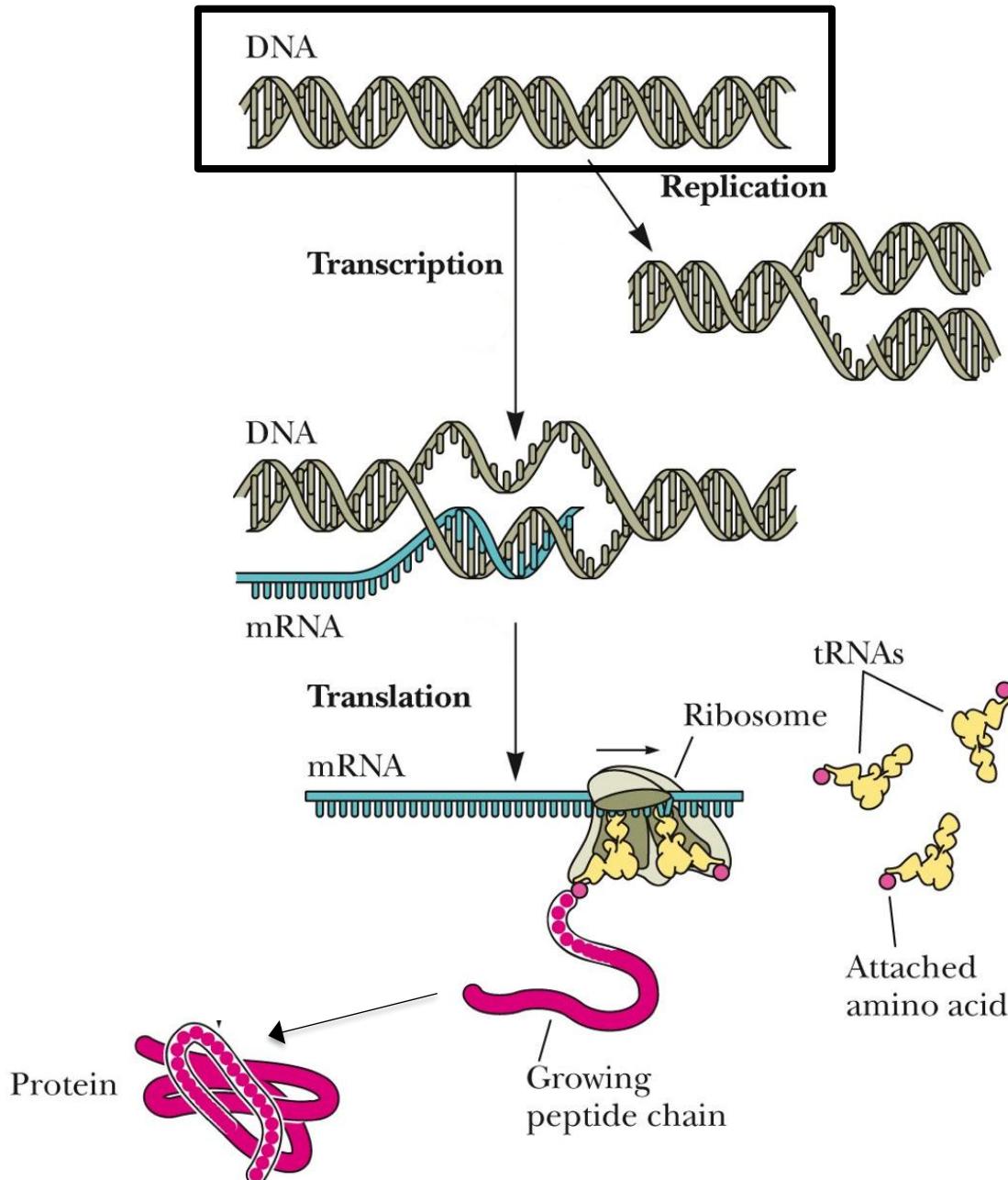


DNA and RNA Structure

The central dogma of molecular biology



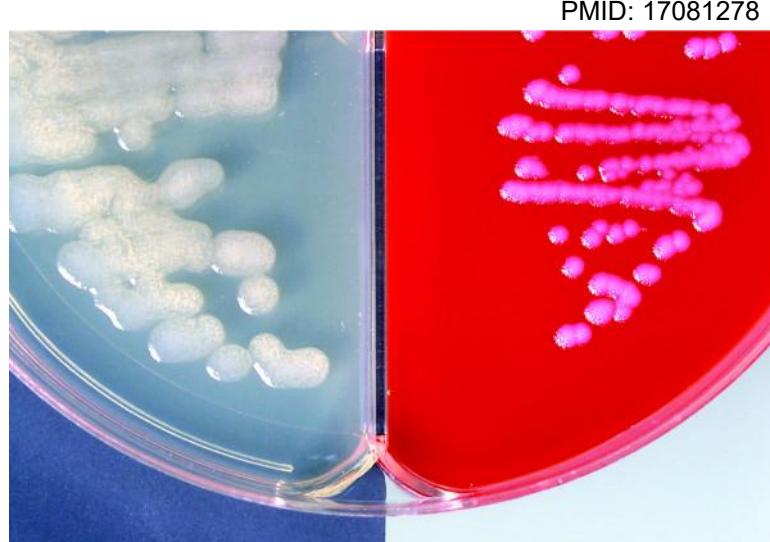
Learning Objectives

1. Understand the methodology and conclusions made from landmark experiments that helped us to understand the function and structure of DNA.
2. Be familiar with Chargaff's rules and be able to compare and contrast the three models of DNA structure.
3. Be able to draw base pair interactions and a nucleic acid structure from a given sequence.
4. Know the stabilizing forces of the DNA double helix.
5. Understand the effects of temperature, GC content, ionic strength, and hydrogen bonders on the stability of DNA and its melting temperature.
6. Know the structural differences between RNA and DNA and how these differences affect their stability.

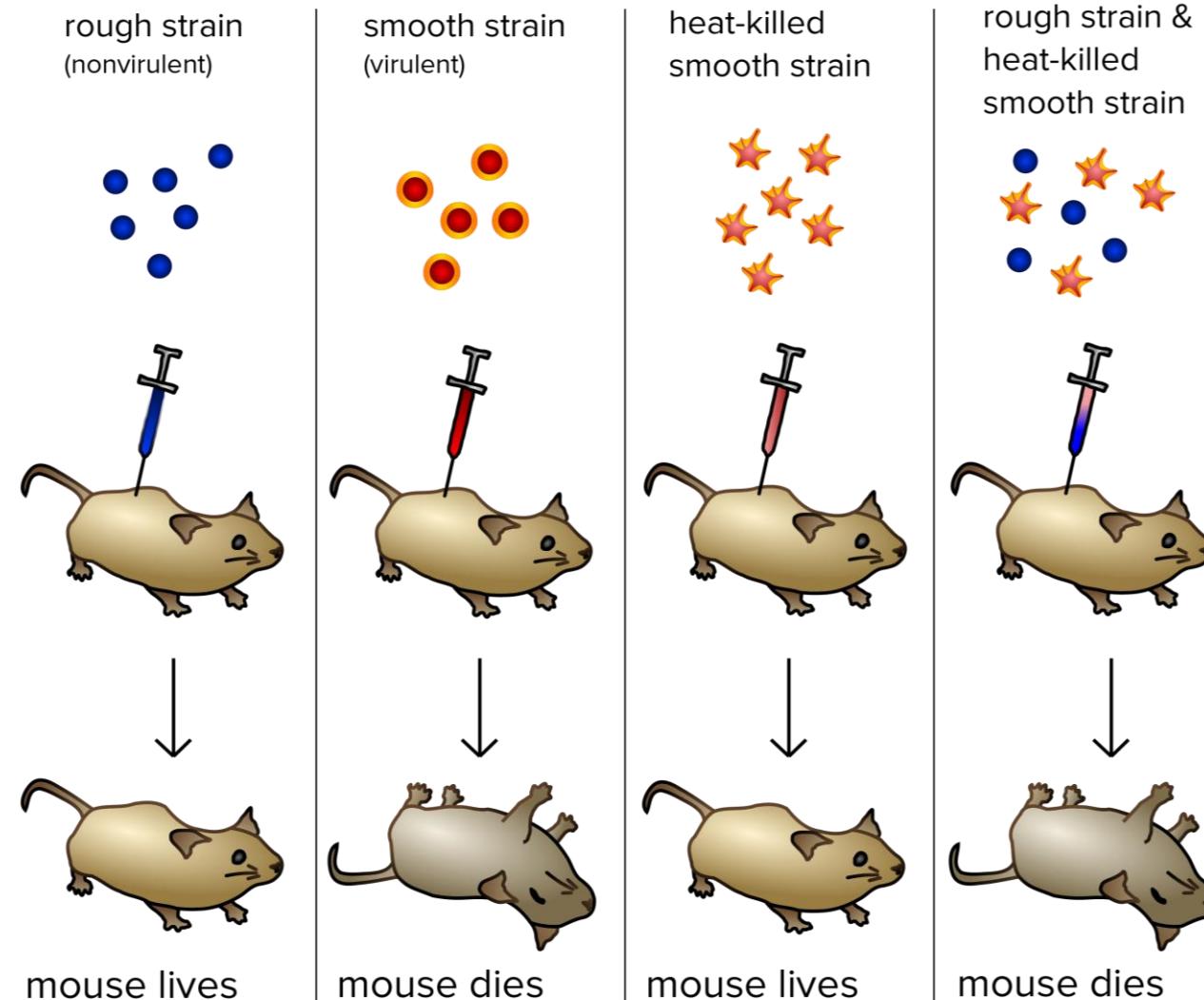
Nucleic acids have a wide variety of functions

Nucleic Acid	Abbreviation	Function
Deoxyribonucleic Acid	DNA	Stores heritable information to make all functional material in the cell
Ribonucleic Acid	RNA	Many! (See below)
Messenger RNA	mRNA	Carries “message” encoded by gene to site of protein synthesis
Transfer RNA	tRNA	Adapter molecules that carry amino acids and match to codon in mRNA
Ribosomal RNA	rRNA	Composes over half of the ribosome where proteins are made
Small nuclear RNA	snRNA	Processing of eukaryotic transcripts into mature mRNA
Small interfering RNA	siRNA	Regulation of gene expression
Long noncoding RNA	lncRNA	Regulation of gene expression

Classic Experiment 1: Frederick Griffith (1928)

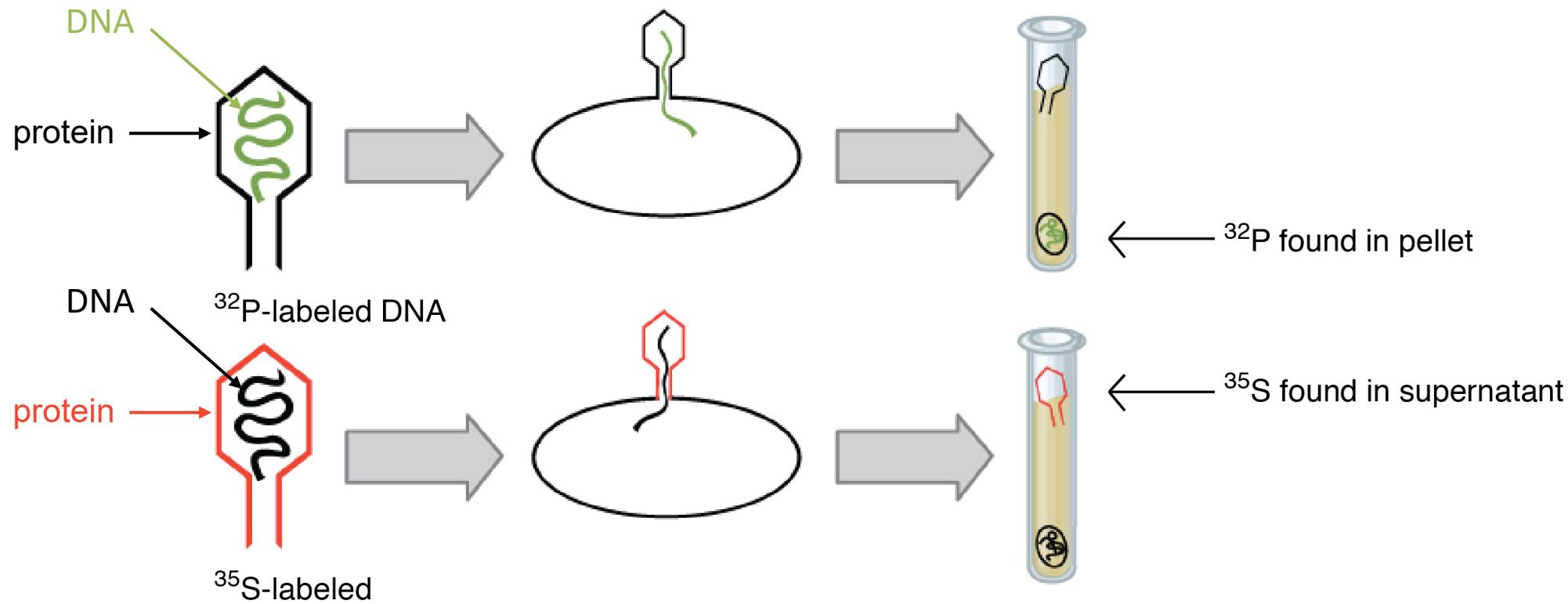


Rough Smooth
Streptococcus pneumoniae



Griffith concluded that the R strain took up a “transforming principle” from the S-strain which allowed it to become virulent.

Classic Experiment 2: Alfred Hershey and Martha Chase (1952)



The Hershey-Chase experiments definitively proved DNA as the genetic material.

DNA Structure 1: Erwin Chargaff (1950)

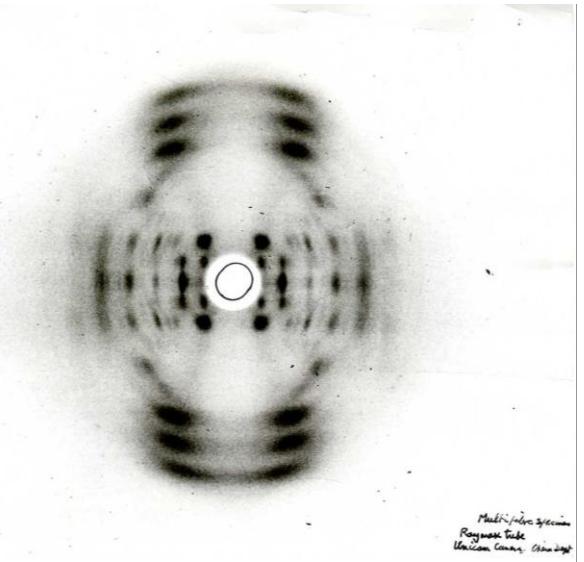
Nitrogen Base Make-Up of Different Organisms' DNA (in Percentages)				
Organism	A	T	G	C
<i>Mycobacterium tuberculosis</i>	15.1	14.6	34.9	35.4
Yeast	31.3	32.9	18.7	17.1
Wheat	27.3	27.1	22.7	22.8
Sea Urchin	32.8	32.1	17.7	17.3
Marine Crab	47.3	47.3	2.7	2.7
Turtle	29.7	27.9	22.0	21.3
Rat Kidney	28.6	28.4	21.4	21.5
Rat Liver	28.7	28.3	21.6	21.3
Human Kidney	30.9	29.4	19.9	19.8
Human Liver	30.8	29.5	20.0	19.7

?

