

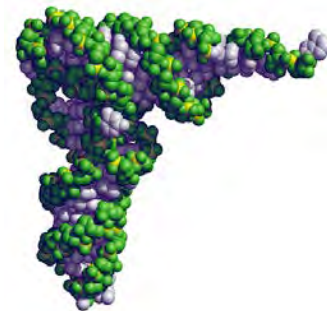
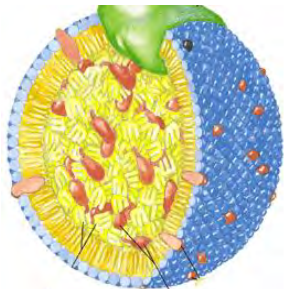


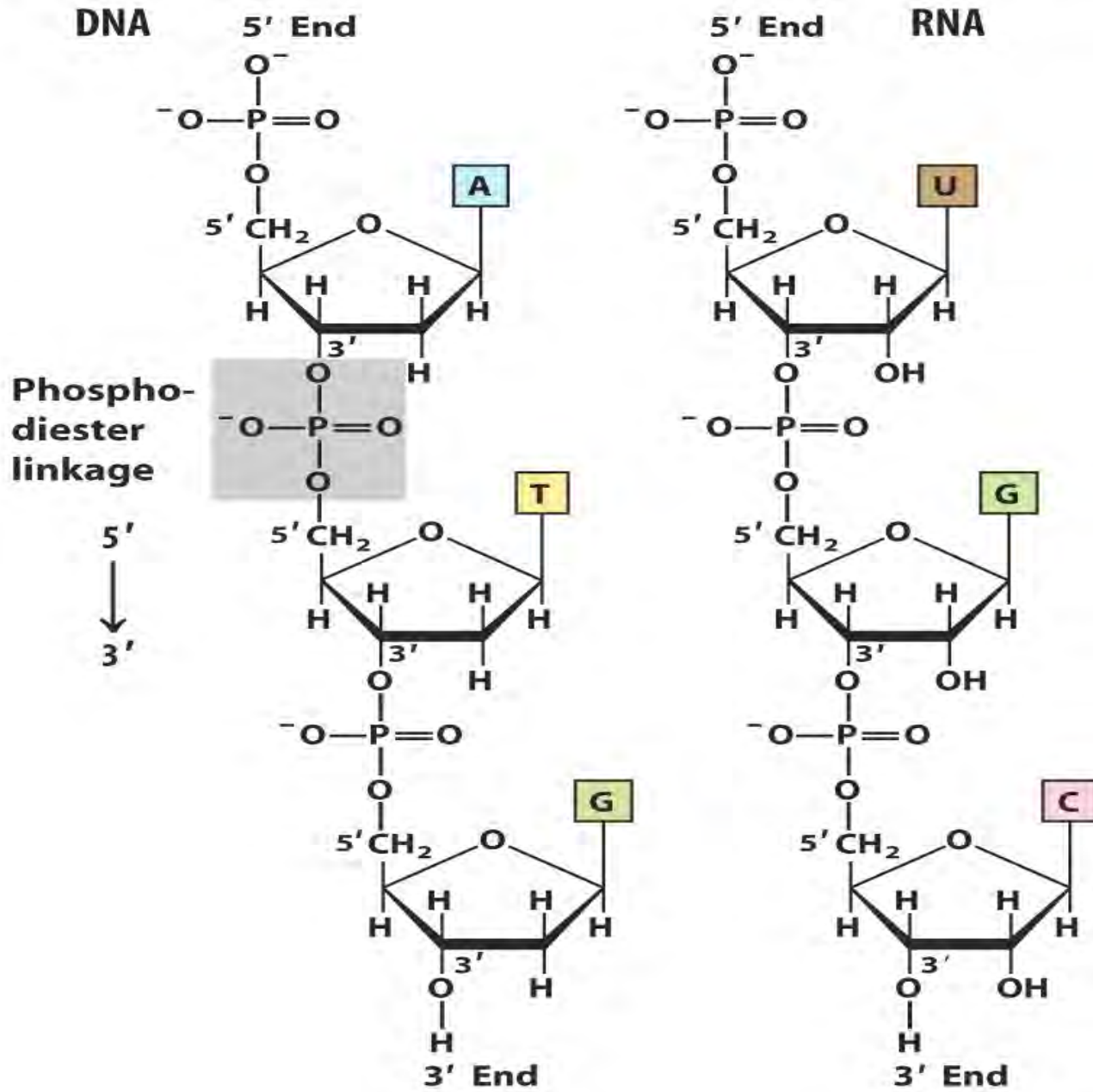
# BIOCHEMISTRY REVIEW

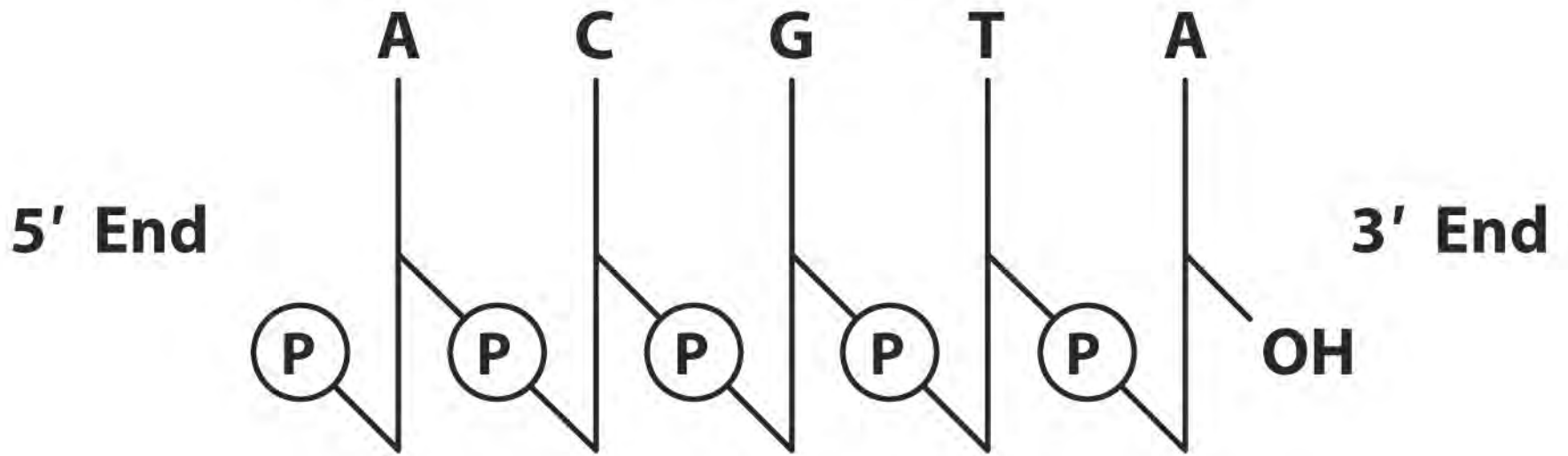
## Overview of Biomolecules

### Chapter 10

### Nucleic Acids







# DNA vs RNA

## DNA

deoxyribose

A, C, G, T

$10^3 - 10^8$  nucleotides

nucleus

double-stranded

one type/ 1-2 copies

permanent

## RNA

ribose

A, C, G, U

$10^2 - 10^4$  nucleotides

cytoplasm

single-stranded

many types/ many copies

temporary



# Are You Getting It??



---

Which properties are shared by **DNA** and **RNA**?  
*(multiple answers)*

- a) Both contain the same sugar.
- b) Both contain the same purines.
- c) Both contain the same pyrimidines.
- d) Both are negatively charged in the cell.
- e) Both contain phosphodiester bonds.
- f) Both have a sugar-phosphate backbone.



