Nucleotide Structure

3 Components of a Nucleotide

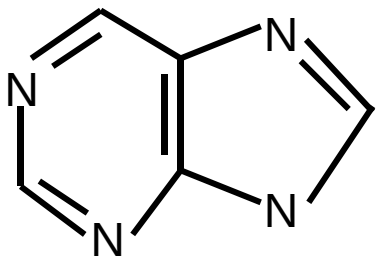
- base
- sugar
- phosphate / $PO_4^{=}$

Both glycosidic and phosphodiester bonds →

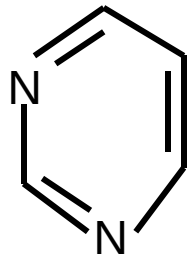
Therefore, these bonds facilitate nucleotide structural features

Base Structure and Nomenclature

purine (Pu) base
(two rings – 9 constituent atoms)



pyrimidine (Pyr) base
(one ring – 6 constituent atoms)



Ring numbering designates specific ring atoms

(note: Pu and Pyr rings are numbered differently)

(note: not all ring atoms are carbons)

BASE STRUCTURE and CHEMISTRY

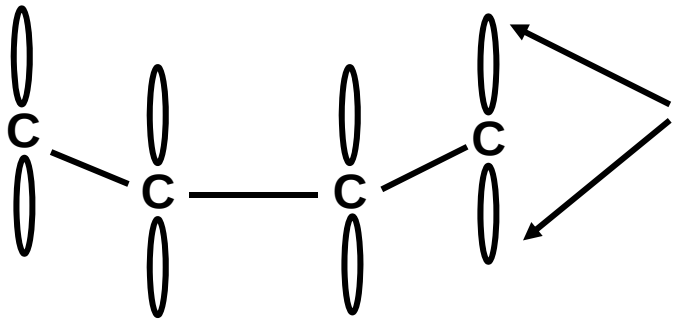
1. Ring Chemistry and Structure

Pu and Pyr rings → **aromatic in character ??**

What are you looking for??

benzene ring

(note: all ring atoms are carbon)



How does non-carbon atoms affect ring structure?? → **Pu / Pyr ring nitrogens**

Pu / Pyr rings aromatic? →

benzene ring structure →

Pu & Pyr ring structure →

Pu / Pyr ring C and N atoms →

Note: electron distribution is uneven thus affecting the chemical and reactive properties of the constituent ring atoms

2. Base Solubility

solvent of cells and living organisms →

pseudoaromatic Pu / Pyr bases →

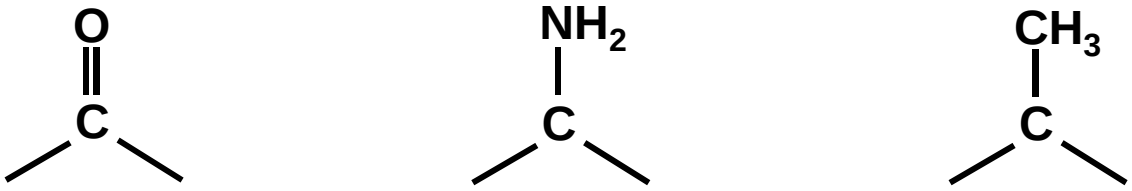
↓

important consequence for nucleic acid structure and base interaction with water ←

hydrophobic interaction between Pu / Pyr bases ↓

3. Base Exocyclic Modifications

three types of exocyclic base modifications



guanine (Pu) —NH_2 (2) =O (6)

adenine (Pu) —NH_2 (6)

cytosine (Pyr) =O (2) —NH_2 (4)