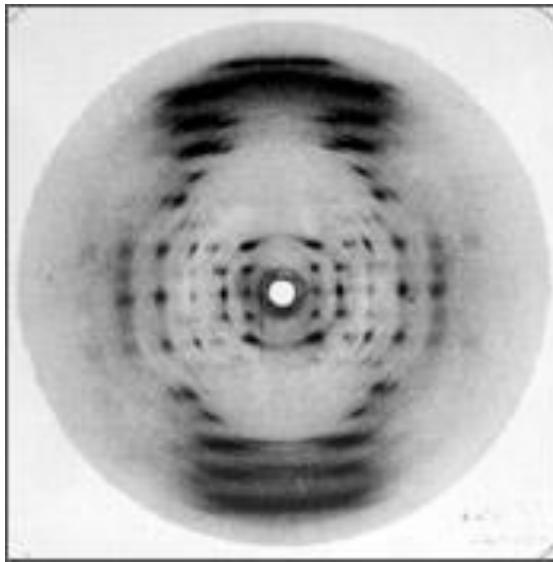
Chargaff's Rules:

1. Base composition between of DNA generally varies from one species to another.
2. DNA specimens from different tissues in the same organism have same base composition.
3. $[A]=[T]$; $[G]=[C]$; $[\text{purines}]=[\text{pyrimidines}]$ or $[A+G]=[T+C]$

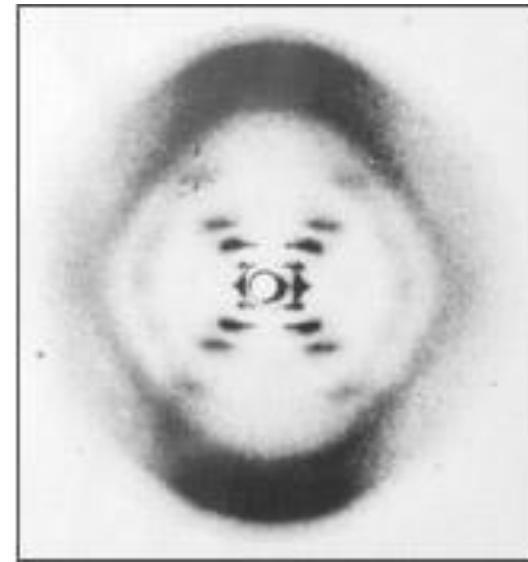
DNA Structure 2: Rosalind Franklin, Maurice Wilkins, Raymond Gosling (1951)



Wilkins and Gosling



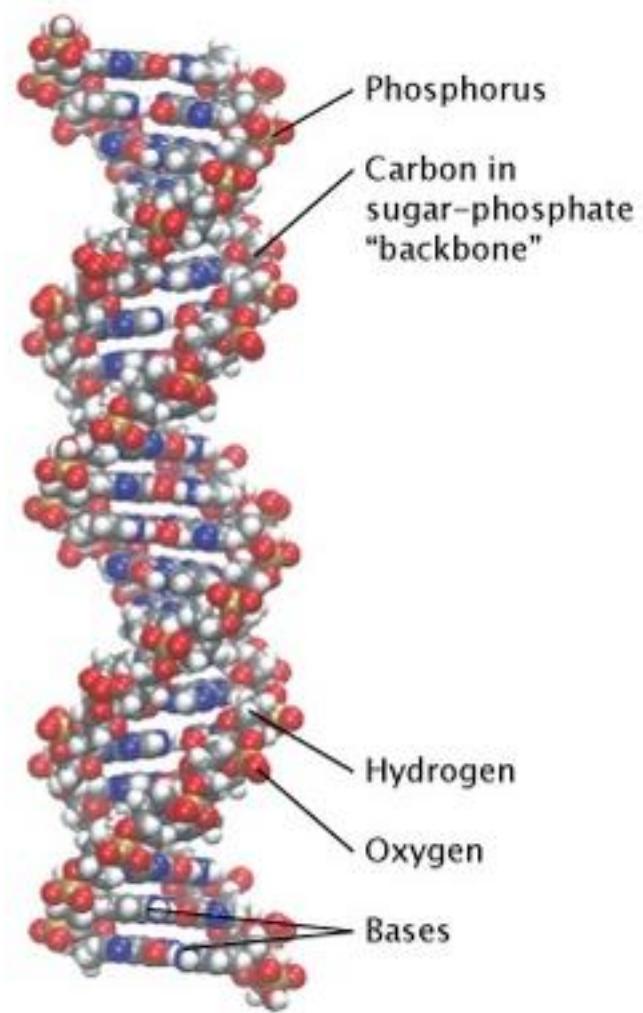
Franklin



Franklin

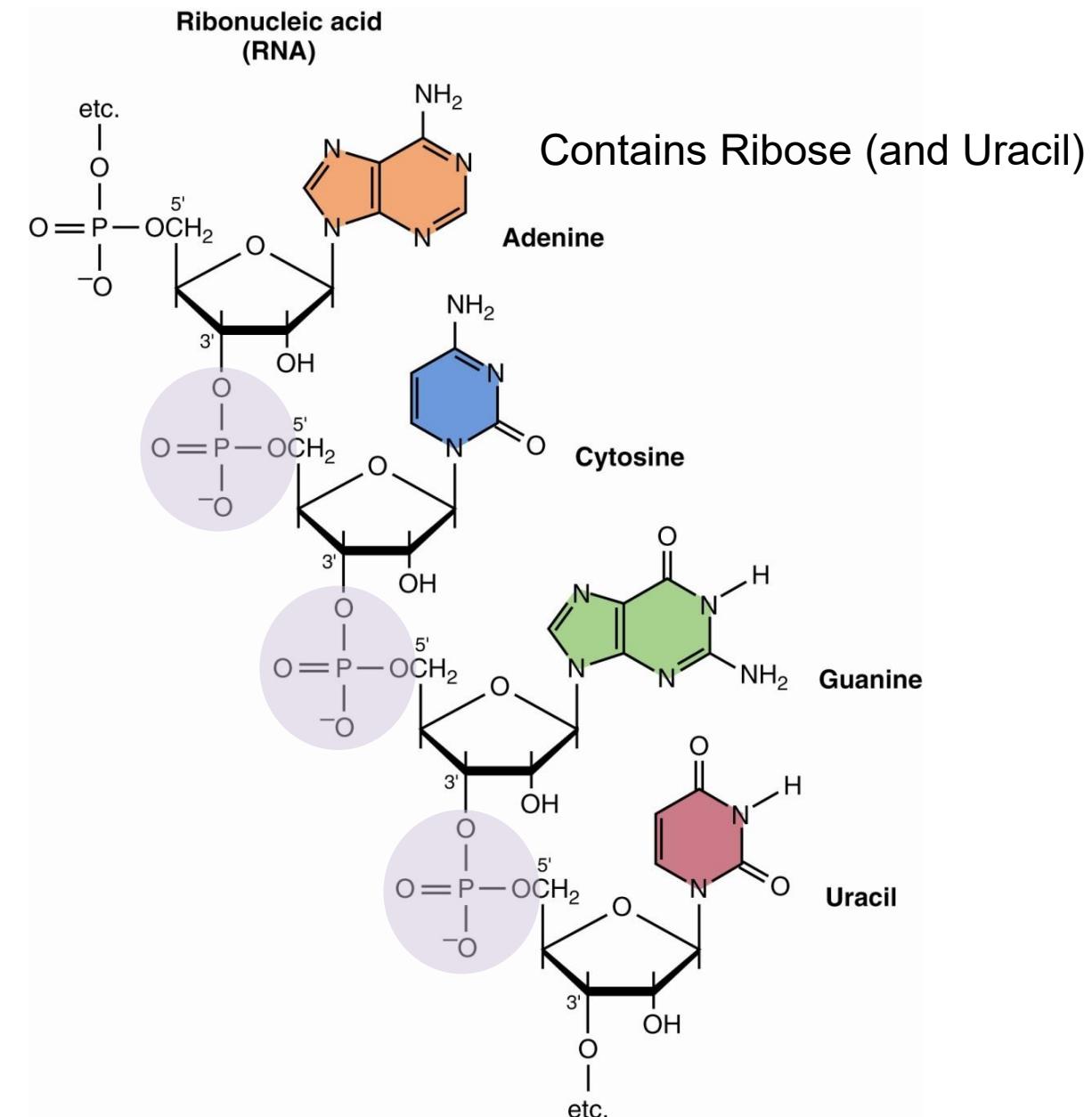
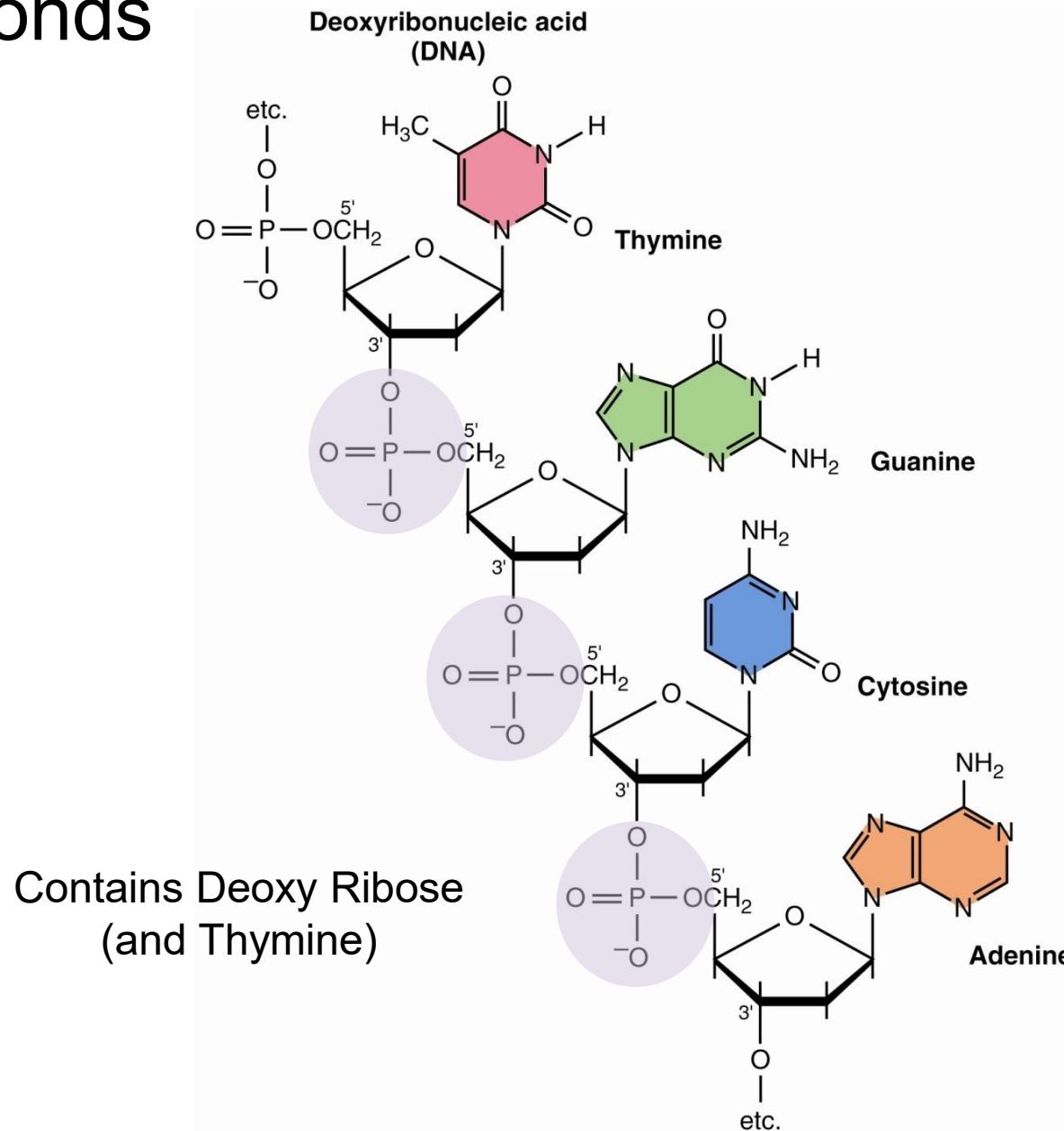
Franklin, Gosling, and Wilkins discovered two forms of DNA, and obtained high quality X-ray images of each. Franklin cautiously proposed a **helical structure, with bases inside, phosphates outside, and antiparallel strands**.

DNA Structure 3: James Watson and Francis Crick (1953)

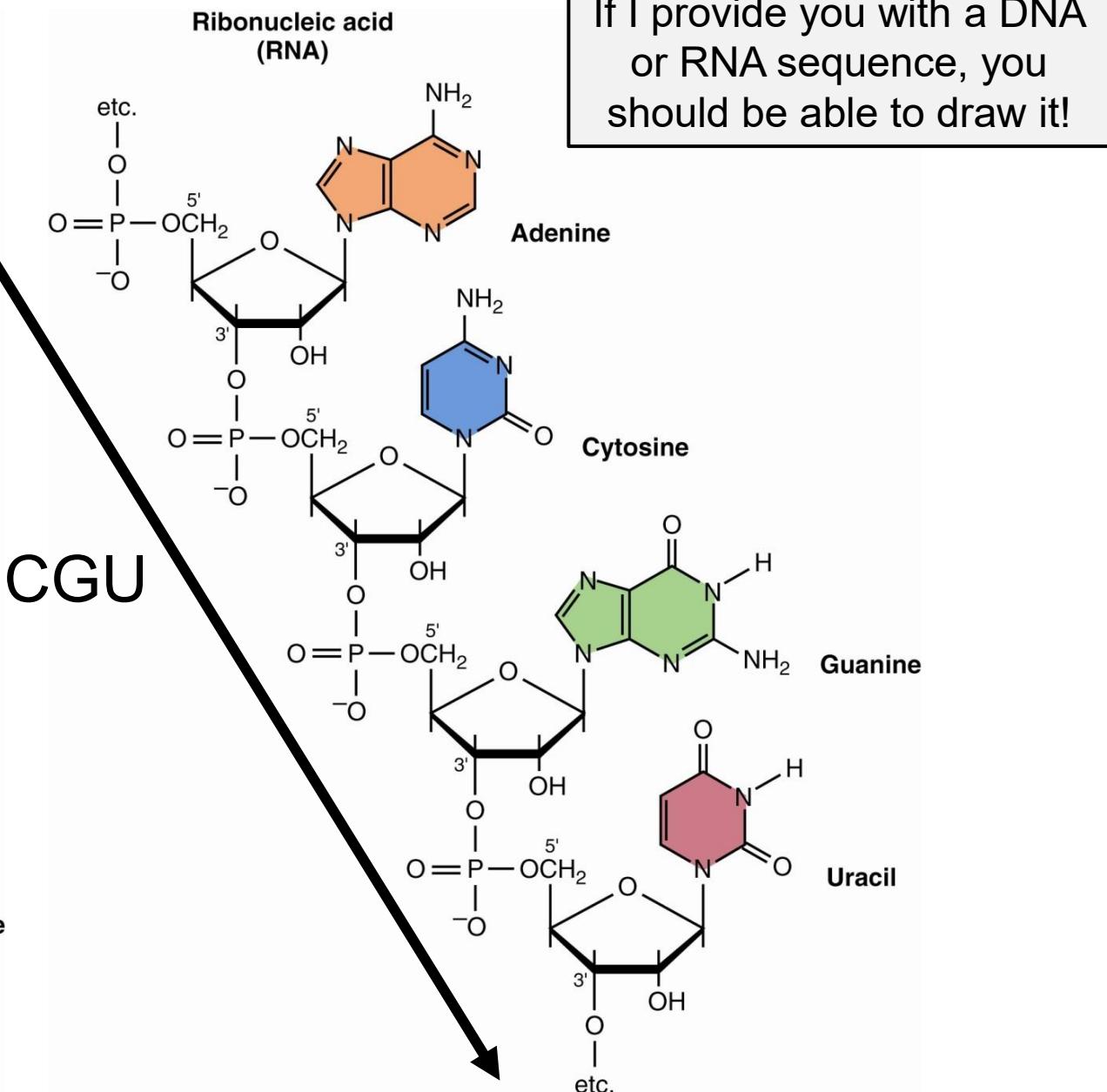
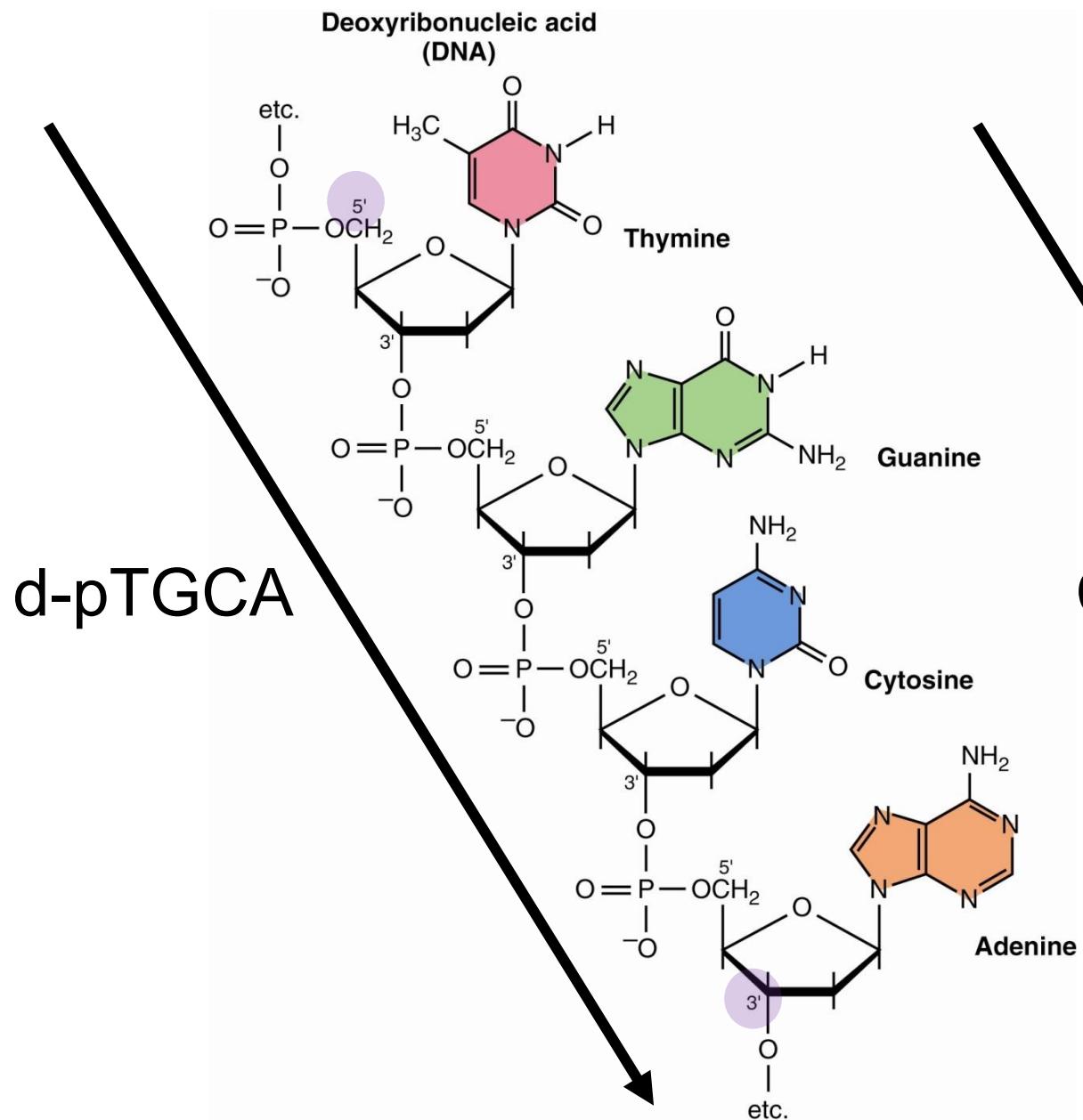


While Watson and Crick identified the correct model of DNA, the discovery would not have been possible without the work of many other scientists and decades of work.

