N
O
OH
O
O
P
O
OH

cAMP


O
C—NH2
Nicotinamide
+
N
O
CH2
O
H
H
H
H
OH
OH
O=P—O−
O
O=P—O−
O
CH2
O
H
H
H
H
OH
OH
NH2
N
N
N
N
Nicotinamide adenine dinucleotide (NAD+)