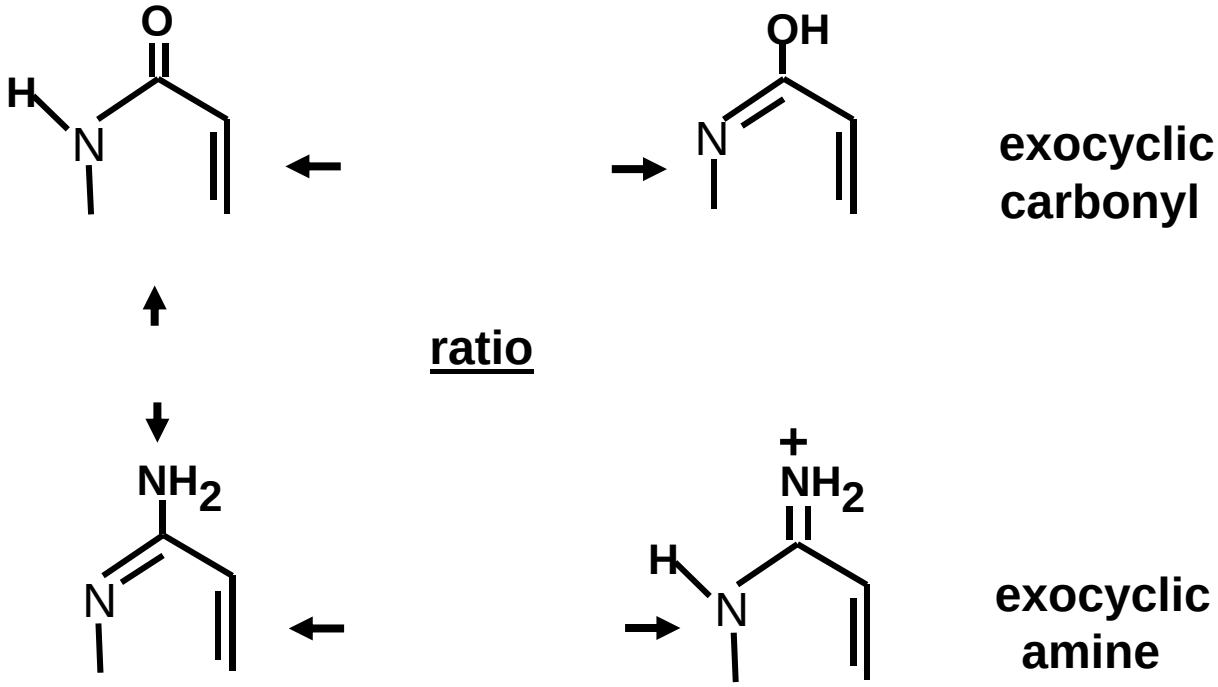
thymine (Pyr) =O (2) =O (4) —CH_3 (5)

uracil (Pyr) =O (2) =O (4)

(numbers in parentheses indicate position of exocyclic modification)

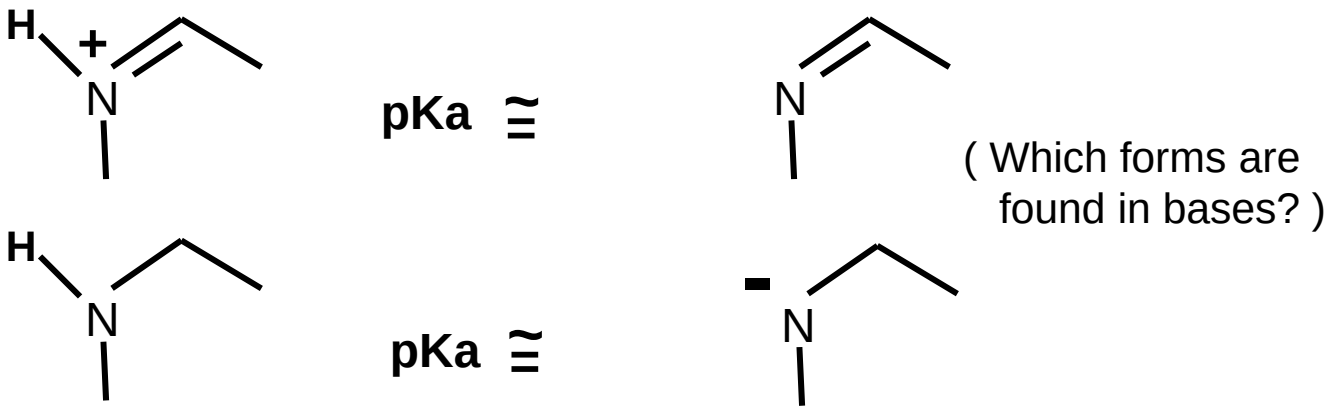
??? → **How do these exocyclic modifications affect the chemical character / reactivity of each base ??**