# Are You Getting It??



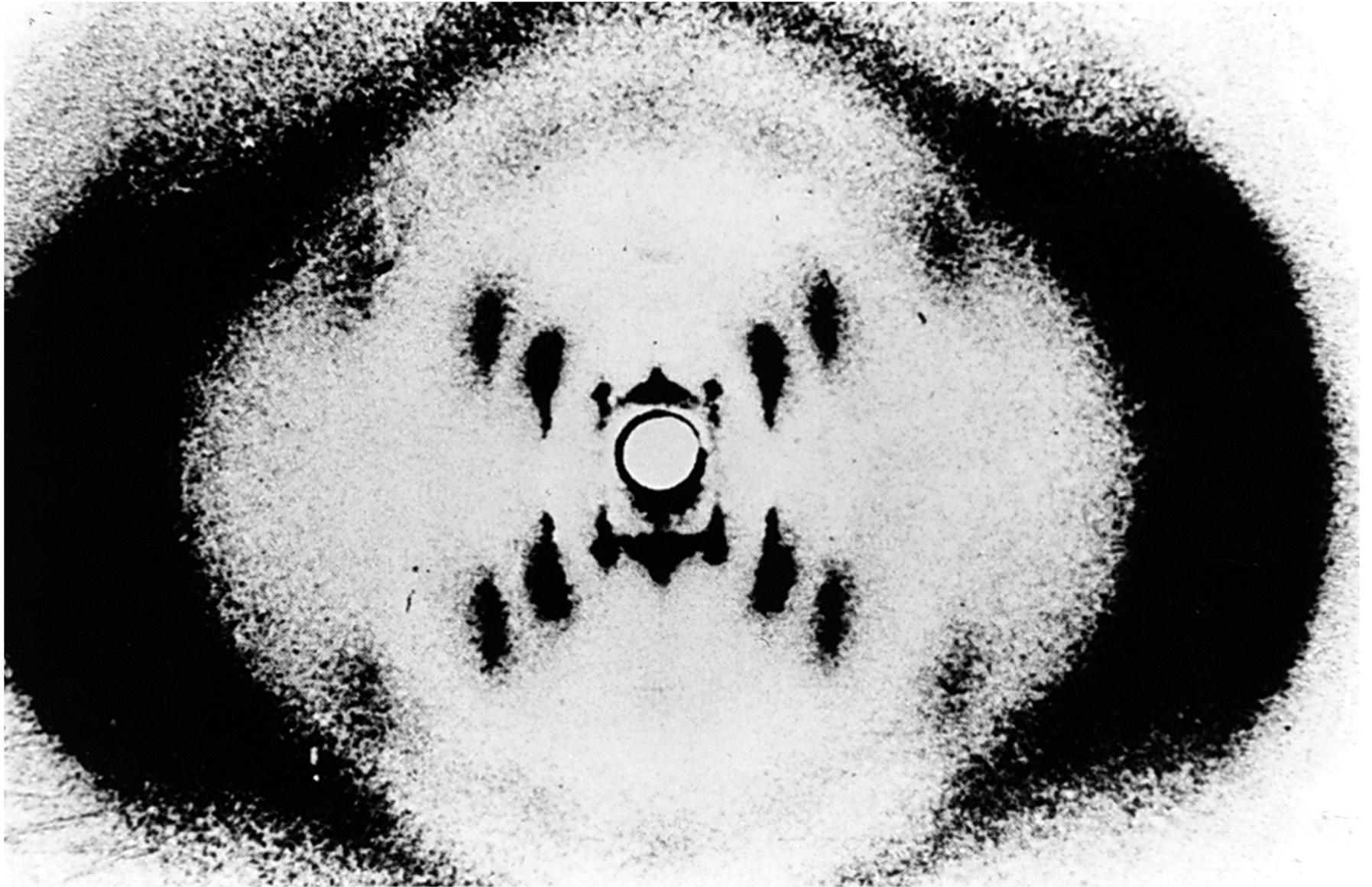
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## Answer

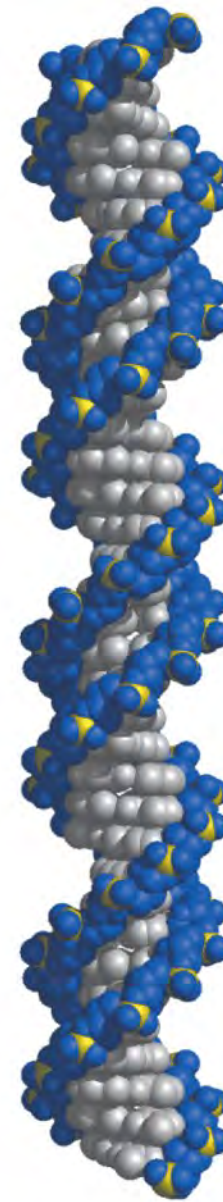
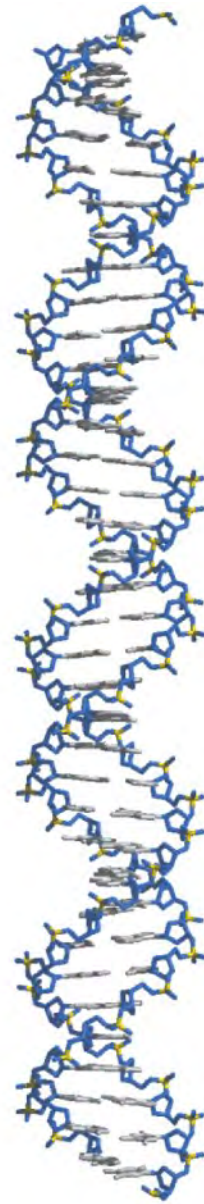
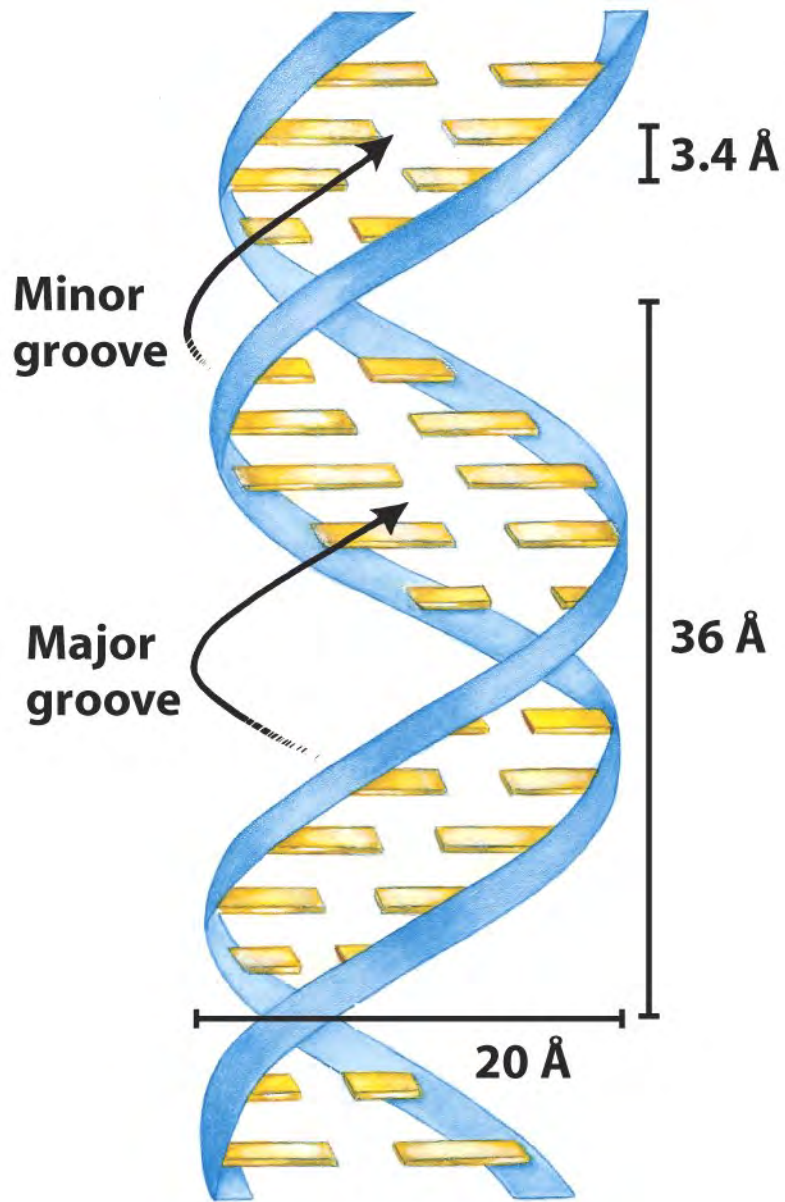
---

Which properties are shared by **DNA** and **RNA**?