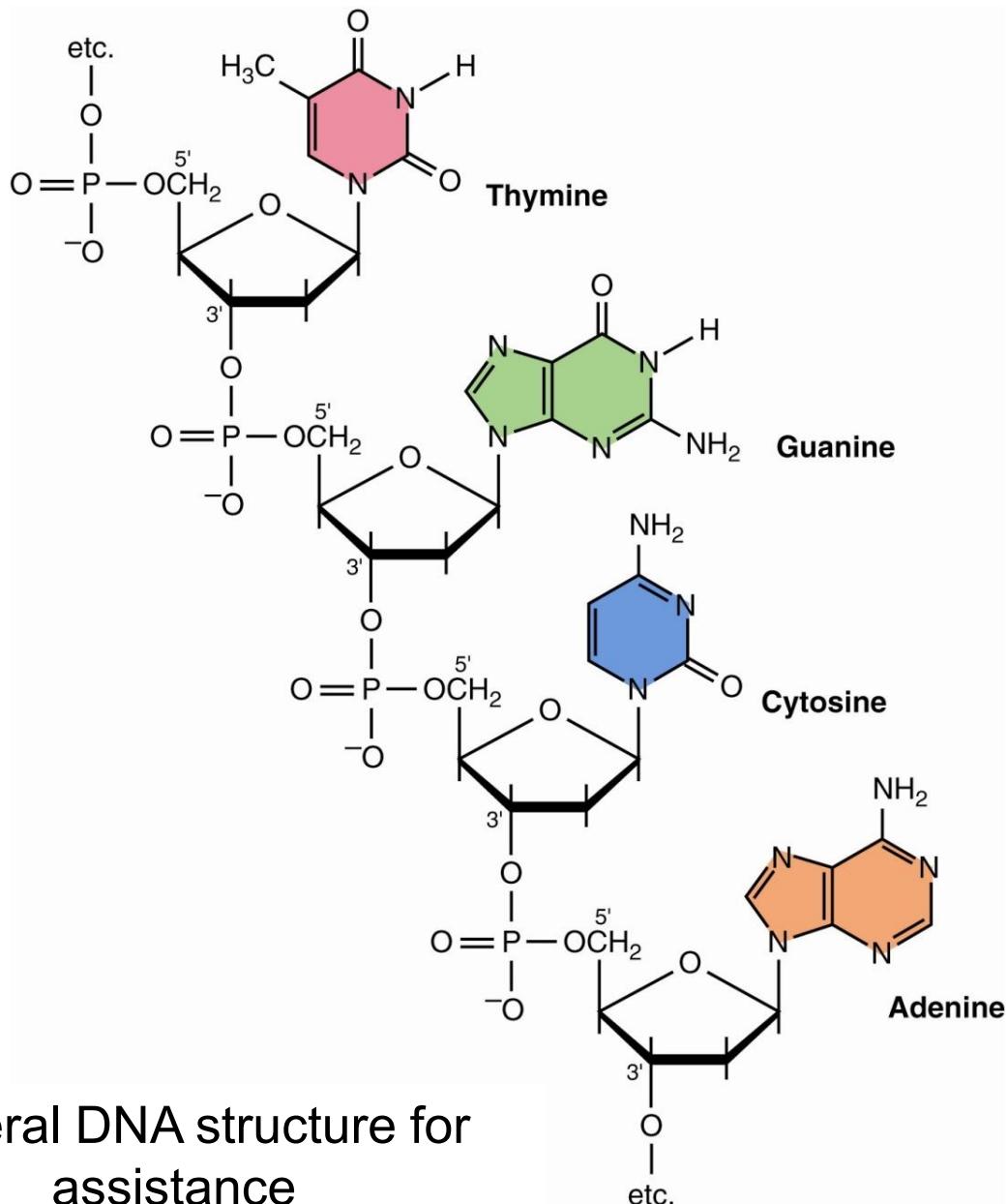
Nucleic Acids: polymers of nucleotides linked by phosphodiester bonds



Nucleic acid sequences are always written from 5' → 3'

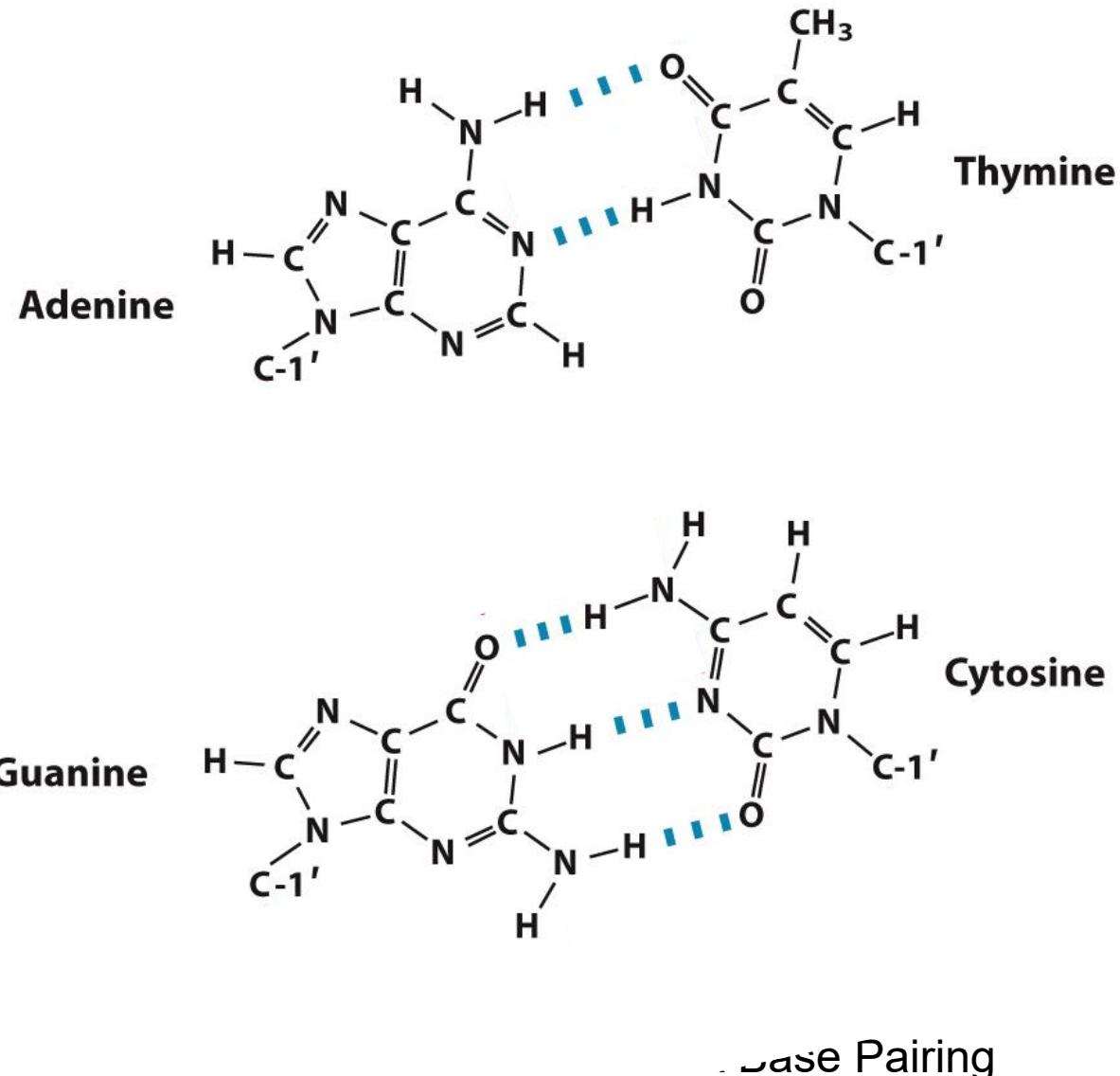
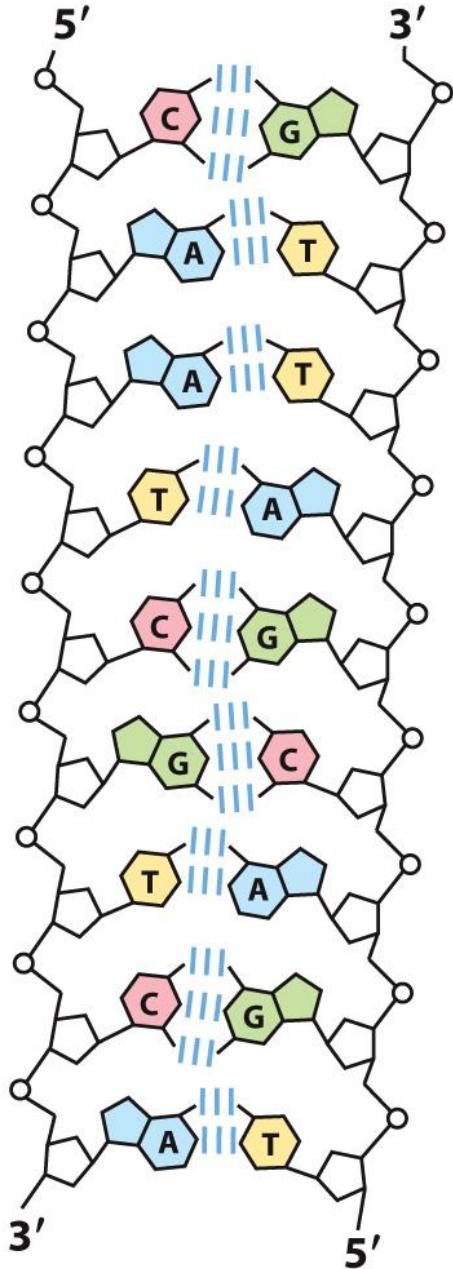


Check-in #1: Draw d-pATC_{pp}

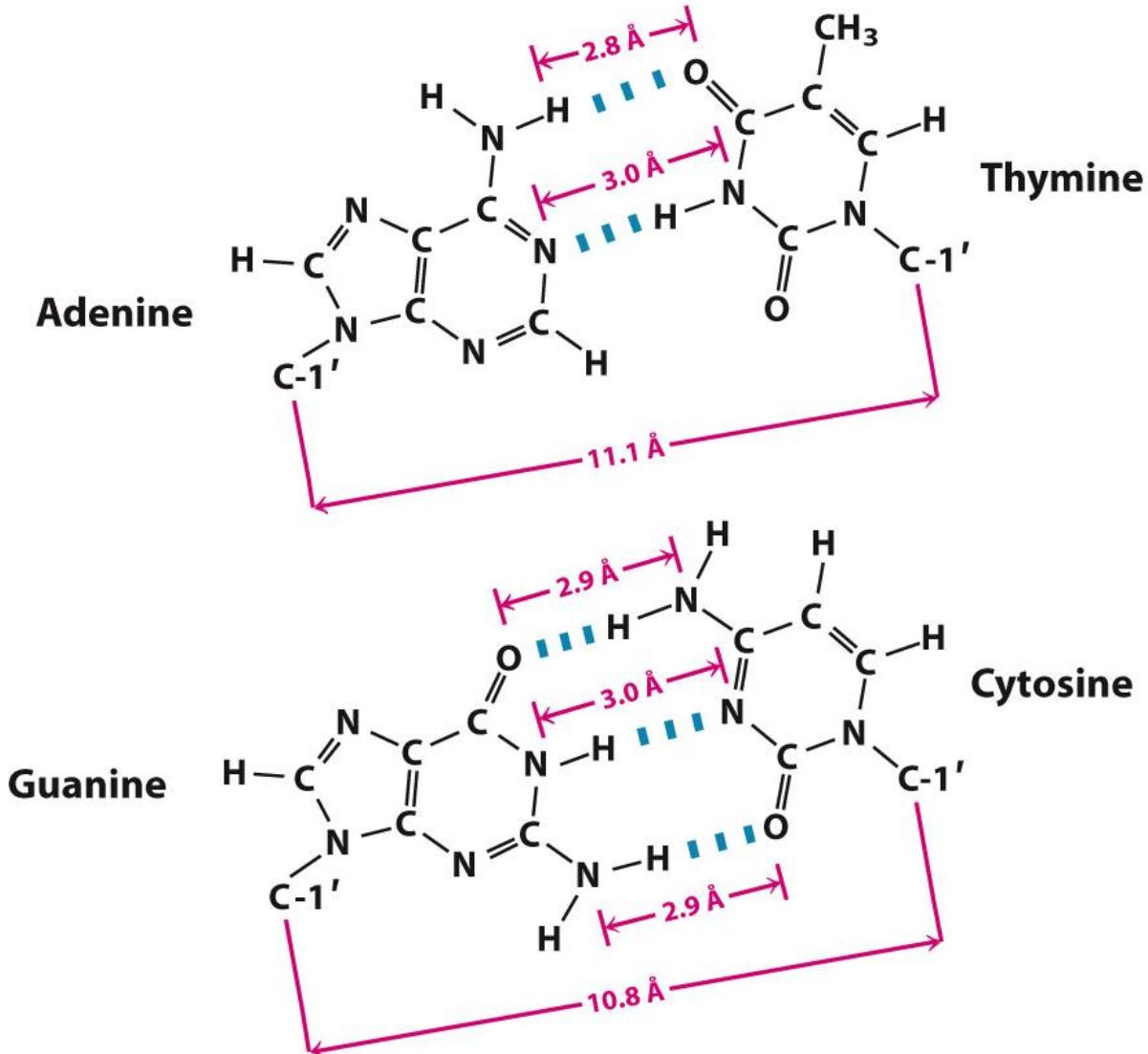
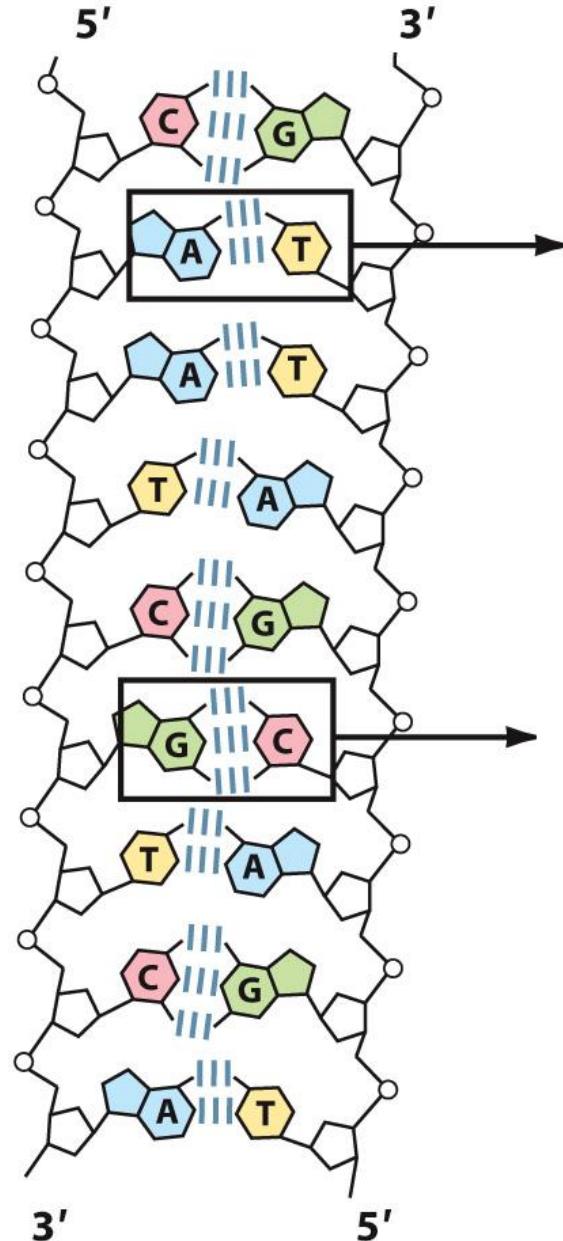