4. Base Tautomeric Forms



5. Ionizable Base Groups → "base" = ionizable with values

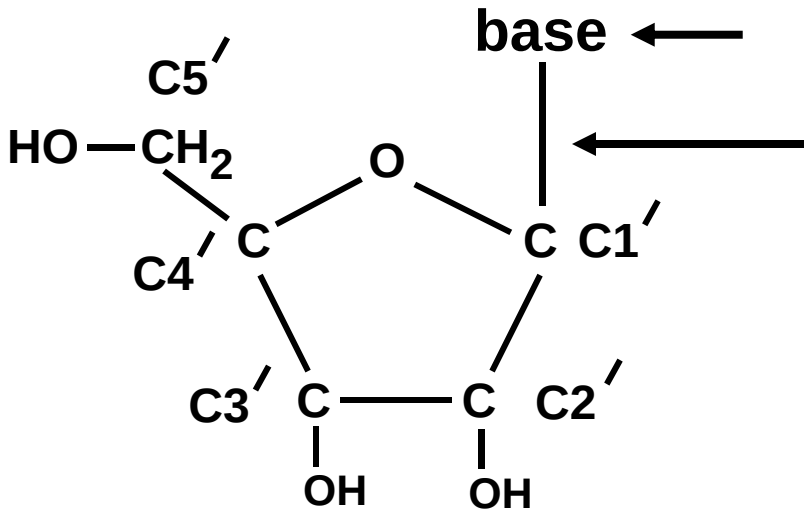
(protons on ring N)



At physiological pH (7.0) → Base charge ? →

Ribose / Deoxyribose Sugar Structure

Ribose → → specific sugar carbons are defined by designation



(beta configuration at the C1' carbon with free 360° rotation)

free rotation described by ↓

ribose →

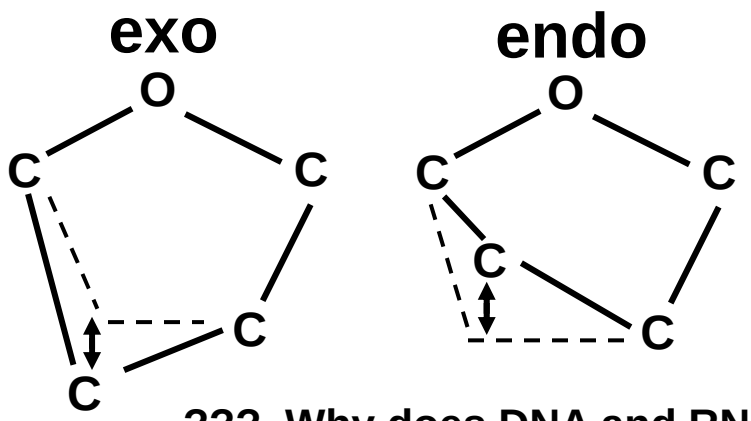
deoxyribose →

Sugar Ring Structure → sugar ring carbons (C2' and C3') can twist out of the plane or ↓