- a) Both contain the same sugar.
- b) Both contain the same purines.**
- c) Both contain the same pyrimidines.
- d) Both are negatively charged in the cell.**
- e) Both contain phosphodiester bonds.**
- f) Both have a sugar-phosphate backbone.**

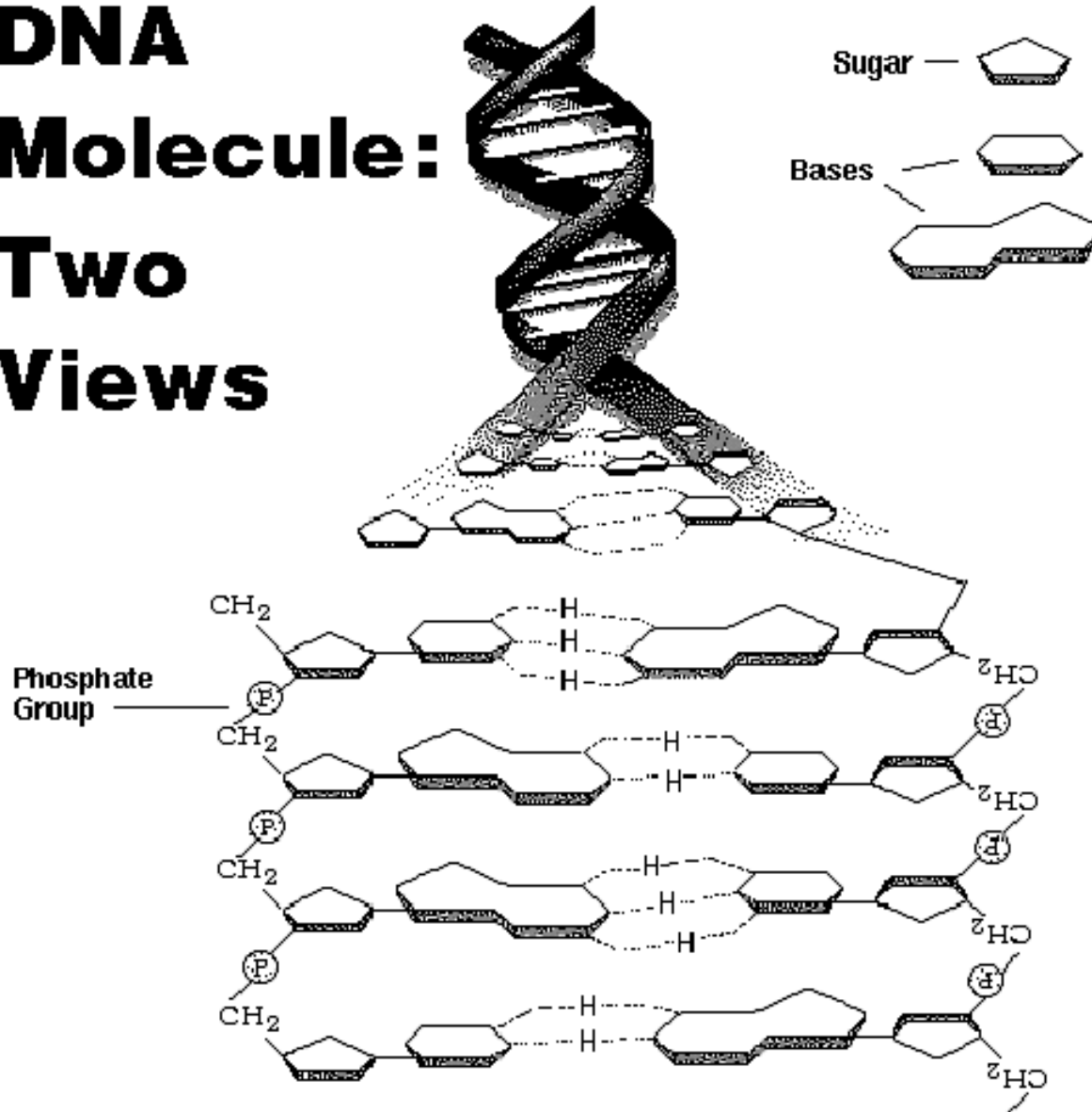


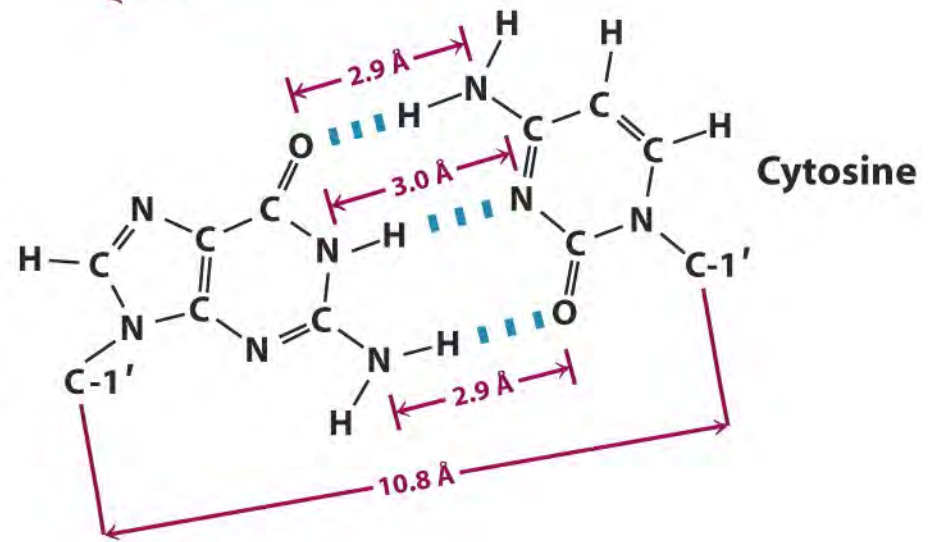
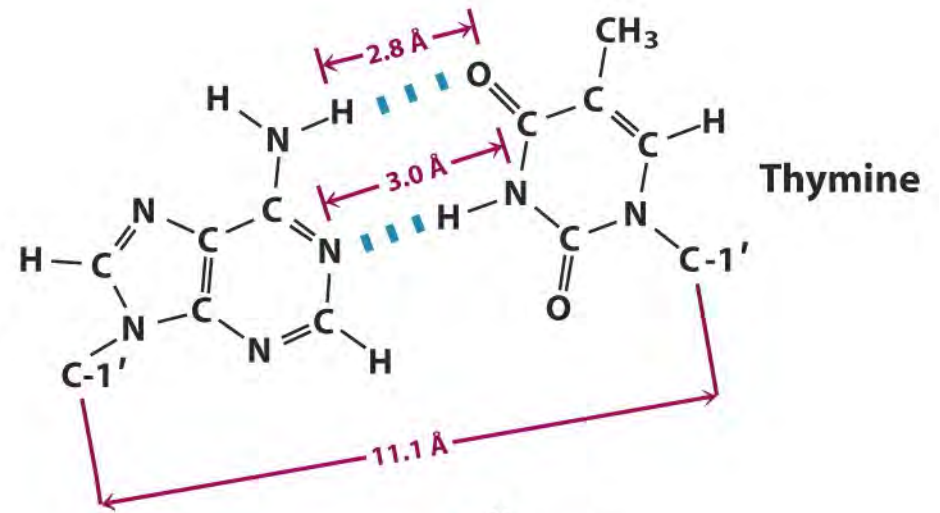
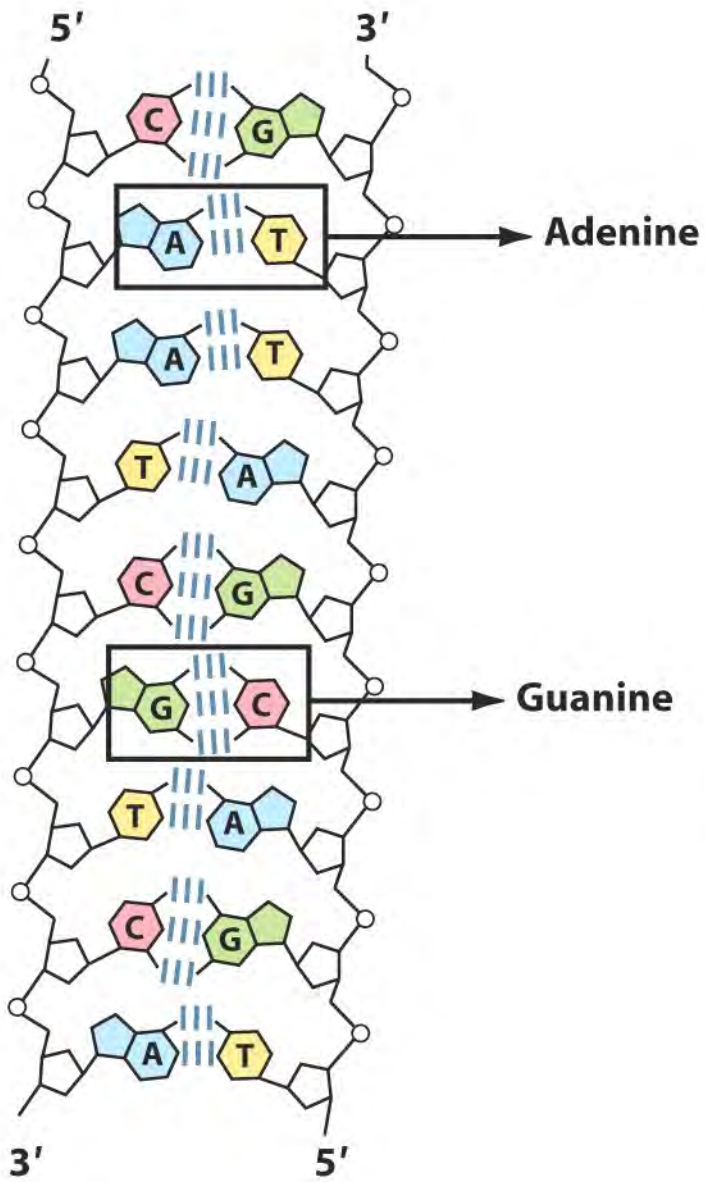