General DNA structure for assistance

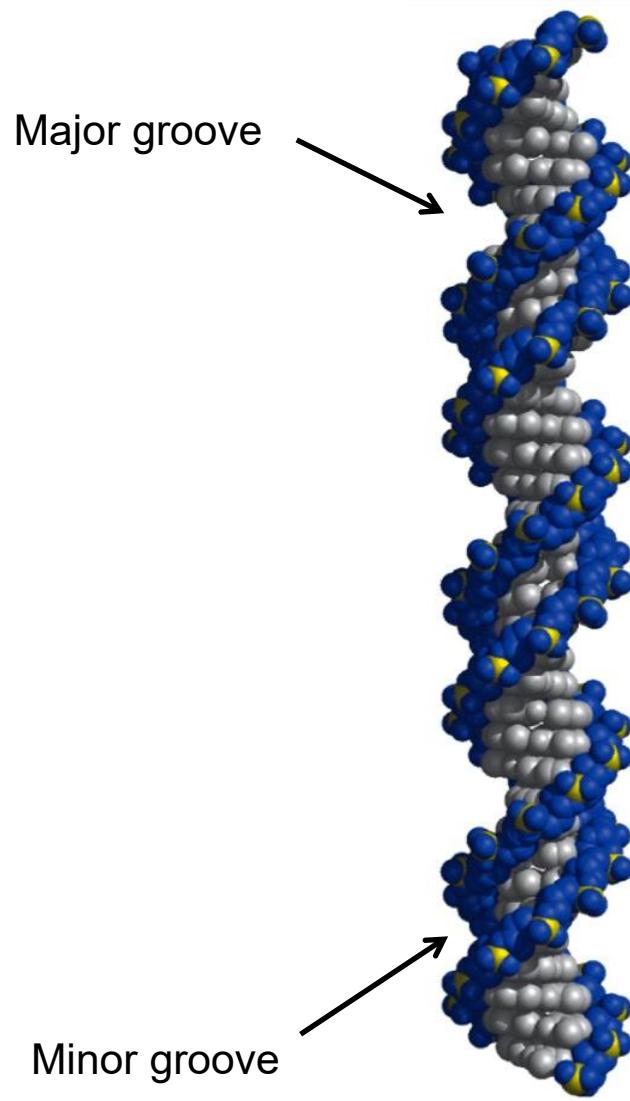
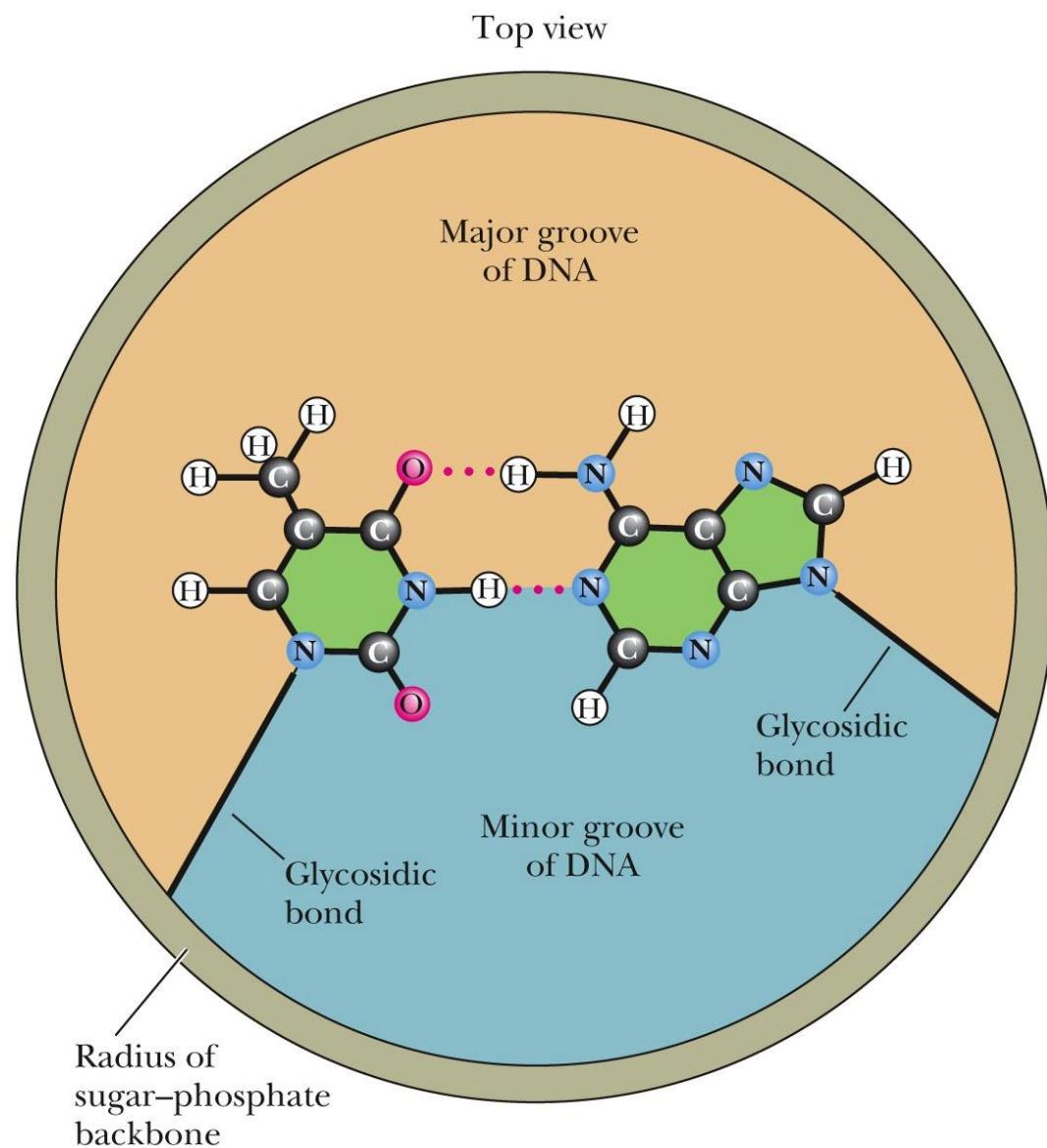
DNA strands are antiparallel and complementary



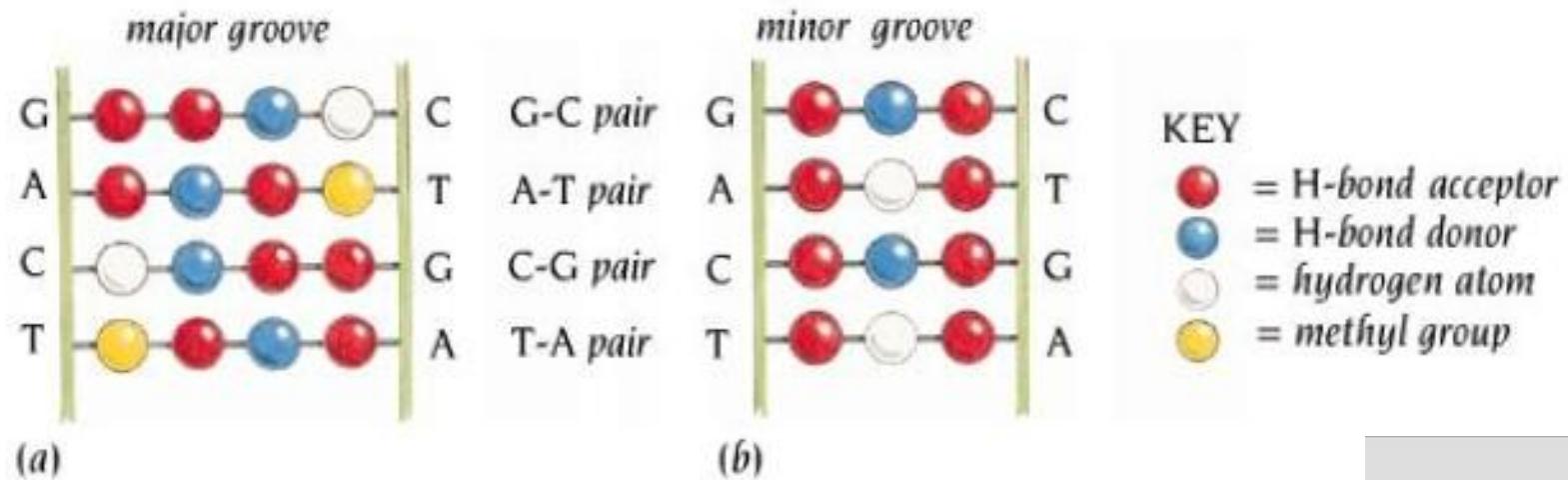
Watson Crick base pairs have nearly identical dimensions



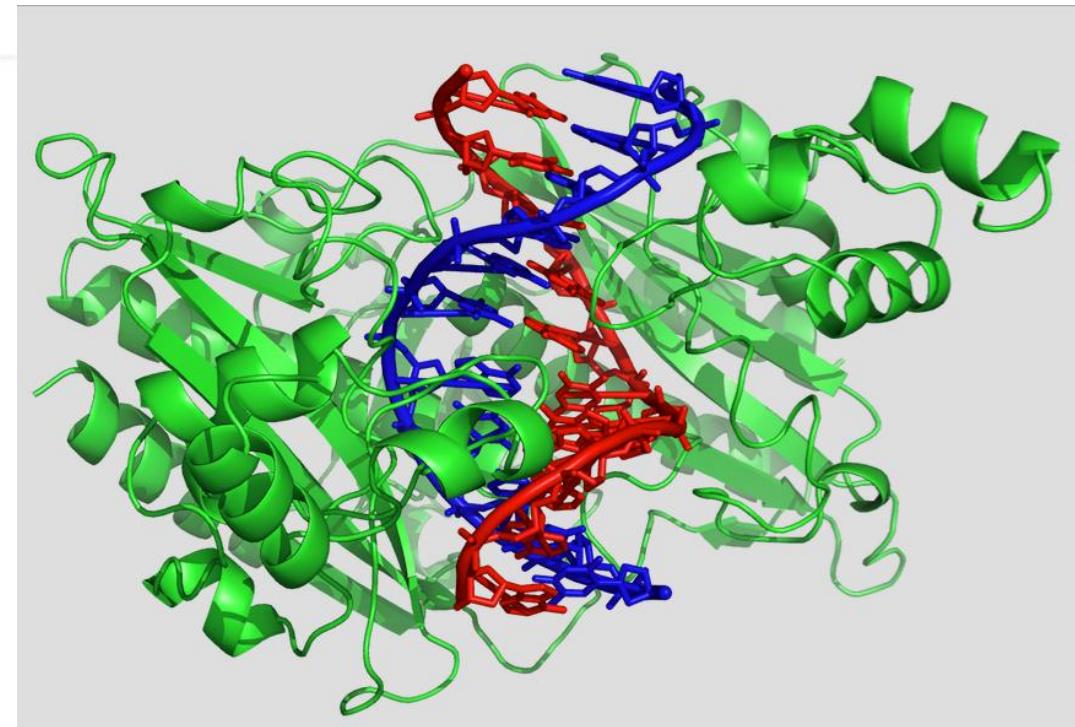
Dimensions of base pairs create major and minor grooves



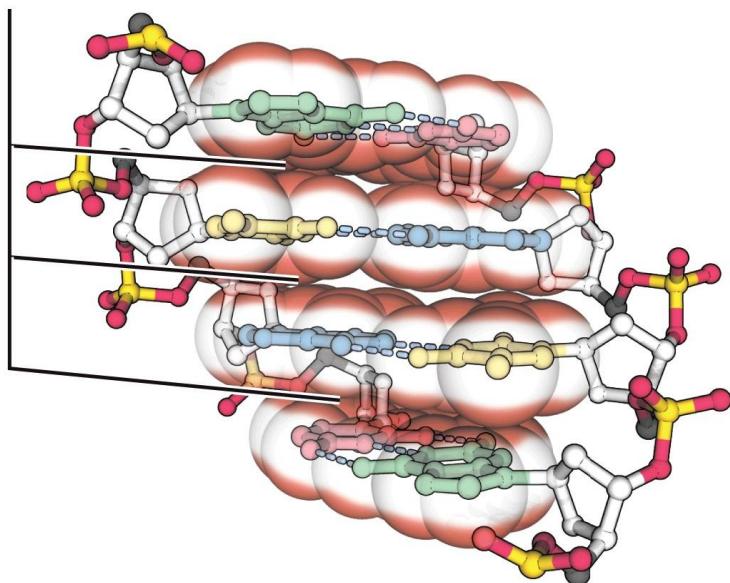
Base pairs are distinguishable in the major groove



EcoRI, a restriction enzyme, recognizes the sequence GAATTC in the major groove



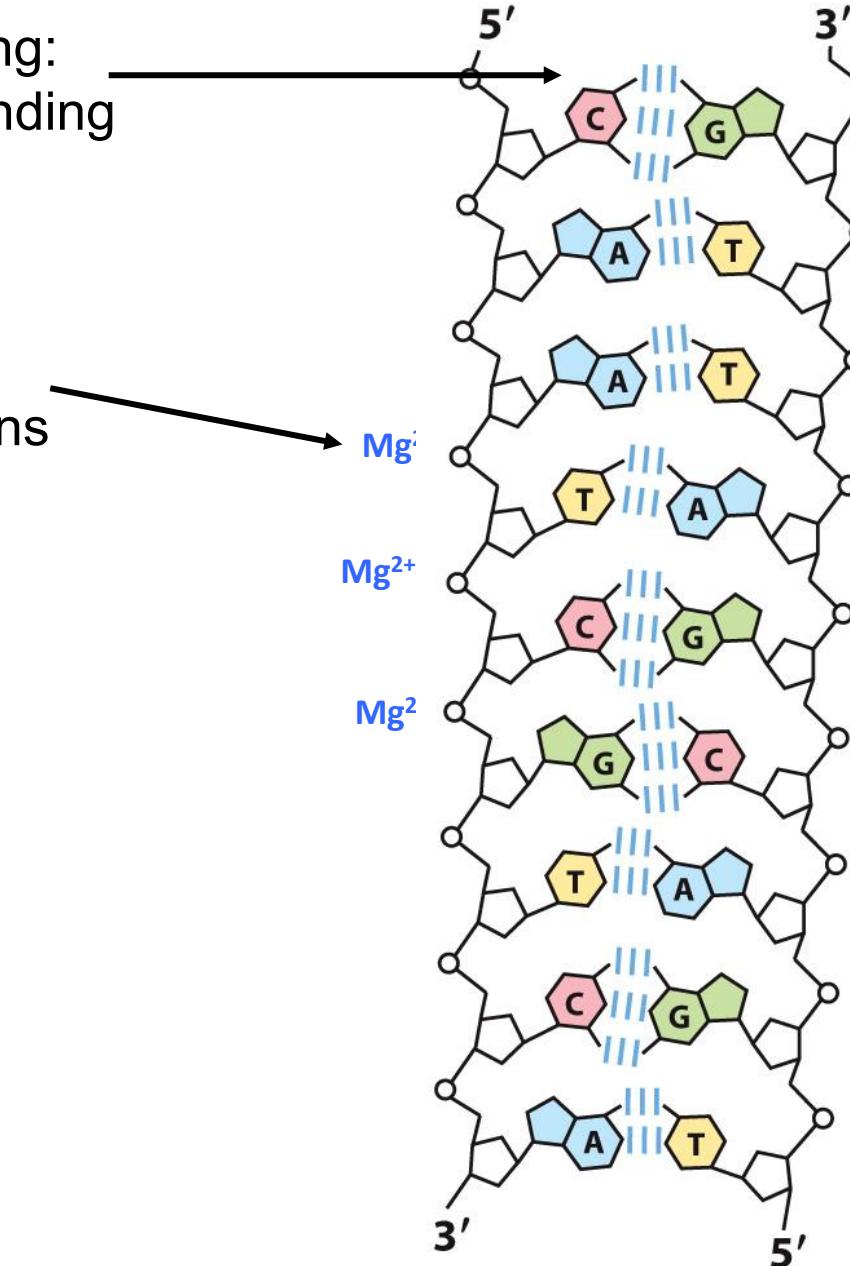
The double helix is stabilized by several intermolecular forces