↓ flat planar ring not stabilized by resonance

→ carbon out of sugar plane towards base

→ carbon out of sugar plane away from base



DNA (typically) =

RNA (typically) =

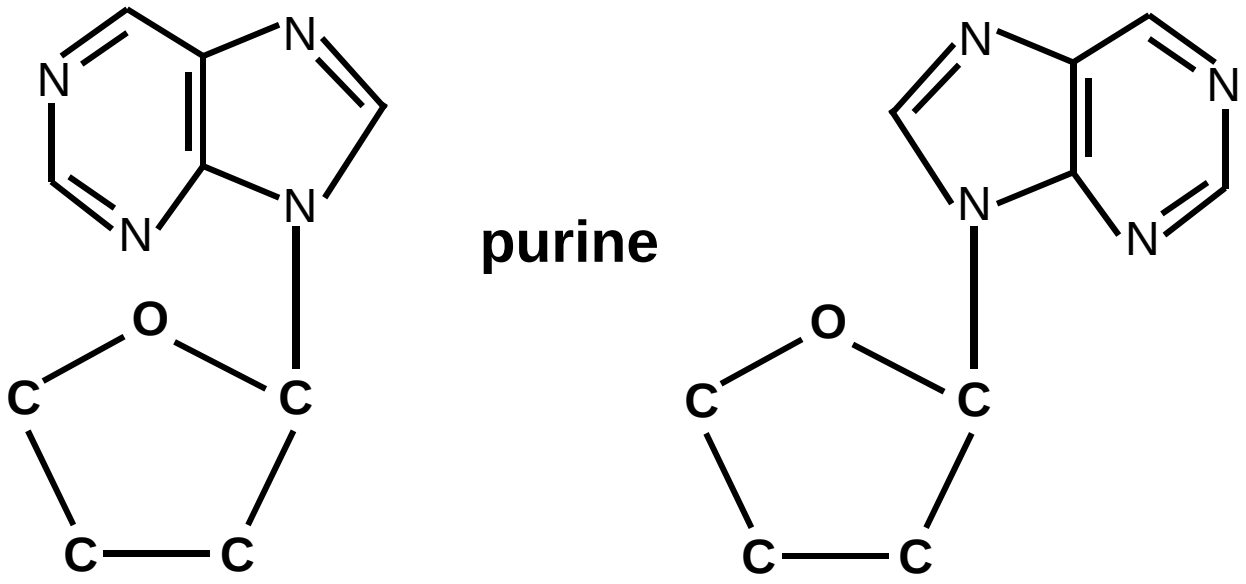
??? Why does DNA and RNA exhibit different puckers?