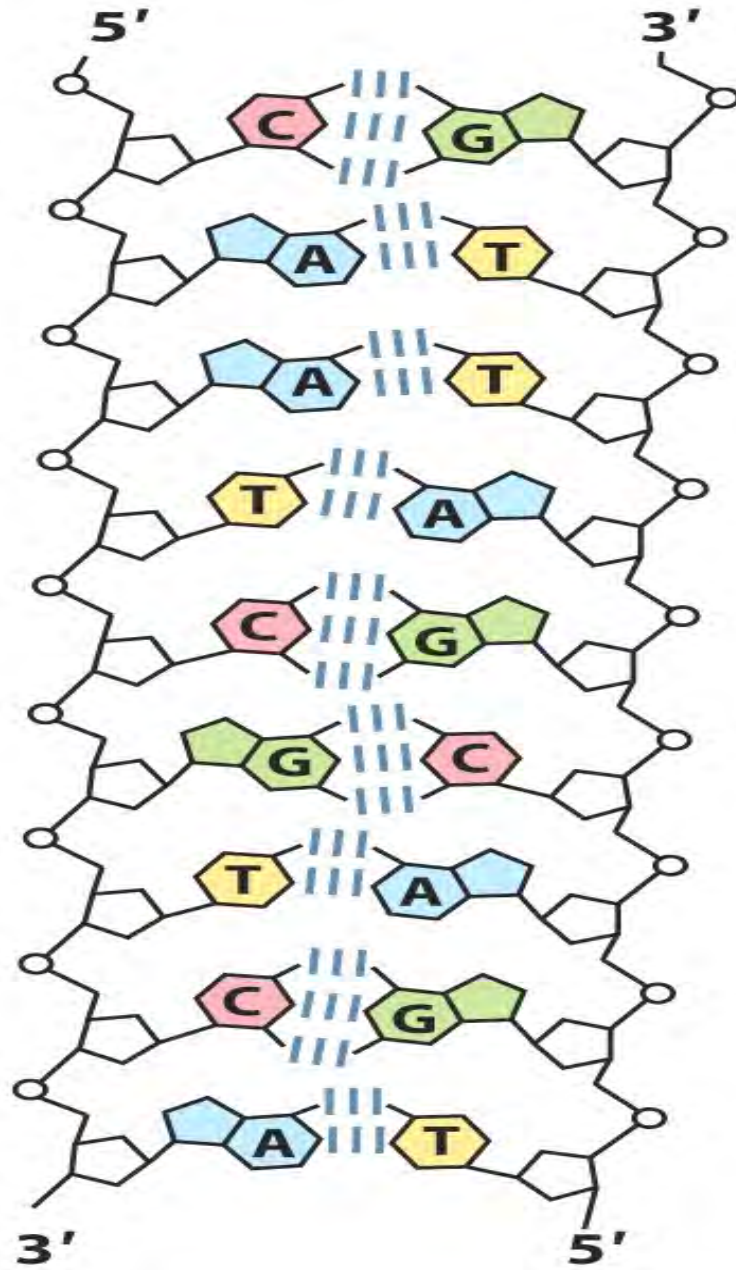




# DNA Molecule: Two Views









# Are You Getting It??



---

**Which forces contribute to the stability of a double-helix?**  
*(multiple answers)*

- a) H-bonds
- b) N-glycosidic bonds
- c) base-stacking
- d) phosphodiester bonds
- e) hydrophobic interactions
- f) covalent bonds



# Are You Getting It??



---

## Answer

---

**Which forces contribute to the stability of a double-helix?**

- a) *H-bonds***
- b) N-glycosidic bonds**
- c) *base-stacking***
- d) phosphodiester bonds**
- e) *hydrophobic interactions***
- f) covalent bonds**



# Are You Getting It??



---

Which can occur when the DNA strand  
**5'AATTCCGGAATTCC3'** forms a double-helix?  
*(multiple answers)*

- a) The complementary strand is **5'TTAAGGCCTTAAGG3'**.
- b) The complementary strand is **5'GGAATTCCGGAATT3'**.
- c) A more stable helix is formed by **5'CCGGCCAATTGGCC3'**.
- d) A more stable helix is formed by **5'AATTAAGGAATTAA3'**.
- e) The helix can be either left-handed or right-handed.
- f) The helix has both hydrophilic parts and hydrophobic parts.



# Are You Getting It??



---

## Answer

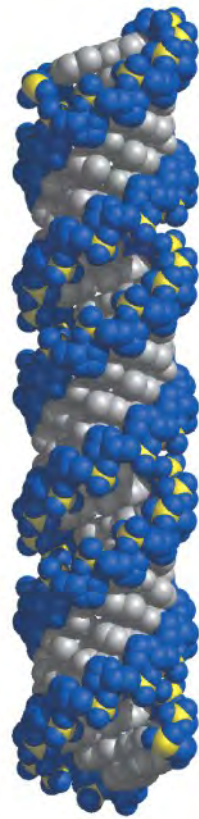
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Which of the following can occur when the DNA strand **5'AATTCCGGAATTCC3'** forms a double-helix?

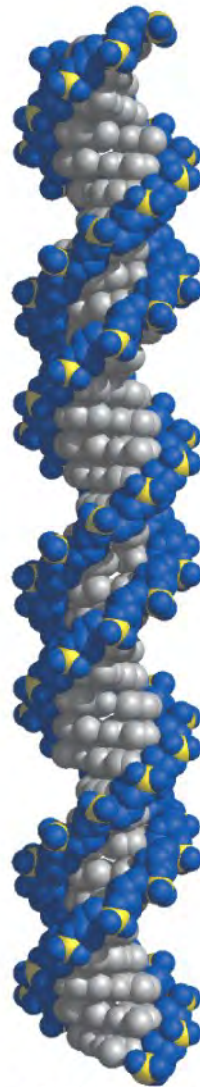
- a) The complementary strand is **5'TTAAGGCCTTAAGG3'**.
- b) The complementary strand is 5'GGAATTCCGGAATT3'.*
- c) A more stable helix is formed by 5'CCGGCCAATTGGCC3'.*
- d) A more stable helix is formed by **5'AATTAAGGAATTAA3'**.
- e) The helix can be either left-handed or right-handed.
- f) The helix has both hydrophilic parts and hydrophobic parts.*