Base-Stacking:
Pi-pi interactions
(Van der Waals)

Base-Pairing:
Hydrogen bonding

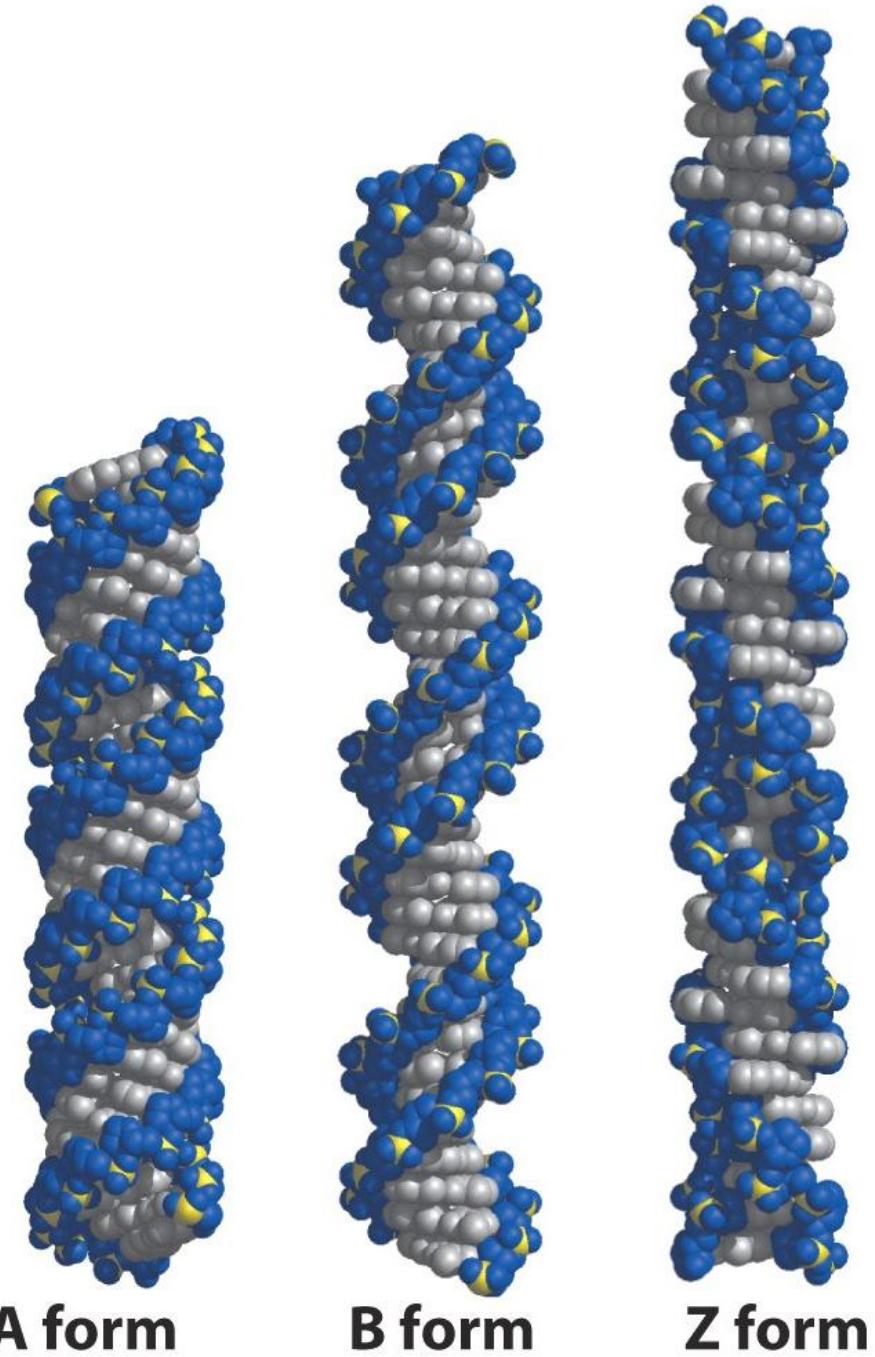
Backbone:
Ionic interactions



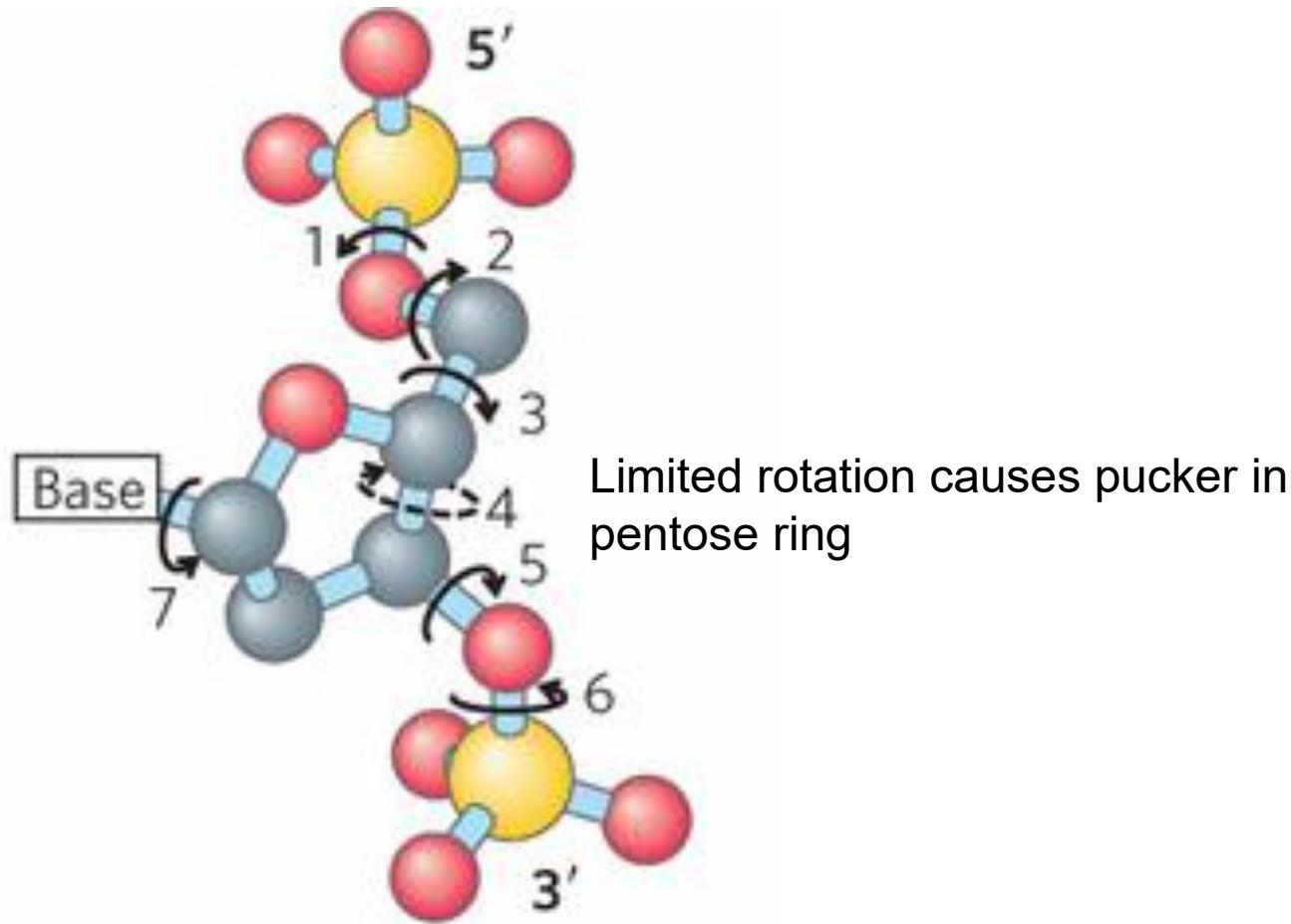
DNA can be found in three different f

The structures are a result of:

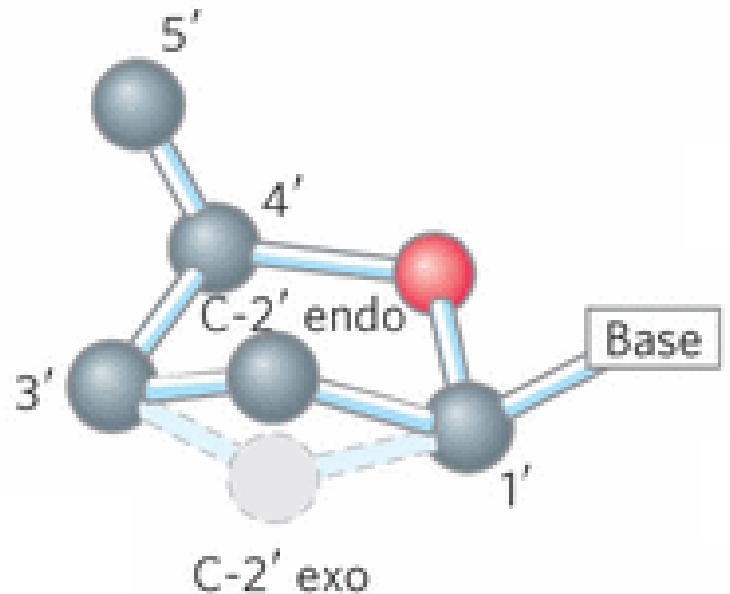
- Conformations of pentose sugar
- Free rotation of the backbone
- Rotation about glycosidic bond



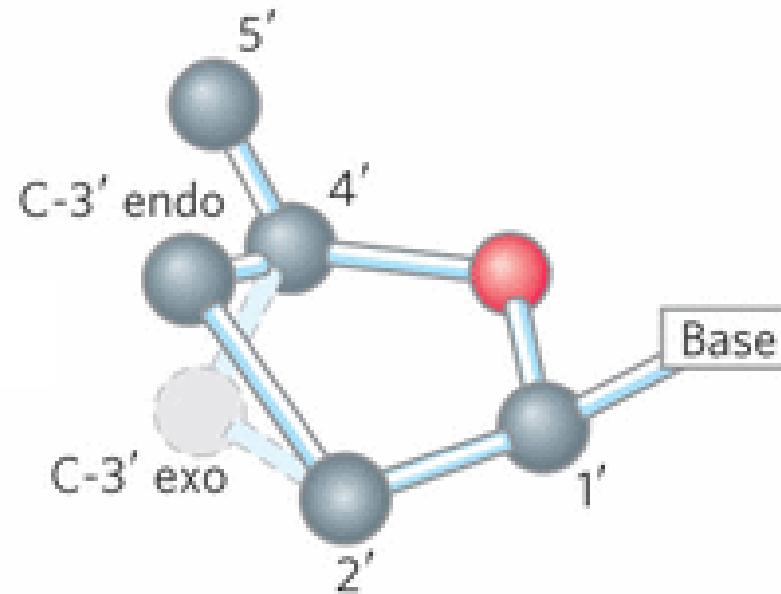
Free rotation around bonds in phosphodiester backbone



Four puckered conformations of pentose sugar

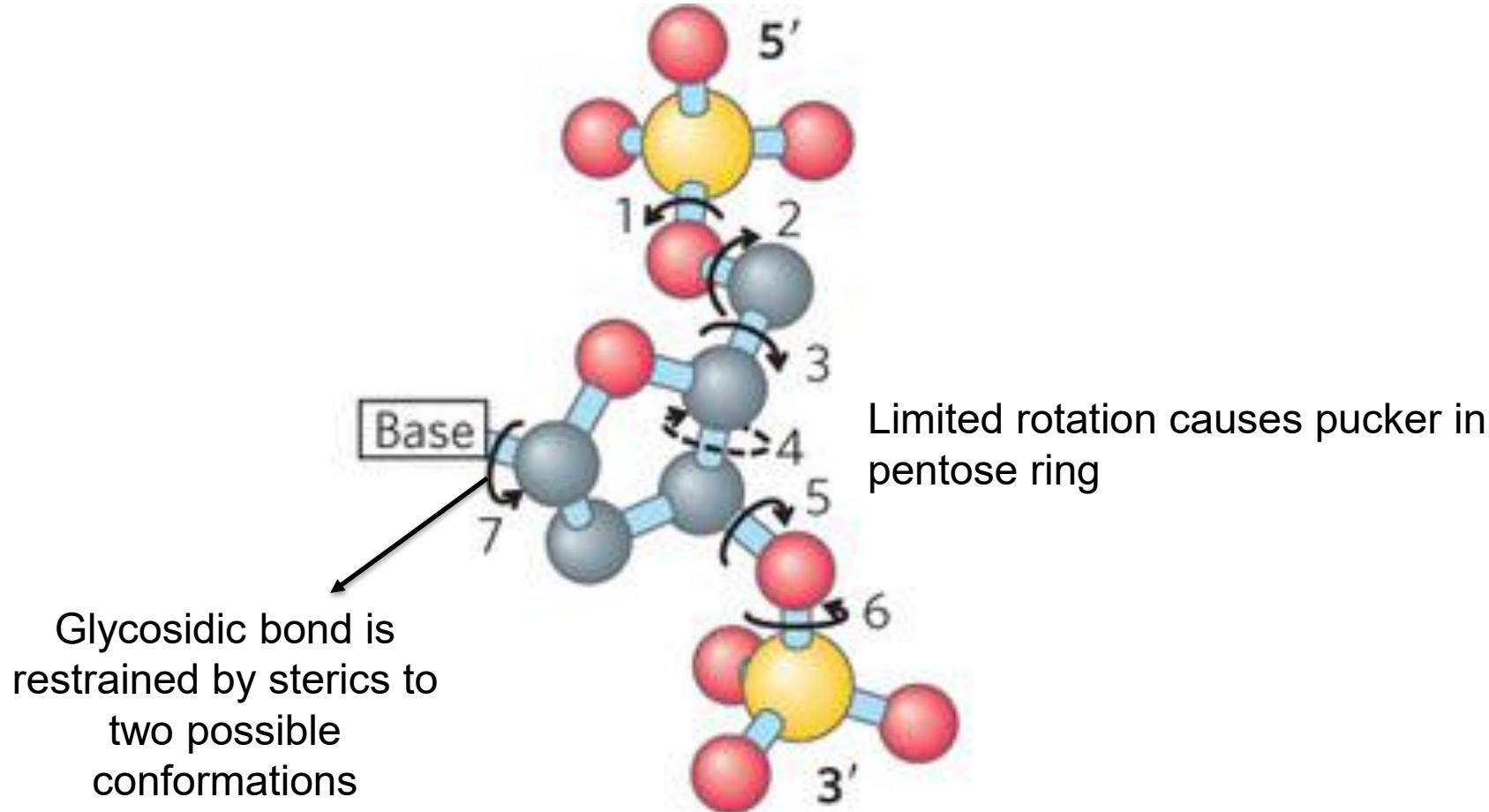


C-2'endo: C2' on same side of ring as C5'
C-2' exo: C2' on opposite side of ring as C5'