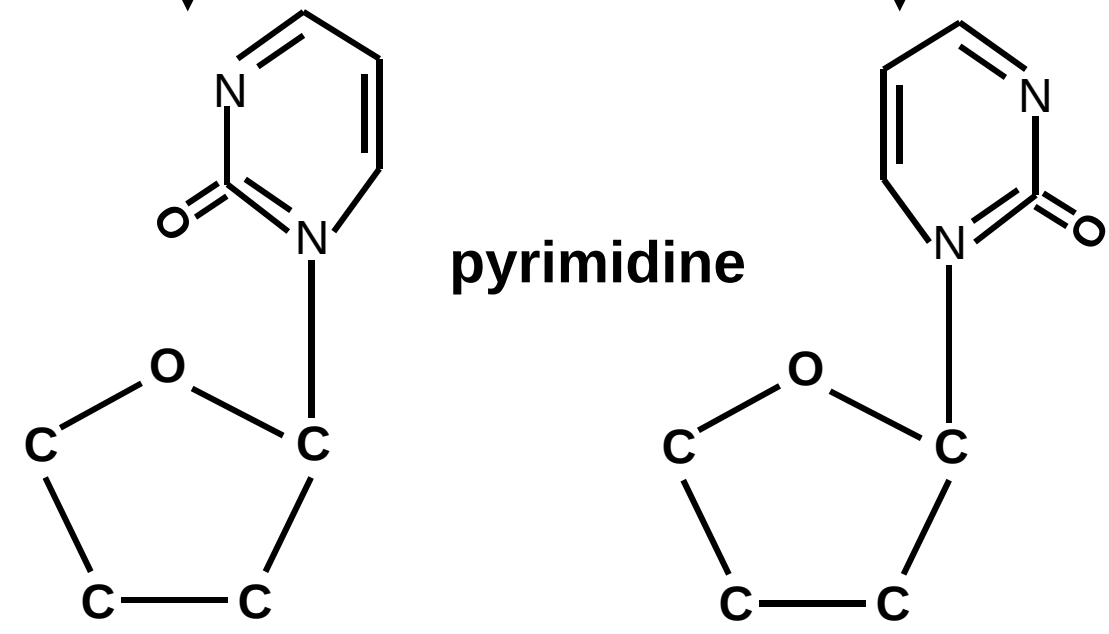
Sugar – Base Linkage: →

→ free 360 degree rotation around glycosidic bond

→ range of motion/angles around χ angle

Base Configuration Around the Glycosidic Bond ⇄





→ **is energetically/sterically favorable**

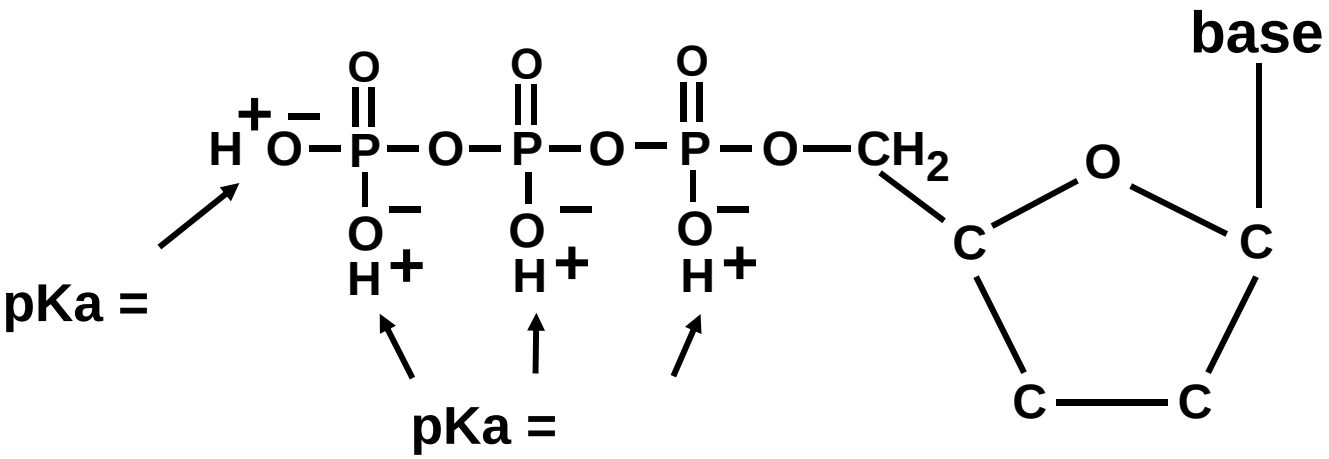
Phosphate Groups →

↓

→

→ ionization state / protonation dependent upon pH

→ $PO_4^{\equiv}$ addition makes the nucleotide more soluble



What is the sugar -- $PO_4^{\equiv}$ backbone charge (pH 7)?? →

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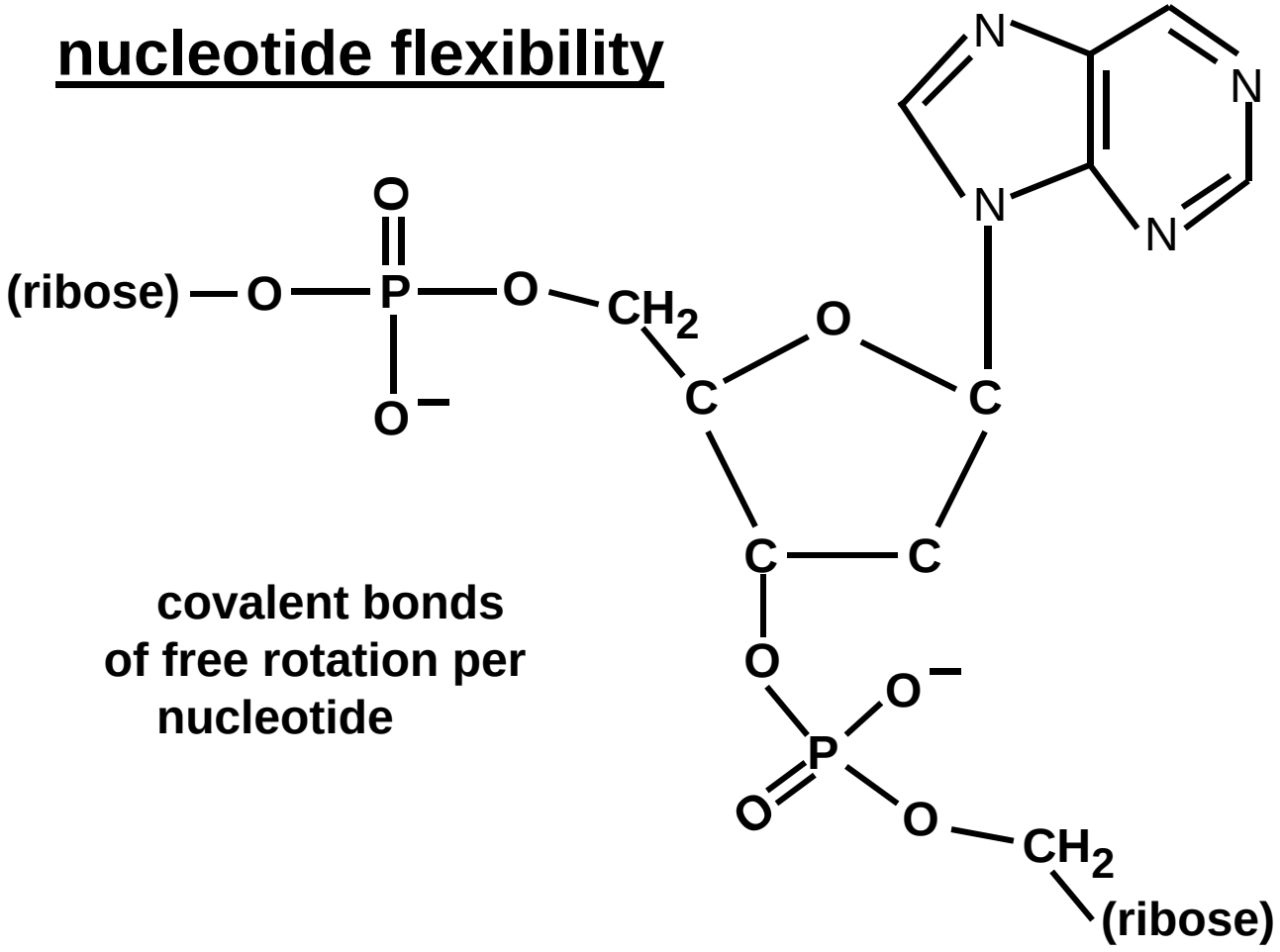