28 Å



**A form**

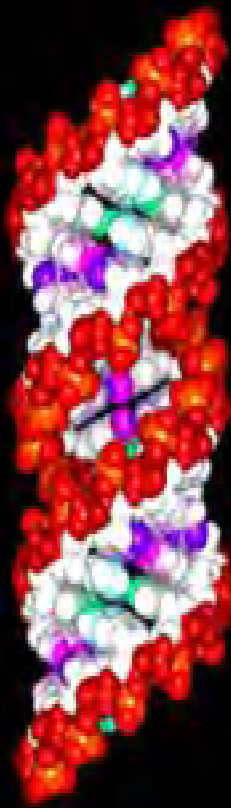


**B form**



**Z form**

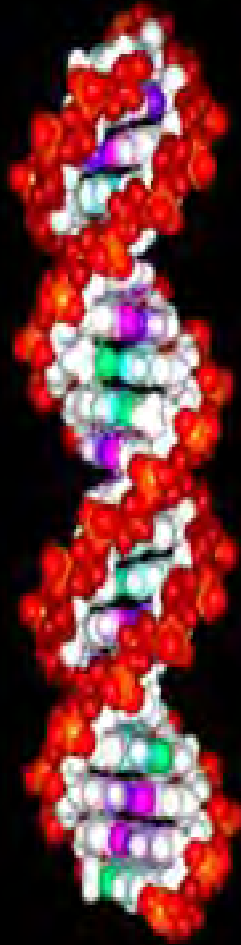
A-DNA



Z-DNA

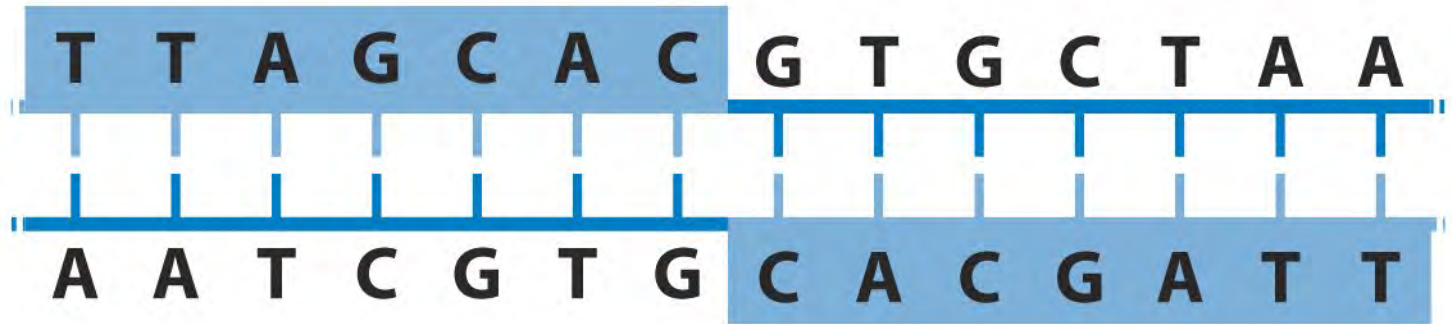


B-DNA

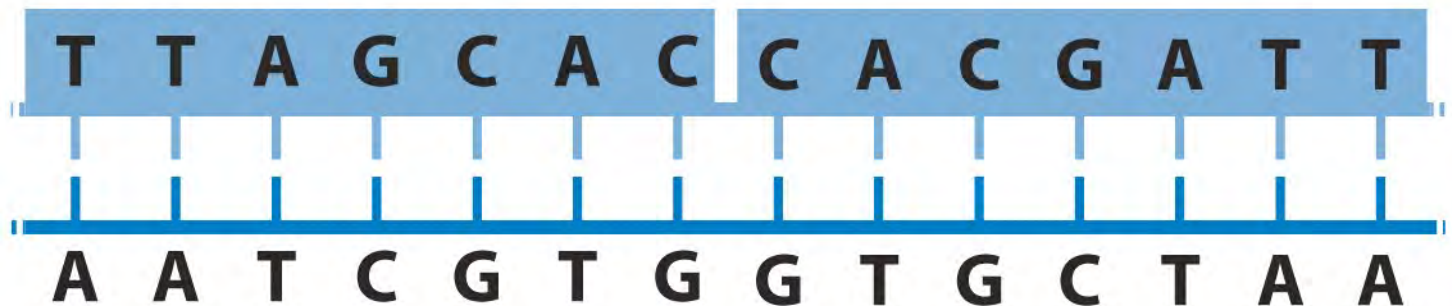


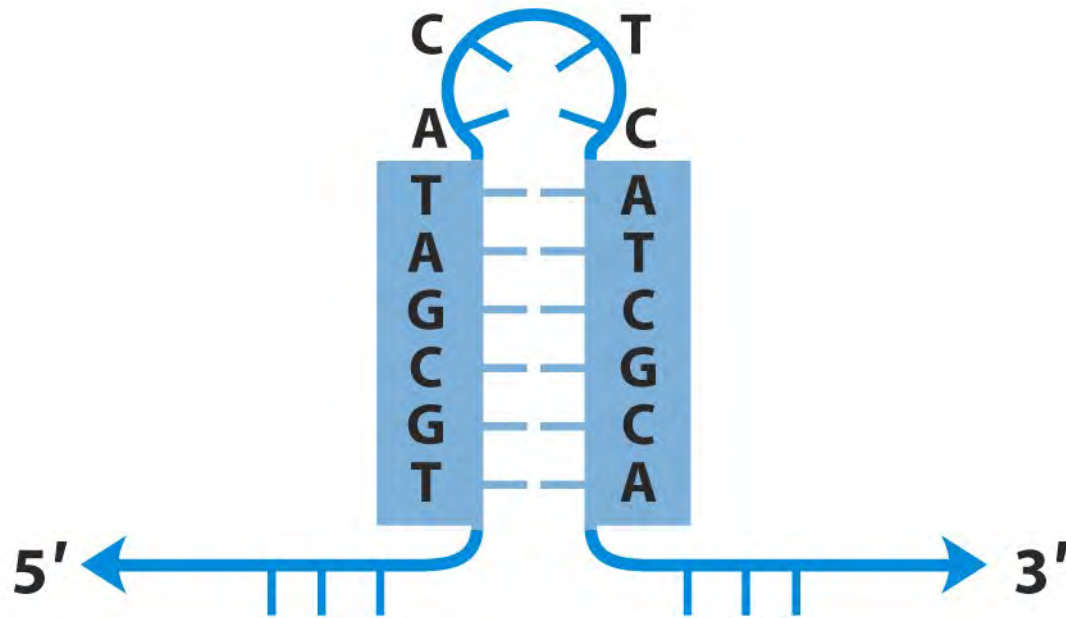
	<i>A form</i>	<i>B form</i>	<i>Z form</i>
Helical sense	Right handed	Right handed	Left handed
Diameter	~26 Å	~20 Å	~18 Å
Base pairs per helical turn	11	10.5	12
Helix rise per base pair	2.6 Å	3.4 Å	3.7 Å
Base tilt normal to the helix axis	20°	6°	7°
Sugar pucker conformation	C-3' endo	C-2' endo	C-2' endo for pyrimidines; C-3' endo for purines
Glycosyl bond conformation	Anti	Anti	Anti for pyrimidines; syn for purines

# Palindrome



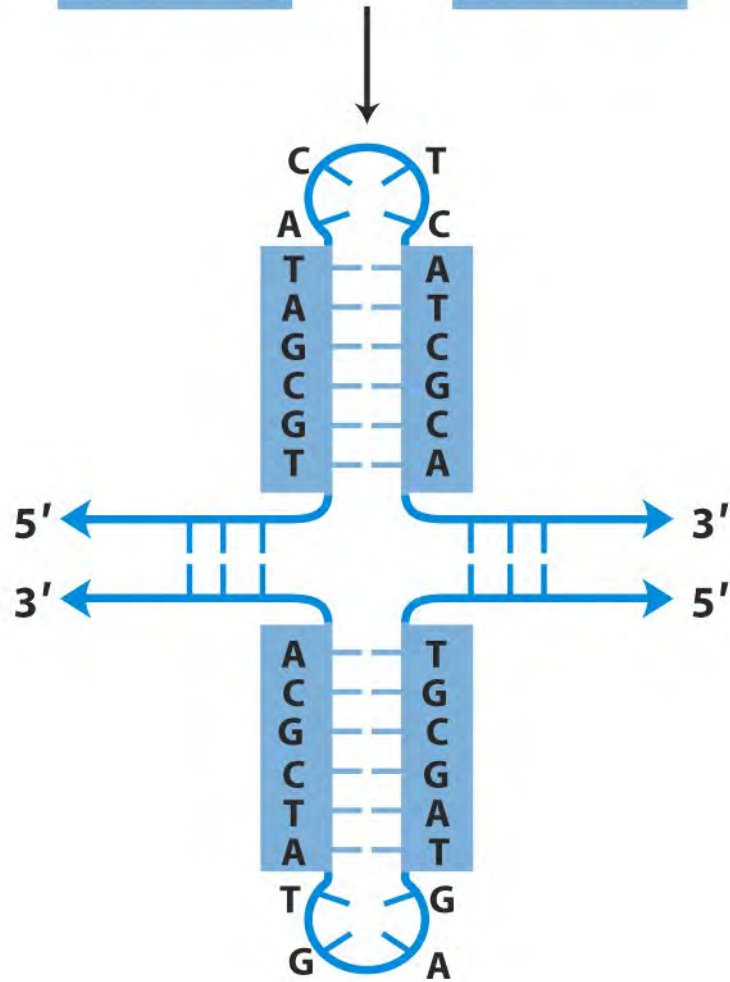
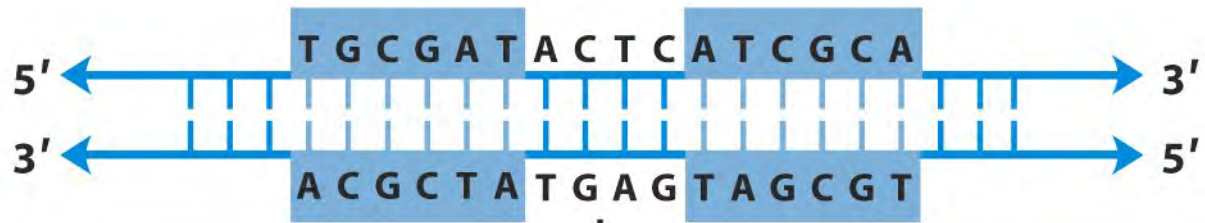
# Mirror repeat