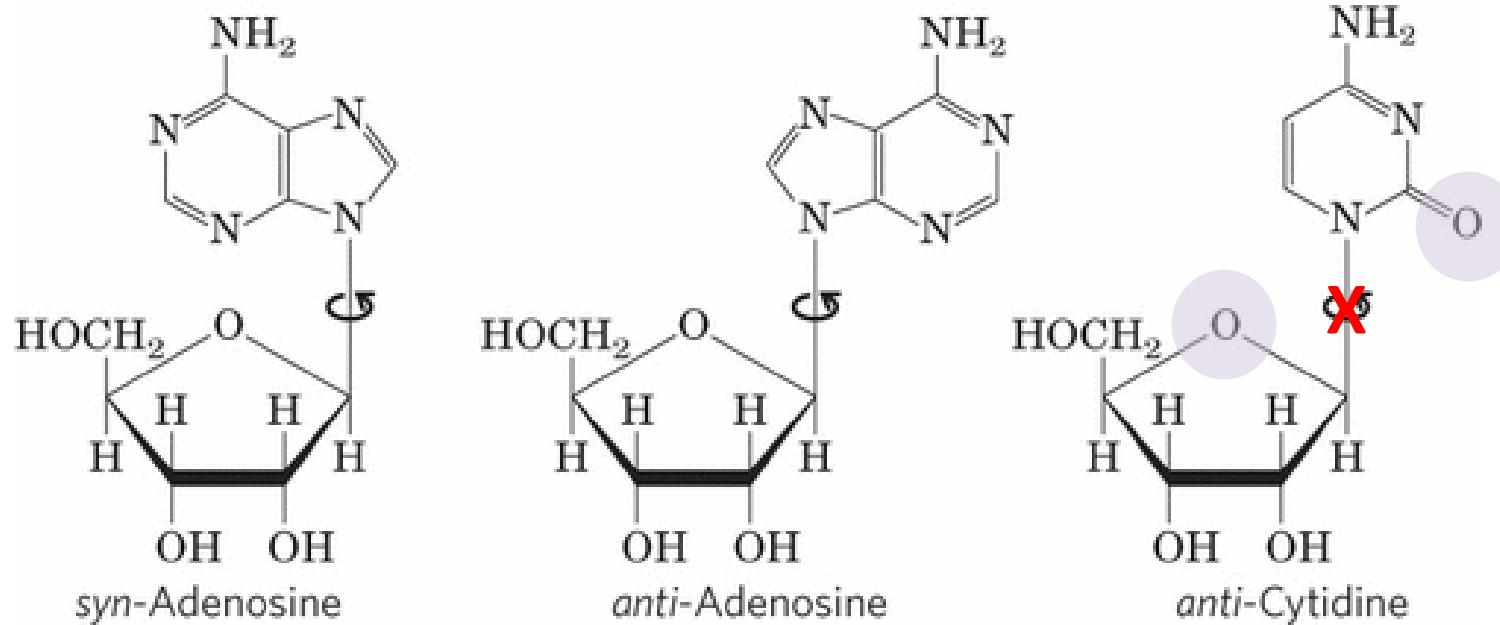


C-3'endo: C3' on same side of ring as C5'
C-3' exo: C3' on opposite side of ring as C5'

Free rotation around bonds in the phosphodiester backbone



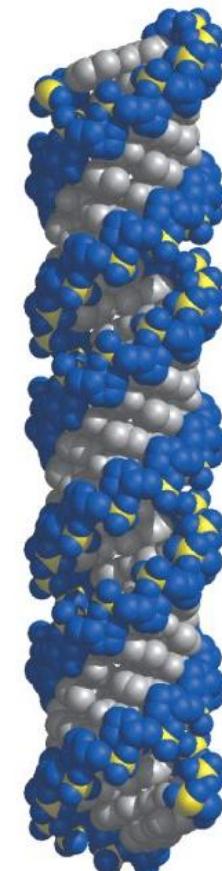
Rotation about the glycosidic bond



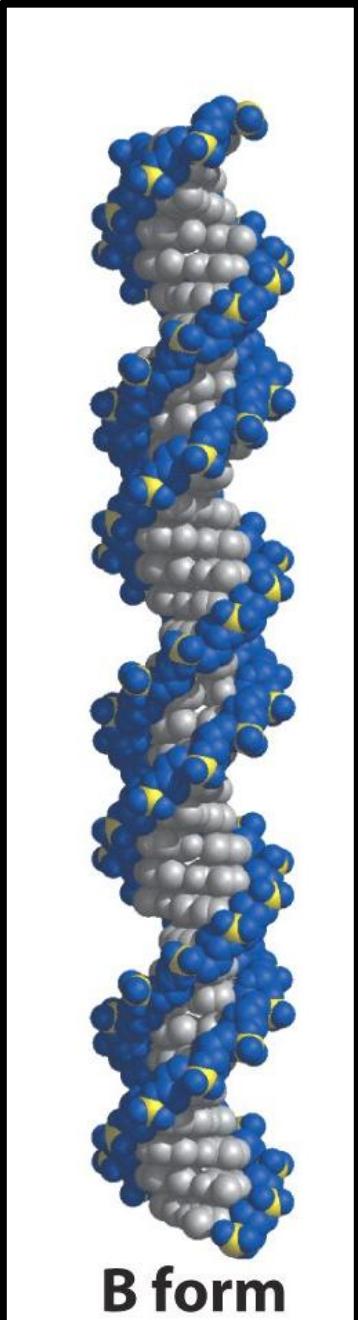
Purines: *syn* or *anti*
Pyrimidines: *anti* only

DNA can be found in three different f

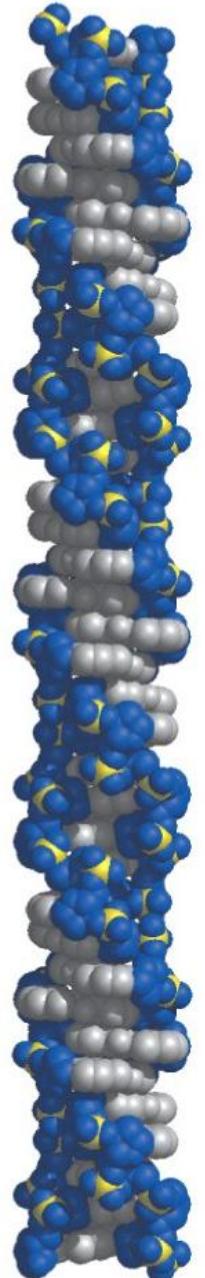
	A Form	B Form “Watson-Crick”	Z Form
Helix	Right-handed	Right-handed	Left-handed
Shape	Short and broad	Longer and thinner	Longest and thinnest
Bp/Helical Turn	11	10.5	12
Sugar Conformation	C-3' endo	C-2' endo	C-2' endo for pyrimidines; C-3' endo for purines
Glycosyl Bond Conformation	Anti	Anti	Anti for pyrimidines; Syn for purines
Found In	Low moisture conditions	Most living forms	High salt conditions, requires alternating CG sequences



A form

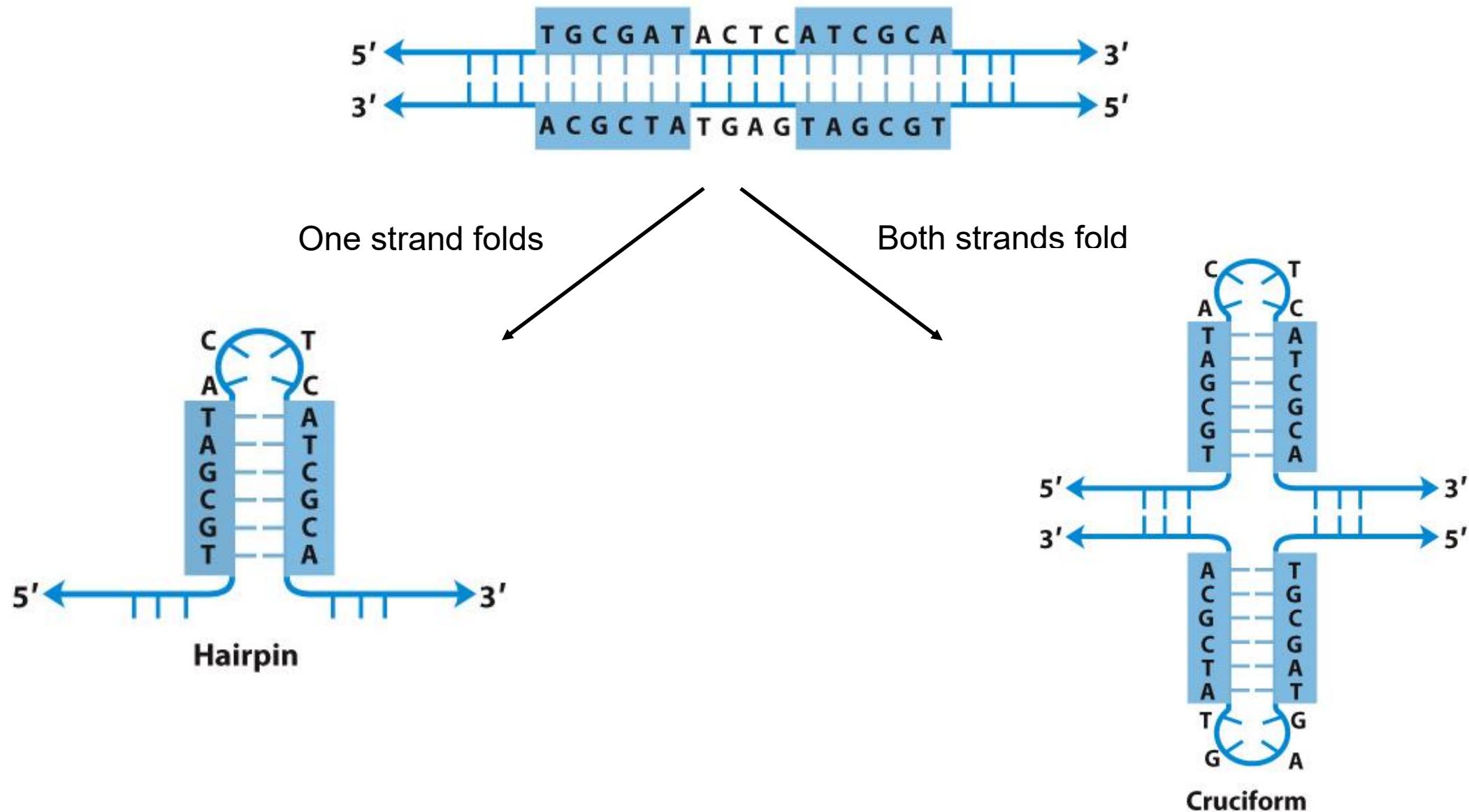


B form

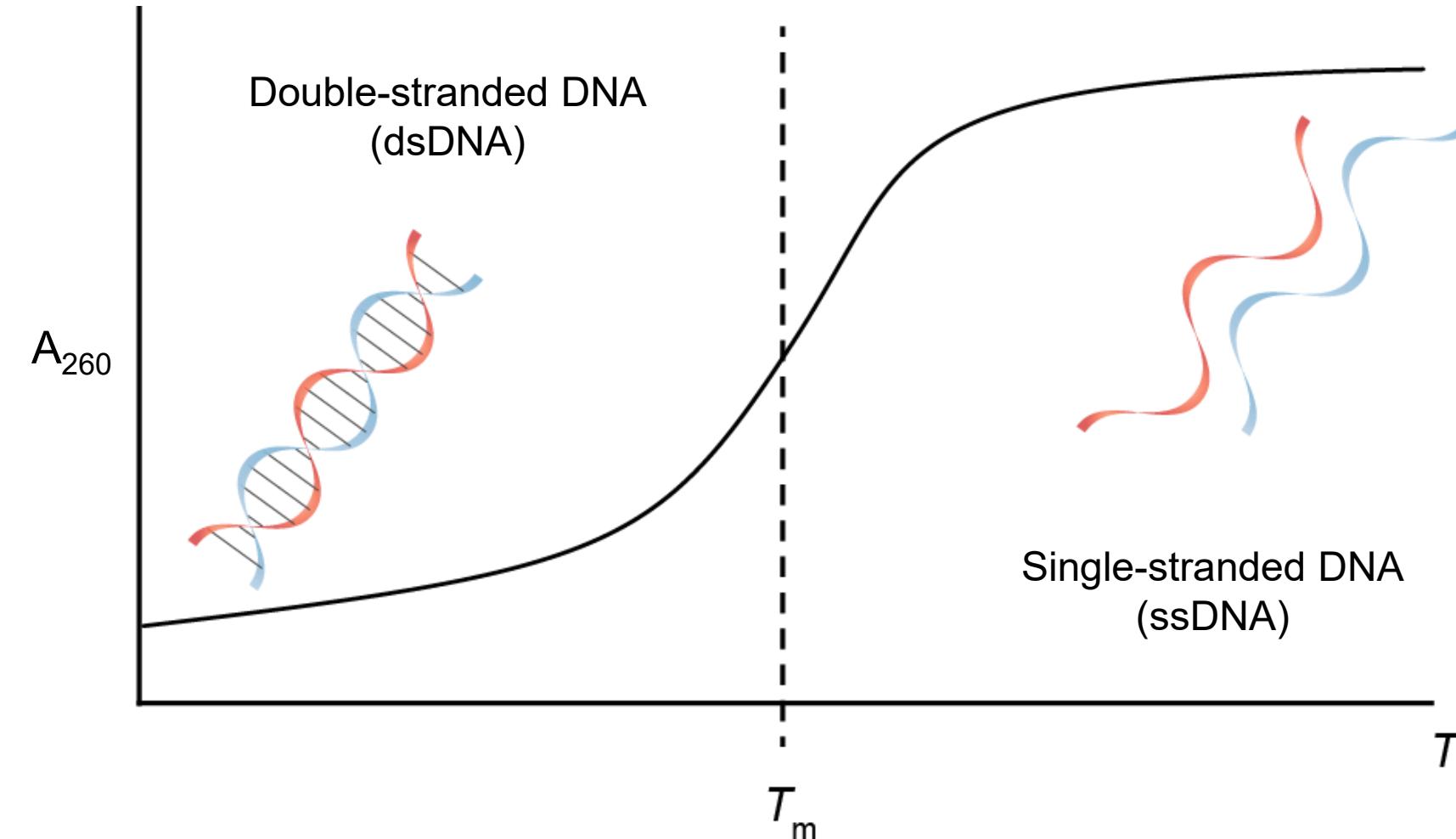


Z form

Palindromic DNA sequences can adopt other structures



The DNA double helix is sensitive to changes in temperature

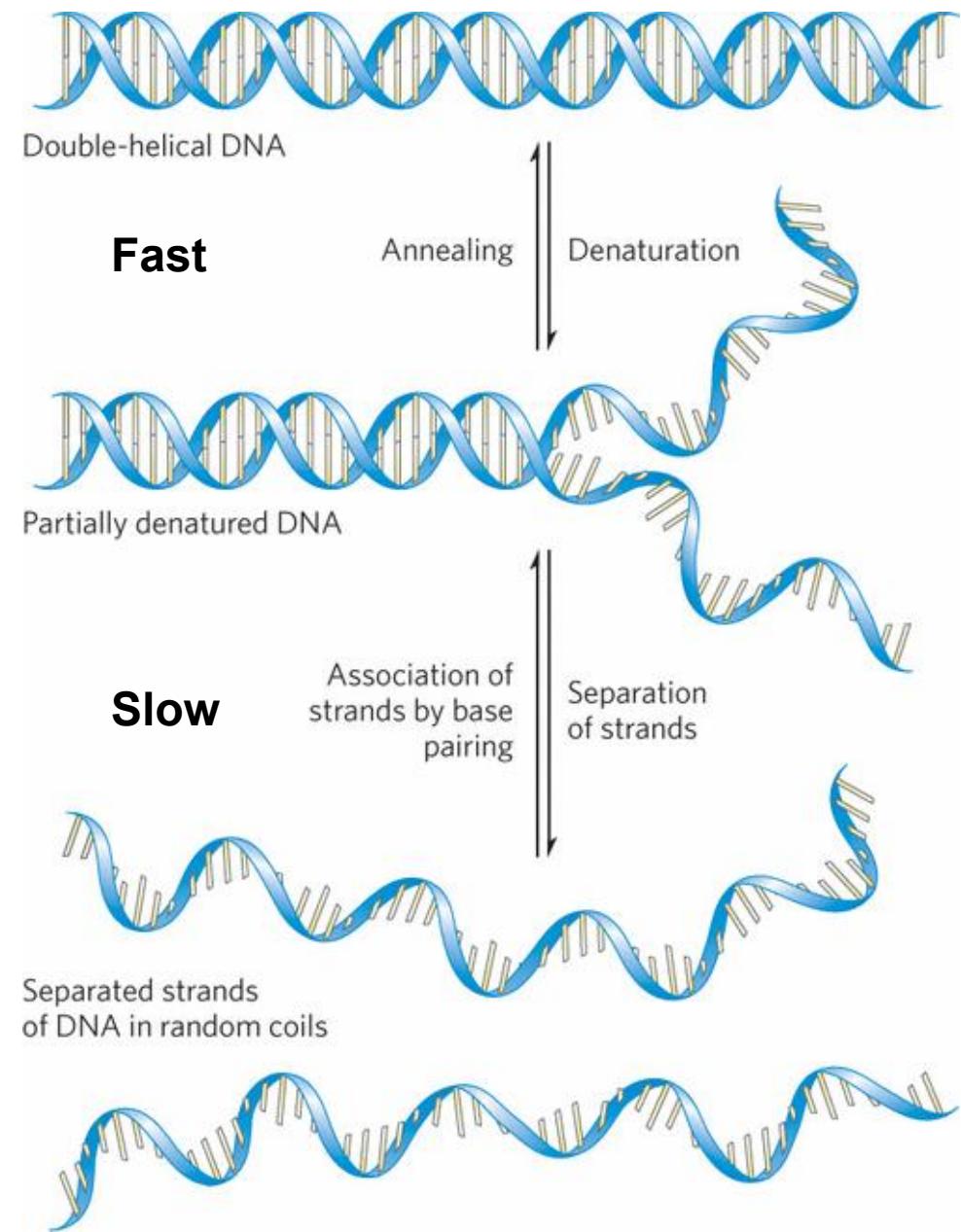


T_m is affected by:

- GC content
- Ionic strength
- Strong H-bonders

DNA “melting curve” can be followed with absorbance – hyperchromic shift

DNA can be de-natured and re-natured





0 response submitted

What is the complementary DNA sequence to the DNA oligonucleotide
GCATTACT?