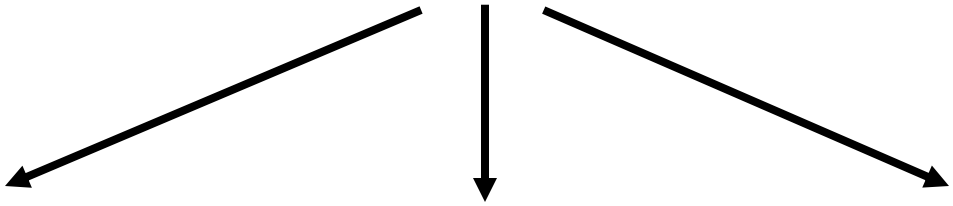
nucleotide flexibility



covalent bonds of free rotation per nucleotide

nucleotide flexibility built into the nt's structure

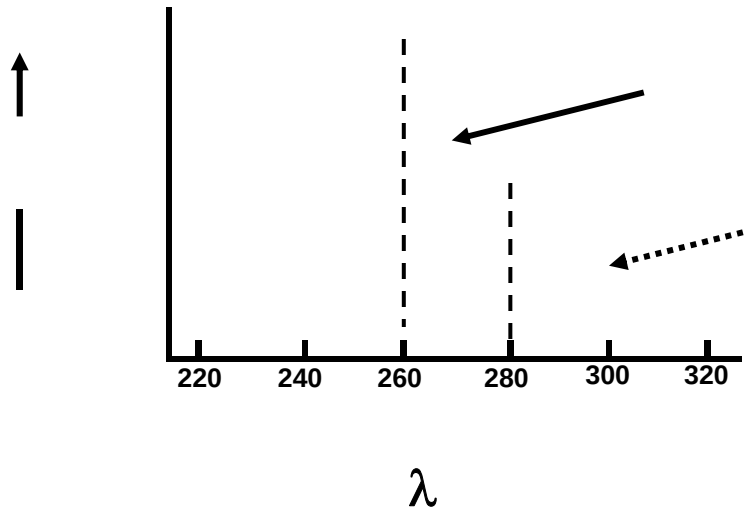


Important physical property of nucleotides/nucleic acids

ablilty to absorb incident radiation or → **nt base is a**

base ring → **absorb UV light** (conjugated double bonds) → **ground to excited state**

nt / nucleic acid absorption spectrum



(nucleotides and nucleic acids)

(proteins)

$$\frac{A_{260}}{A_{280}}$$ **ratio =**

(nts / nucleic acids)

?? What happens to A260/A280 ratio with protein contamination?