**Hairpin**

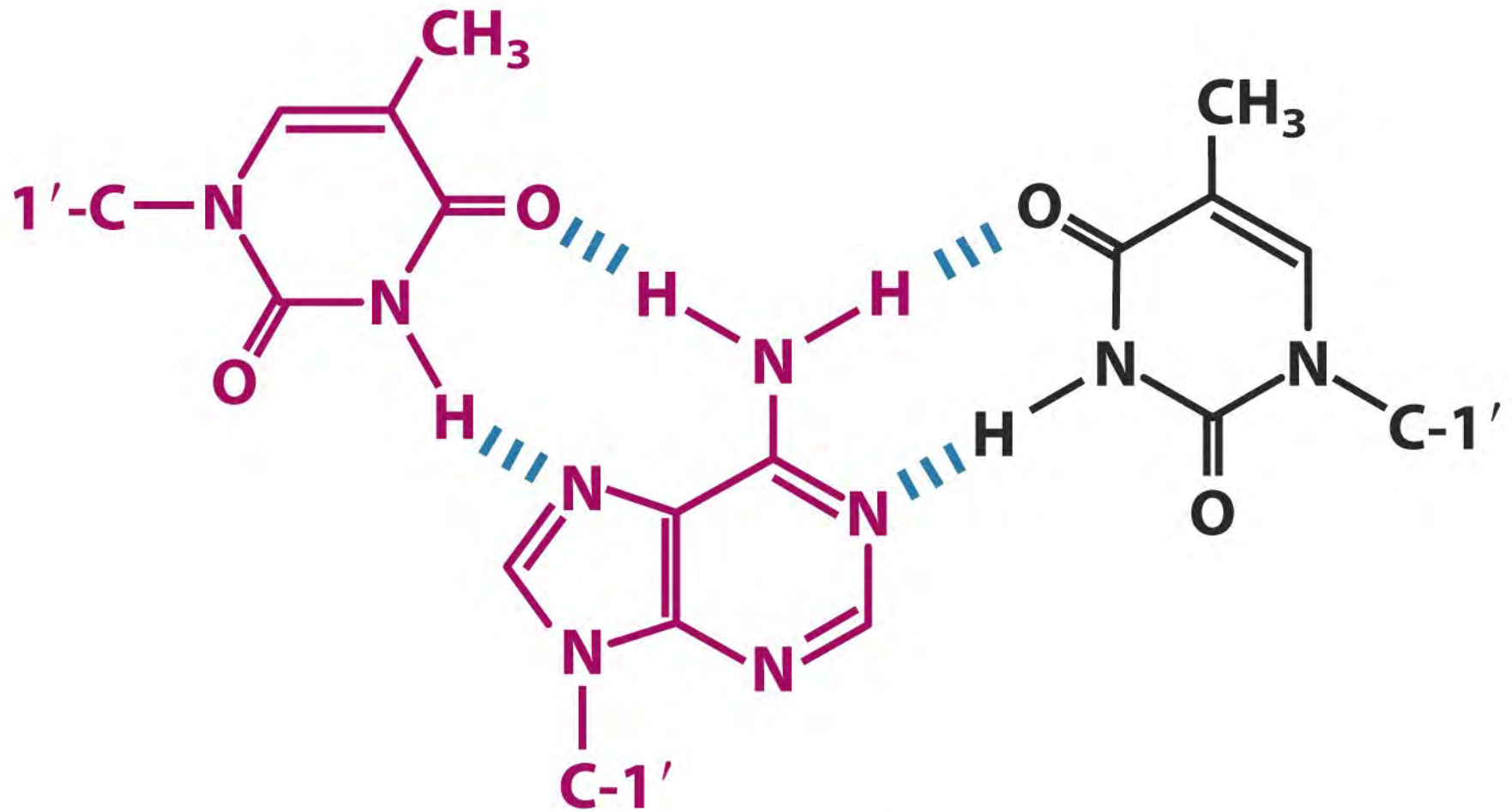




**Cruciform**

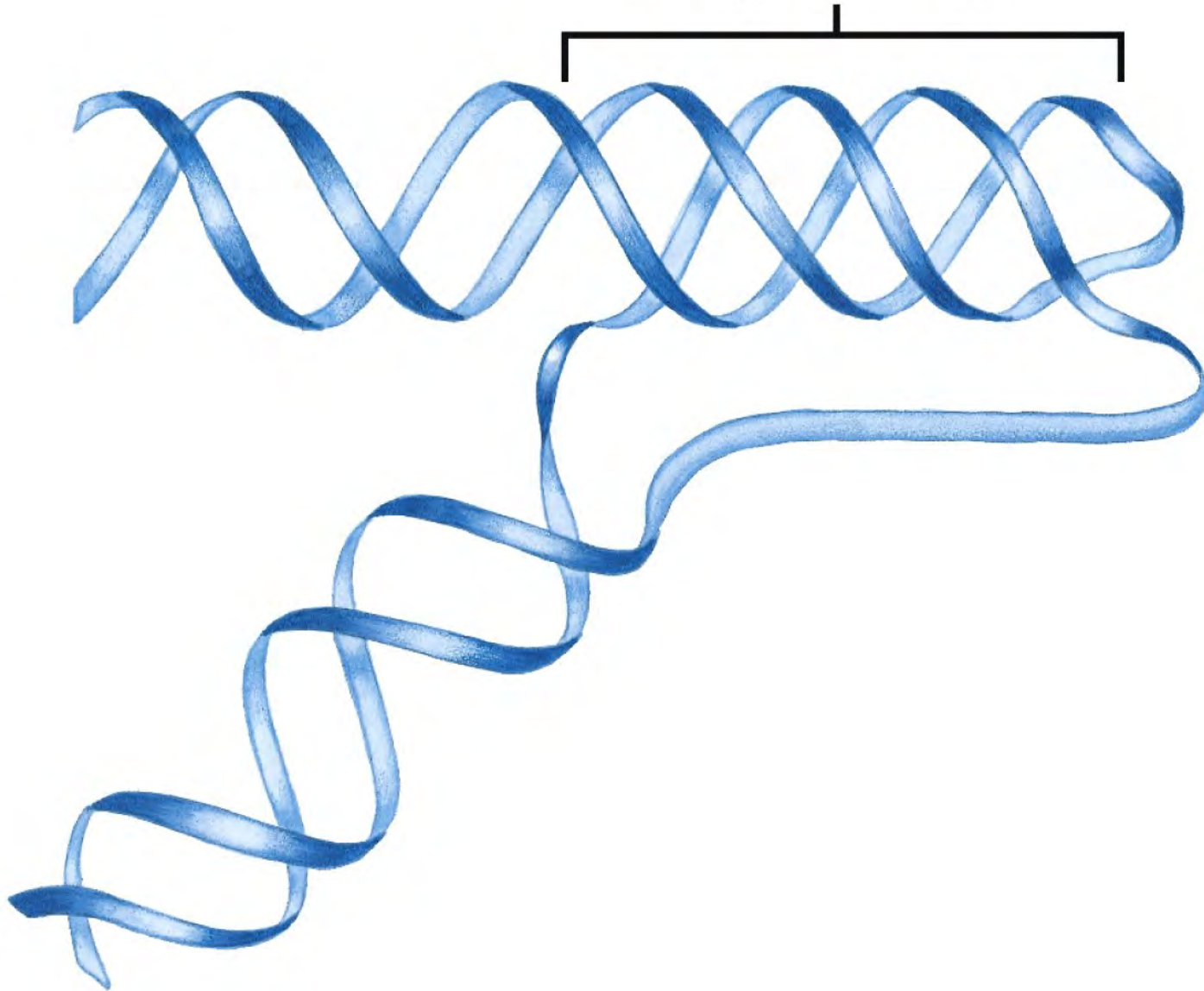






**T=A•T**

# Triple helix





# Are You Getting It??



Which characteristics apply to:

**B-DNA**; **A-DNA**; **Z-DNA**; **H-DNA**; **a cruciform**?

- a) The structure is a double-helix.
- b) The structure is a right-handed helix.
- c) The structure requires a palindrome.
- d) The structure requires a specific sequence of purines and pyrimidines.
- e) The structure contains hydrogen-bonds.