Scan the QR or use
link to join



[https://forms.office.com
/r/QfgpLkBt8a](https://forms.office.com/r/QfgpLkBt8a)

Copy link



CGTAATC

AGTAATGC

AACGTTGG

Treemap

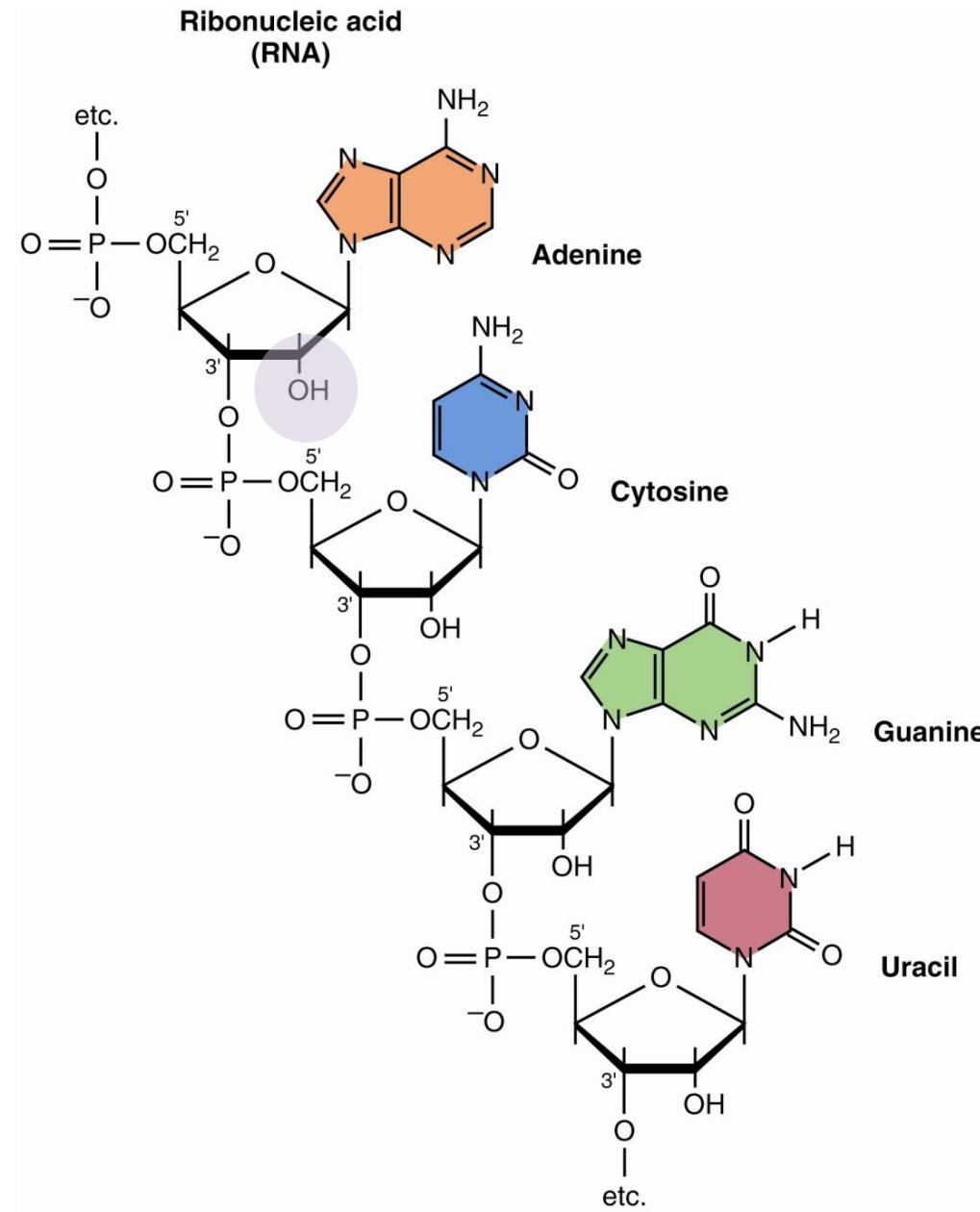
Bar



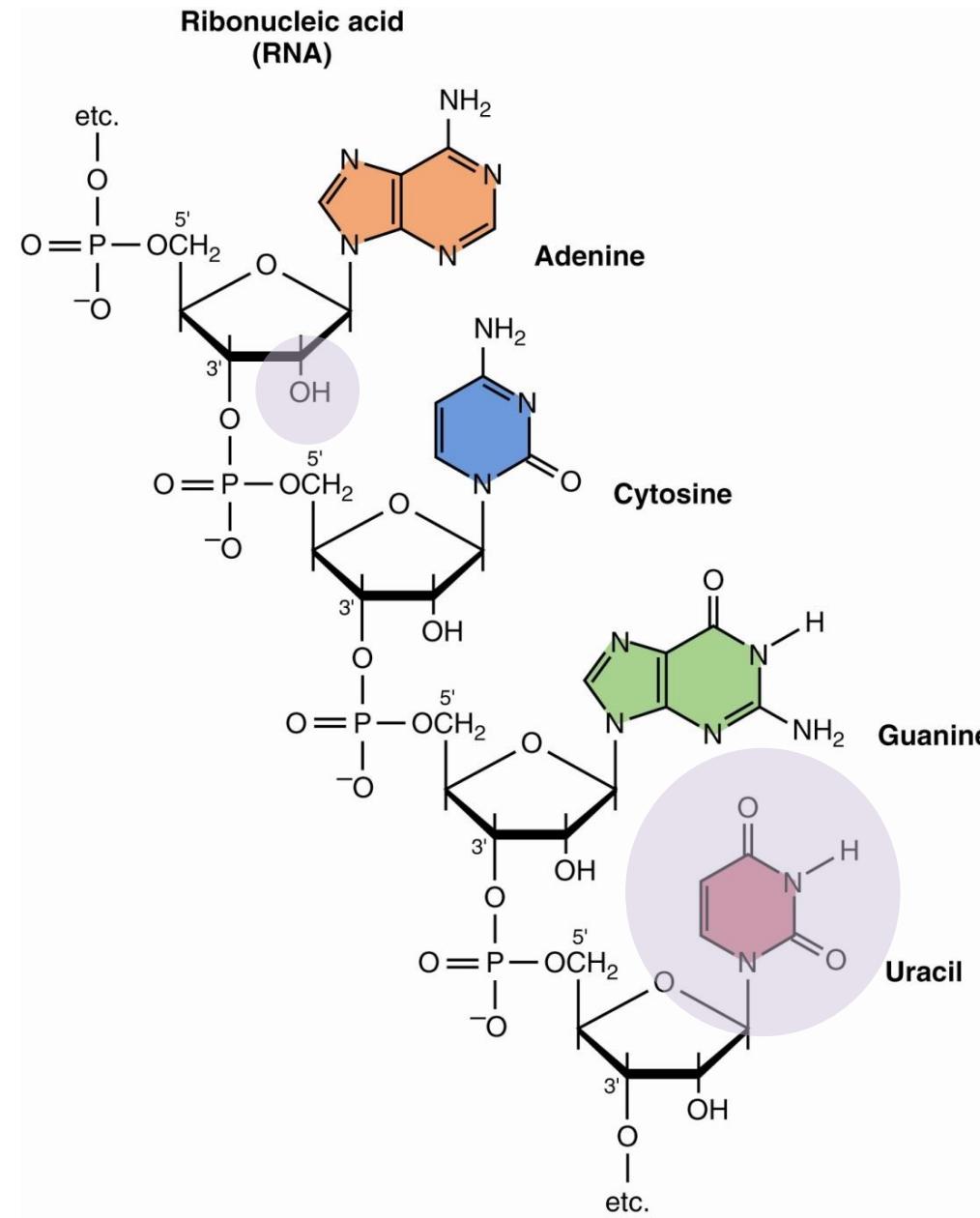
1 of 3



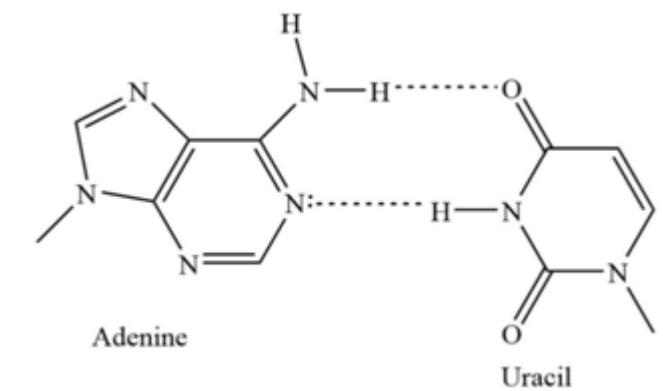
Quick Review: Differences between RNA and DNA



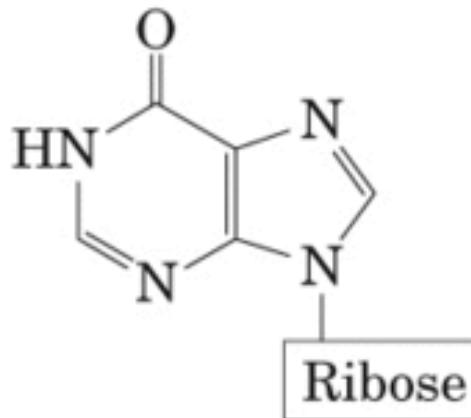
Quick Review: Differences between RNA and DNA