# Are You Getting It??



---

## Answer

---

Which characteristics apply to:

**B-DNA**; **A-DNA**; **Z-DNA**; **H-DNA**; **a cruciform**?

- a) The structure is a double-helix. **A, B, Z**
- b) The structure is a right-handed helix. **A, B**
- c) The structure requires a palindrome. **cruciform**
- d) The structure requires a specific sequence of purines and pyrimidines. **Z, H**
- e) The structure contains hydrogen-bonds. **all**



**Double-helical  
DNA**

**Denaturation**      **Annealing**

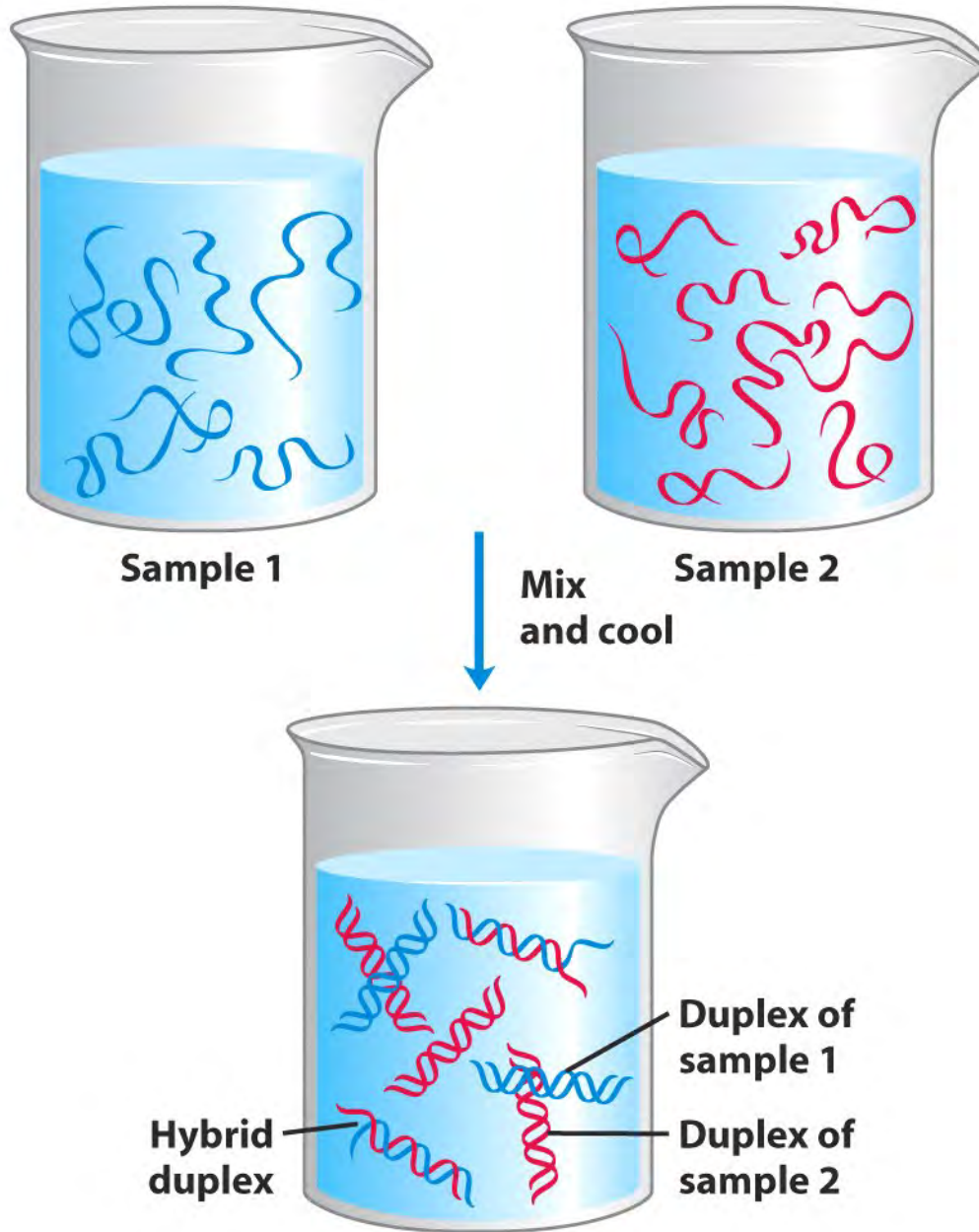


**Partially denatured  
DNA**

**Separation  
of strands**      **Association of  
strands by base  
pairing**



**Separated strands  
of DNA in random coils**





# Are You Getting It??



---

Which characteristics will be shared by all DNA double-helices? *(multiple answers)*

- a) They all have the same amount of adenine.
- b) They all have a base composition where  $A=T$ .
- c) They all have two strands with complementary sequences.
- d) They all denature at the same temperature.
- e) They all hybridize at high pH.





# Are You Getting It??



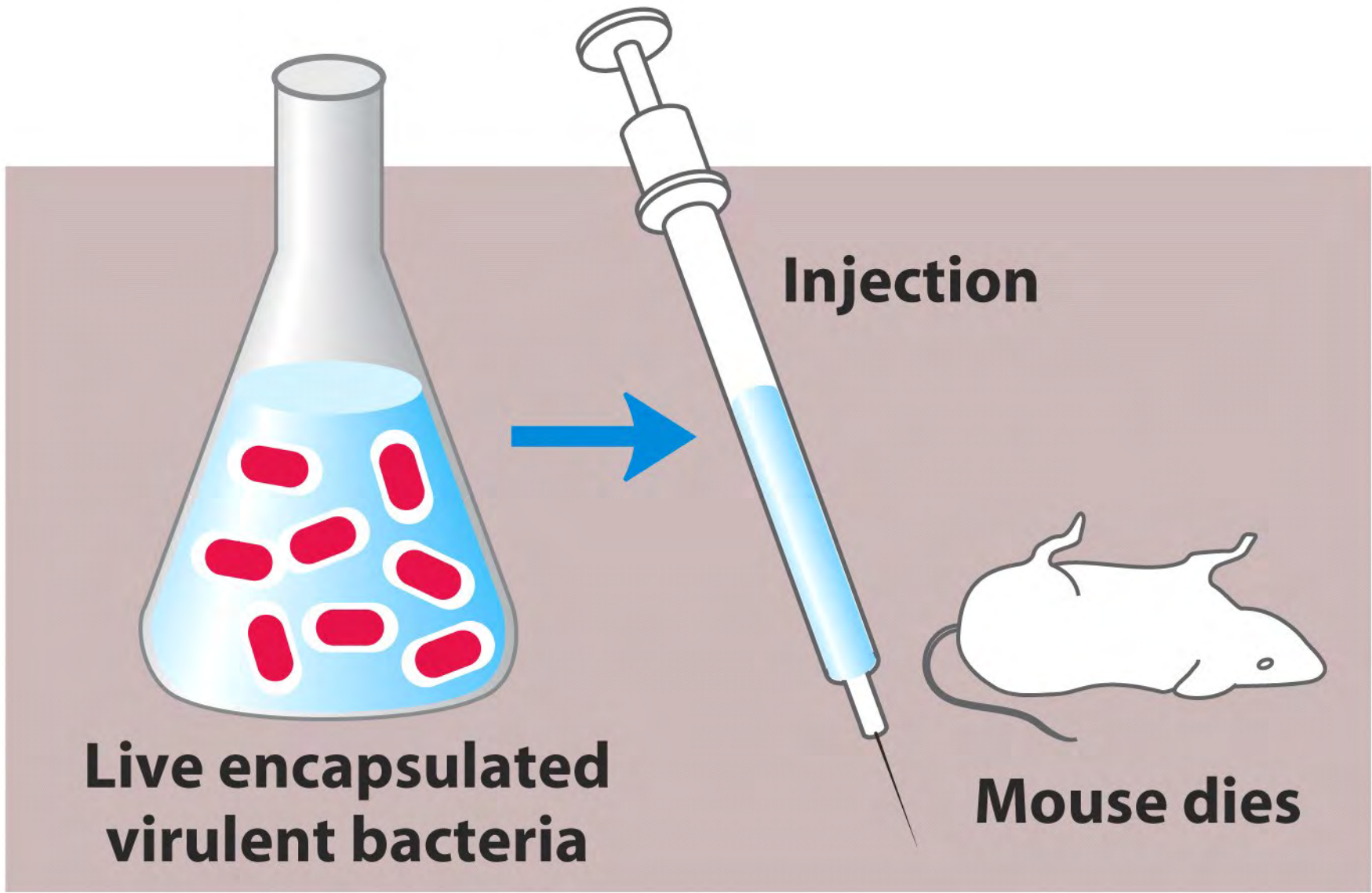
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## Answer

---

Which characteristics will be shared by all DNA double-helices?