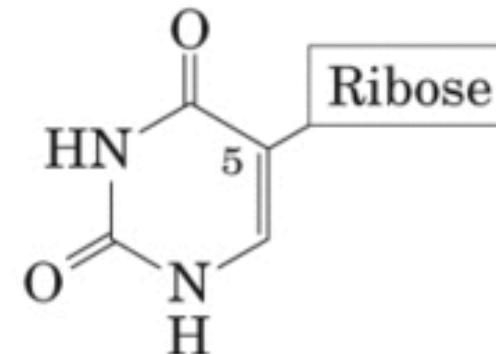
In RNA, uracil H-bonds with adenine



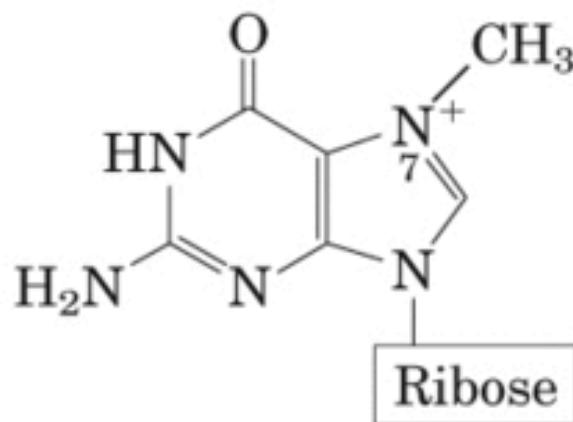
Unusual bases can be found in RNA



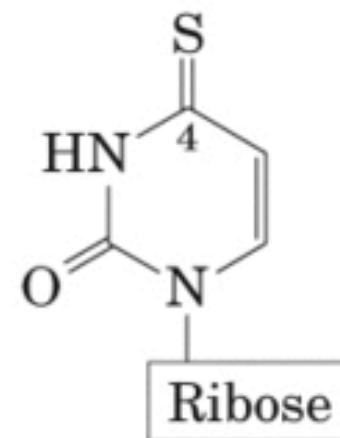
Inosine



Pseudouridine

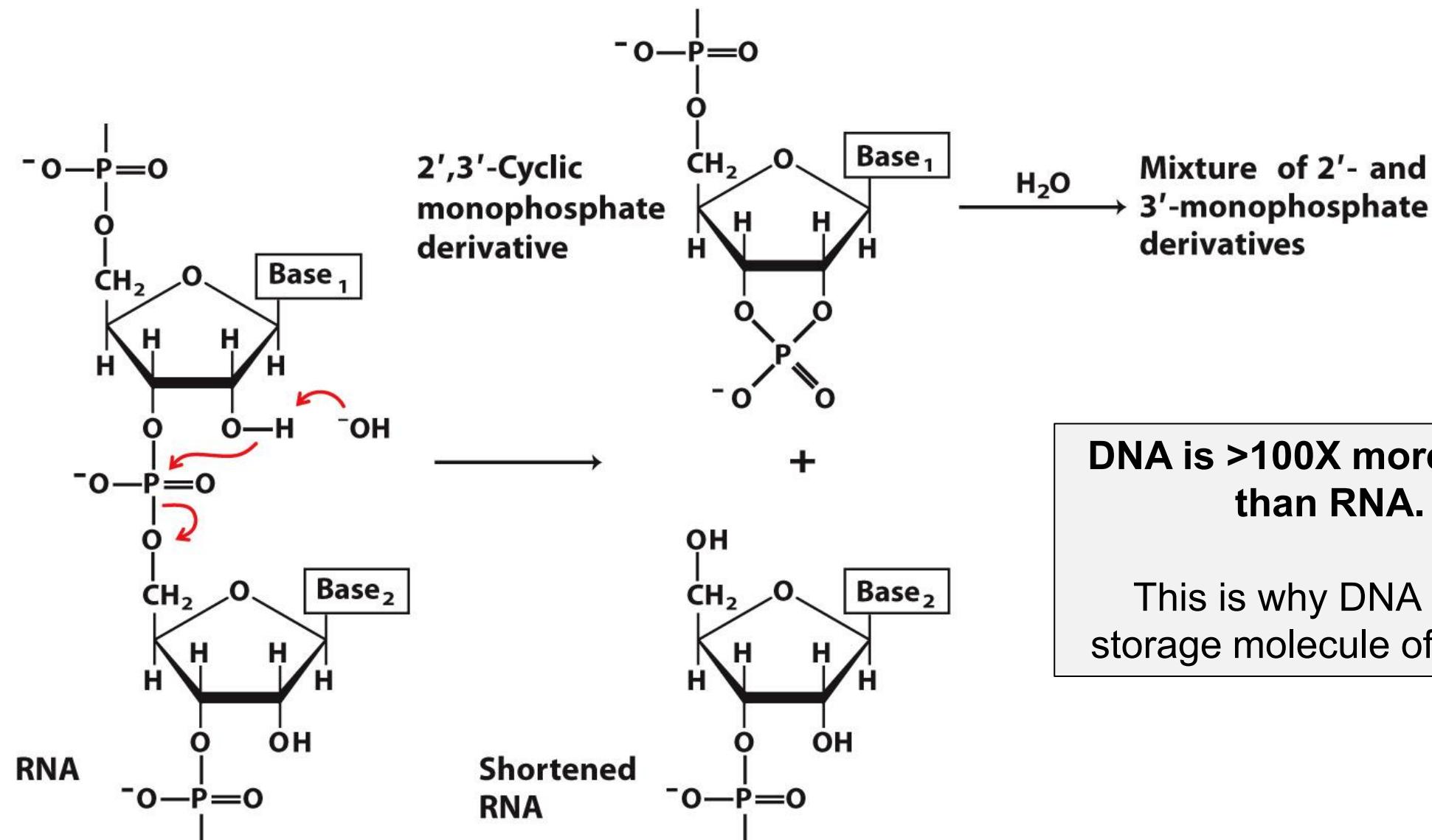


7-Methylguanosine



4-Thiouridine

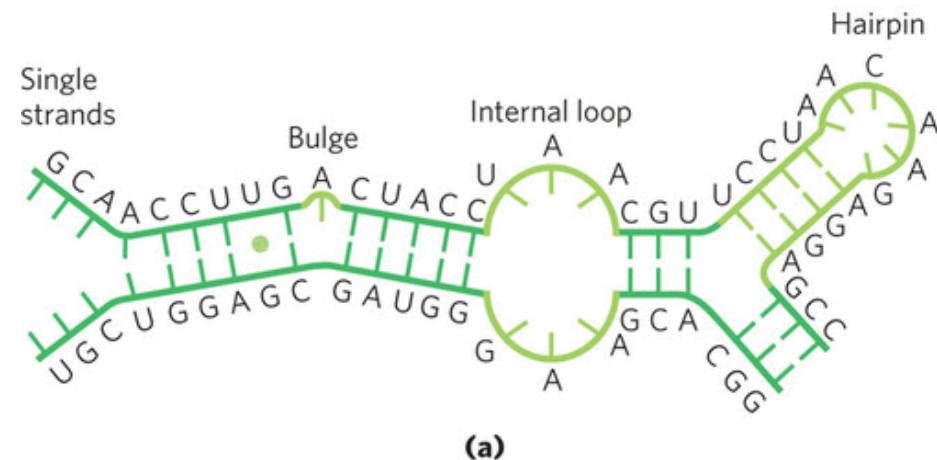
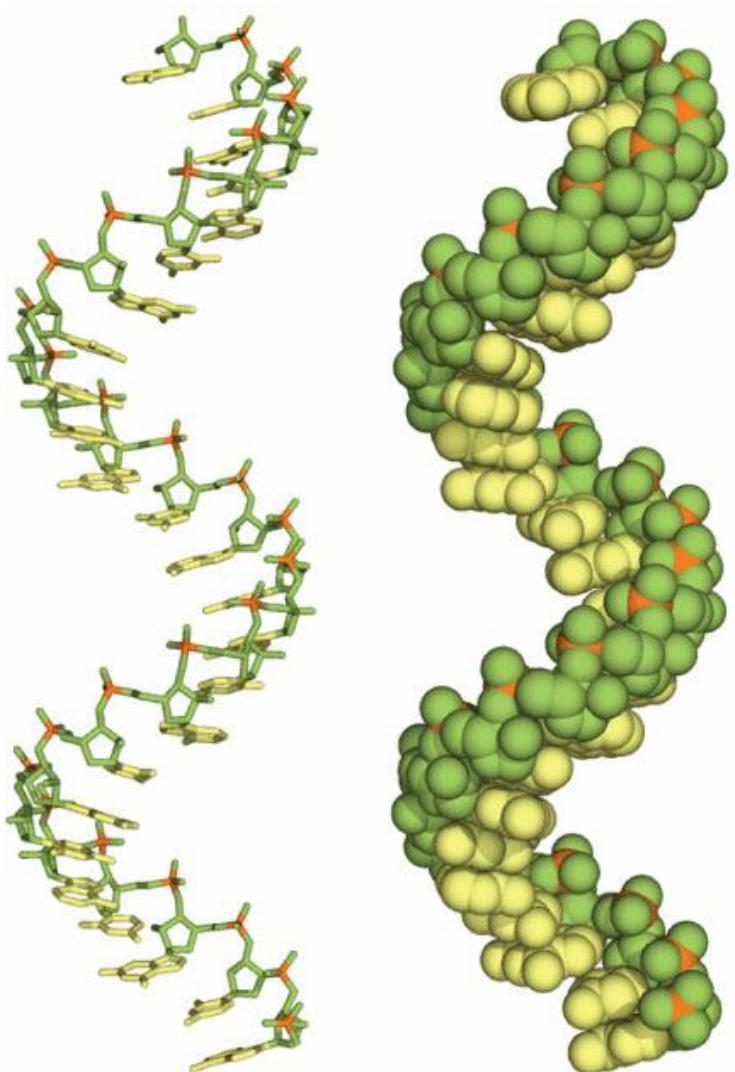
The ribose 2' OH makes RNA susceptible to hydrolysis



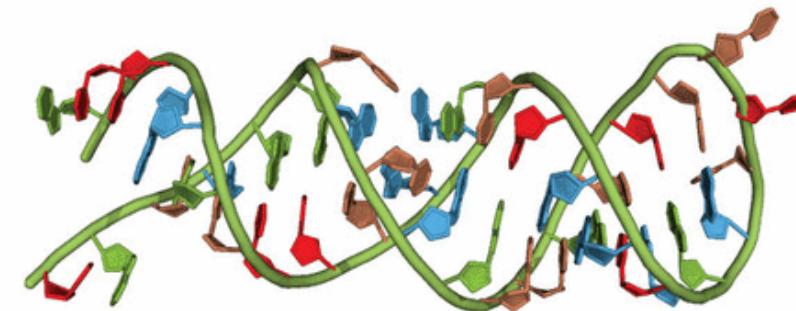
DNA is >100X more stable than RNA.

This is why DNA is our storage molecule of choice!

RNA can adopt multiple secondary structures



(a)



Hairpin double helix

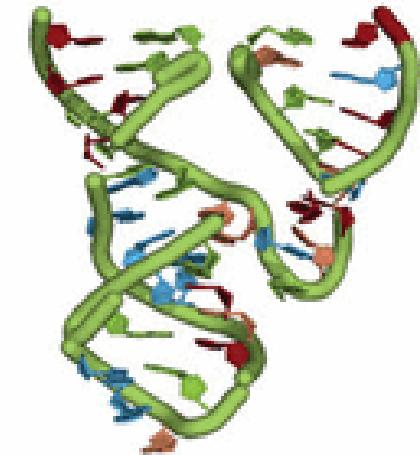
(b)

Tertiary structures of RNA are as diverse as their functions

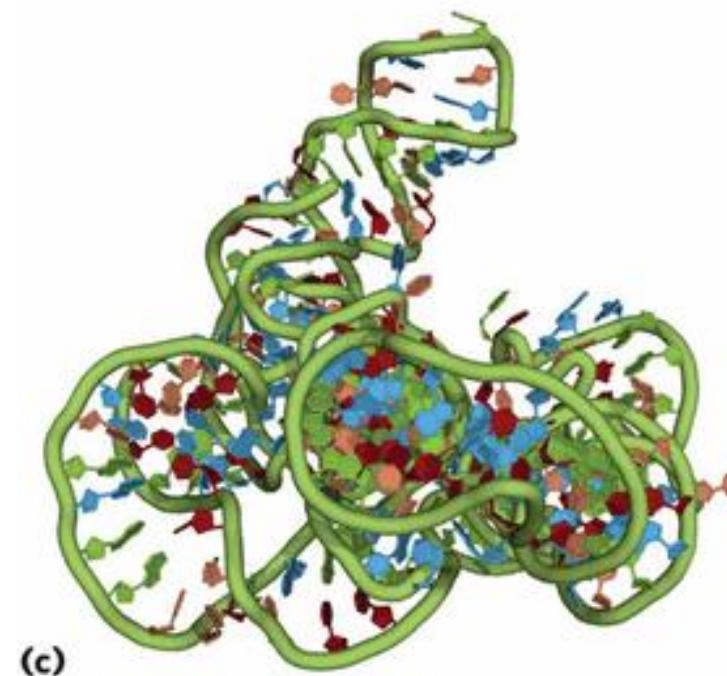


Transfer RNA (tRNA)

Messenger RNA (mRNA)



Ribozyme (RNA enzyme)



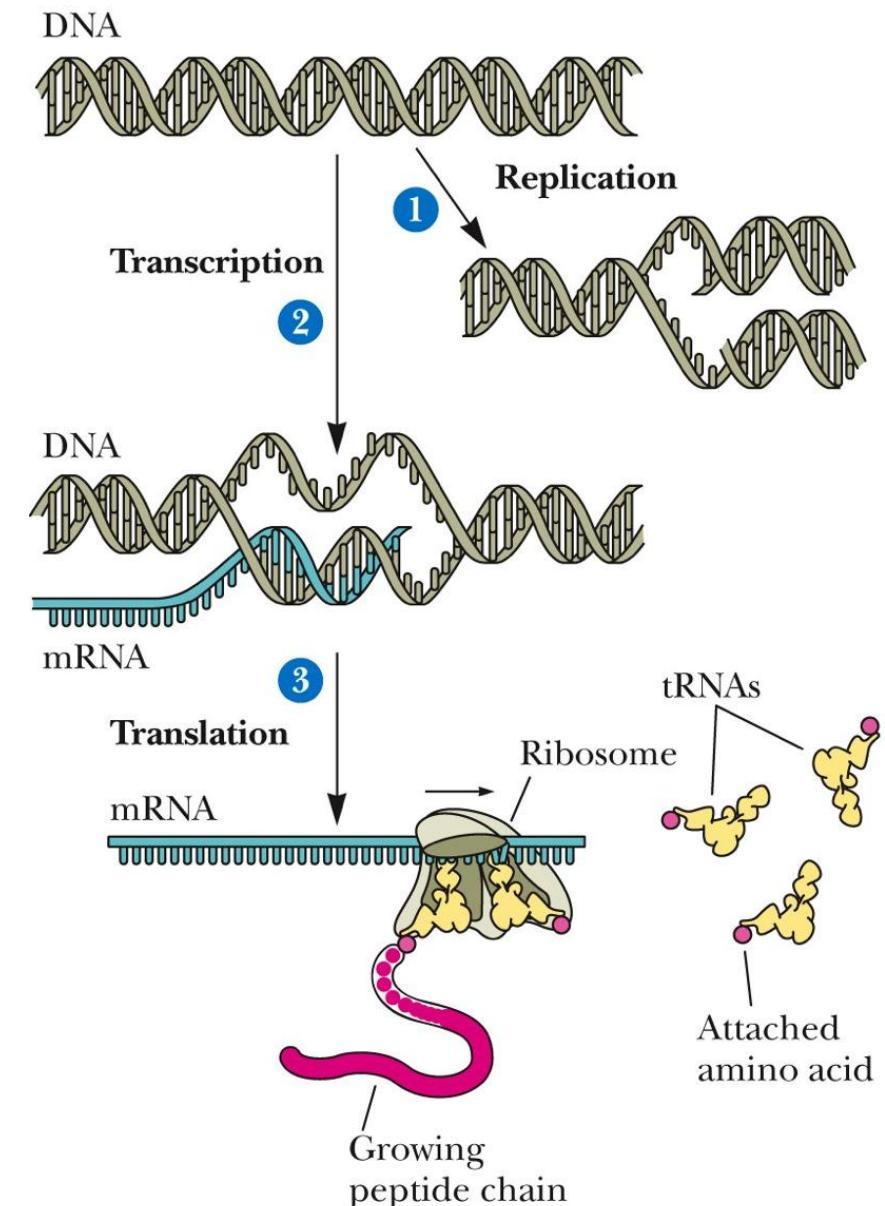
Which came first, DNA or RNA? RNA!

The RNA World Hypothesis:

Long ago, RNA was *both* the genetic and catalytic material

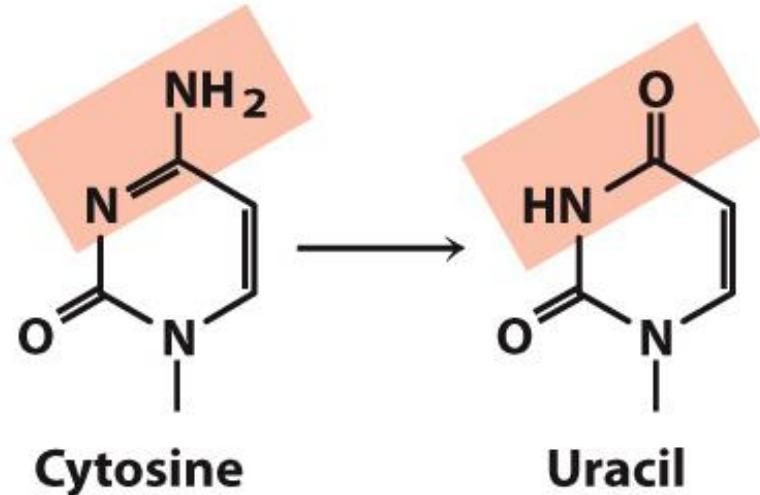
RNA is central to life's basic processes:

- Ribosome
- Ribozymes
- dNTPs
- Cofactors

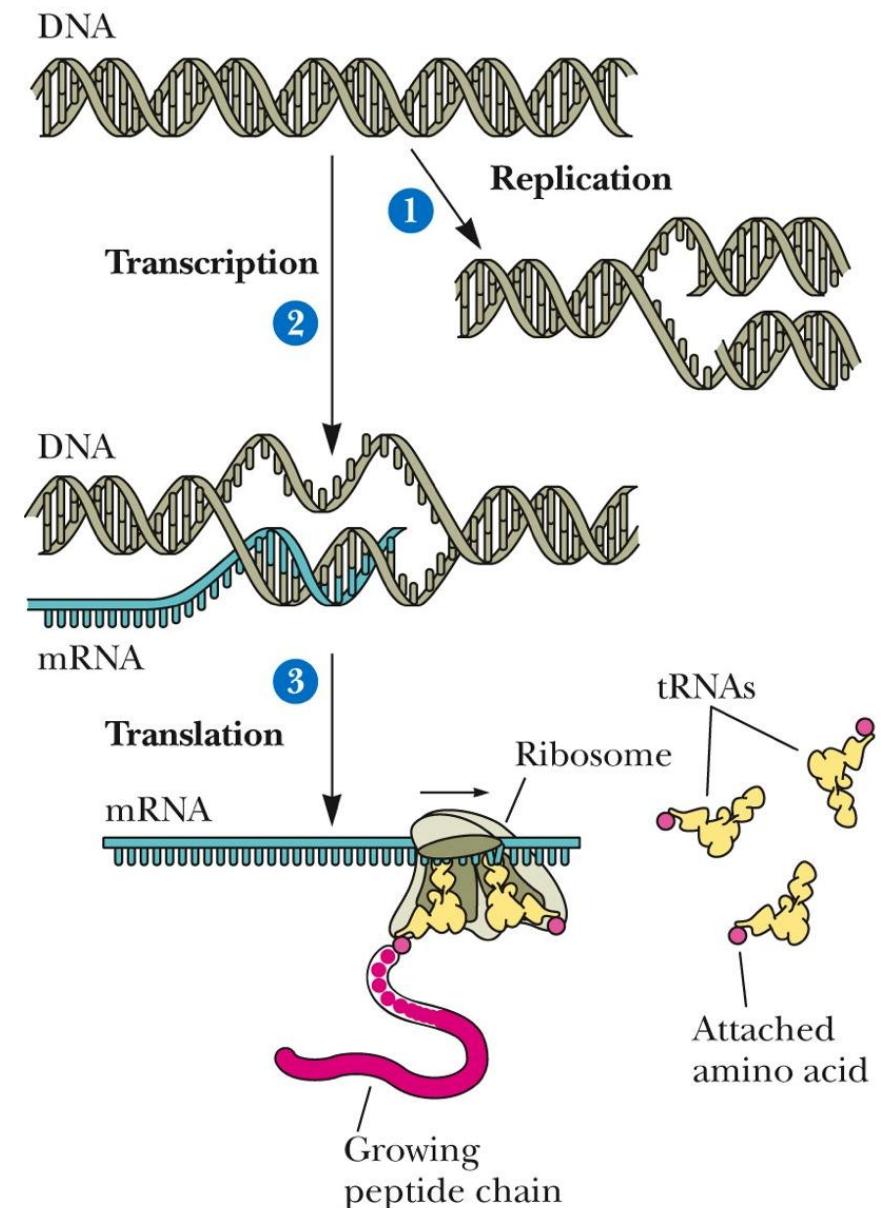


Why is DNA a great molecule for information storage?

1. DNA is ~100x more stable than RNA
2. DNA is double stranded
3. U vs. T



10^7 cytidine residues every 24 hrs!



Check-in #3: A comparison of DNA and RNA

Feature	DNA	RNA
Function		
Bases		
Type of Pentose Sugar		
Single or Double Stranded		
Stability		