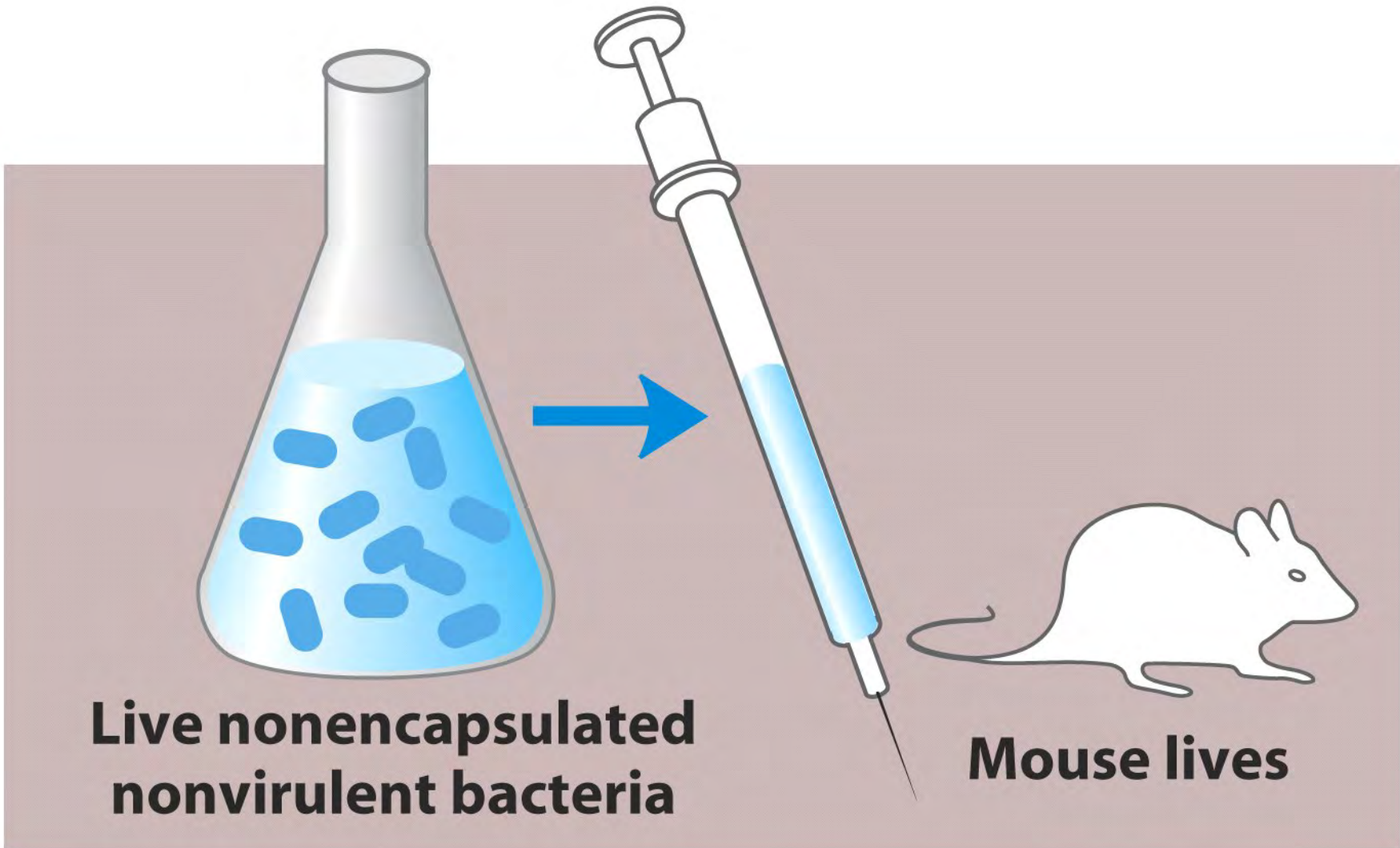
- a) They all have the same amount of adenine.
- b) They all have a base composition where  $A=T$ .**
- c) They all have two strands with complementary sequences.**
- d) They all denature at the same temperature.
- e) They all hybridize at high pH.



**Live encapsulated virulent bacteria**

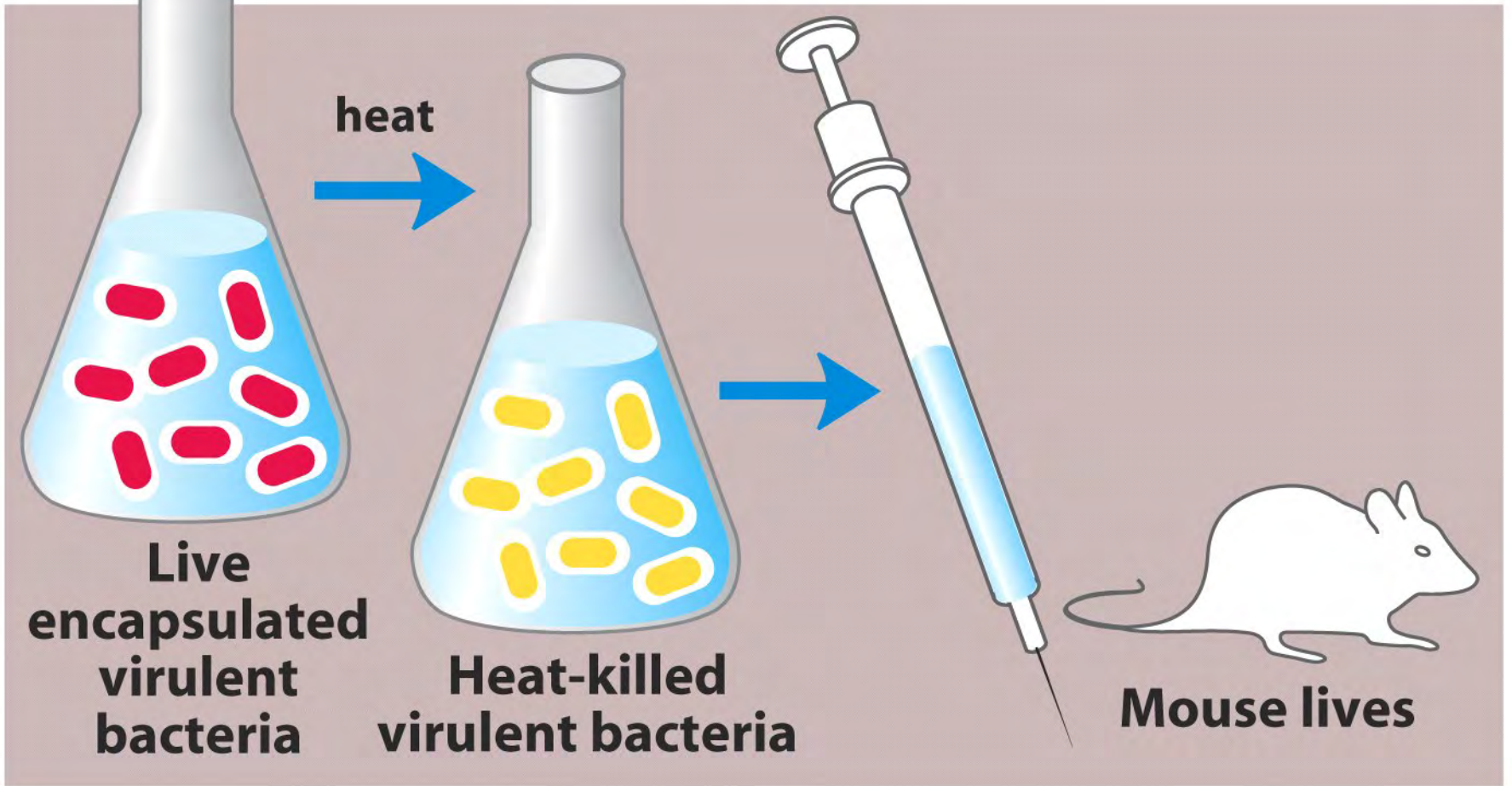
**Injection**

**Mouse dies**

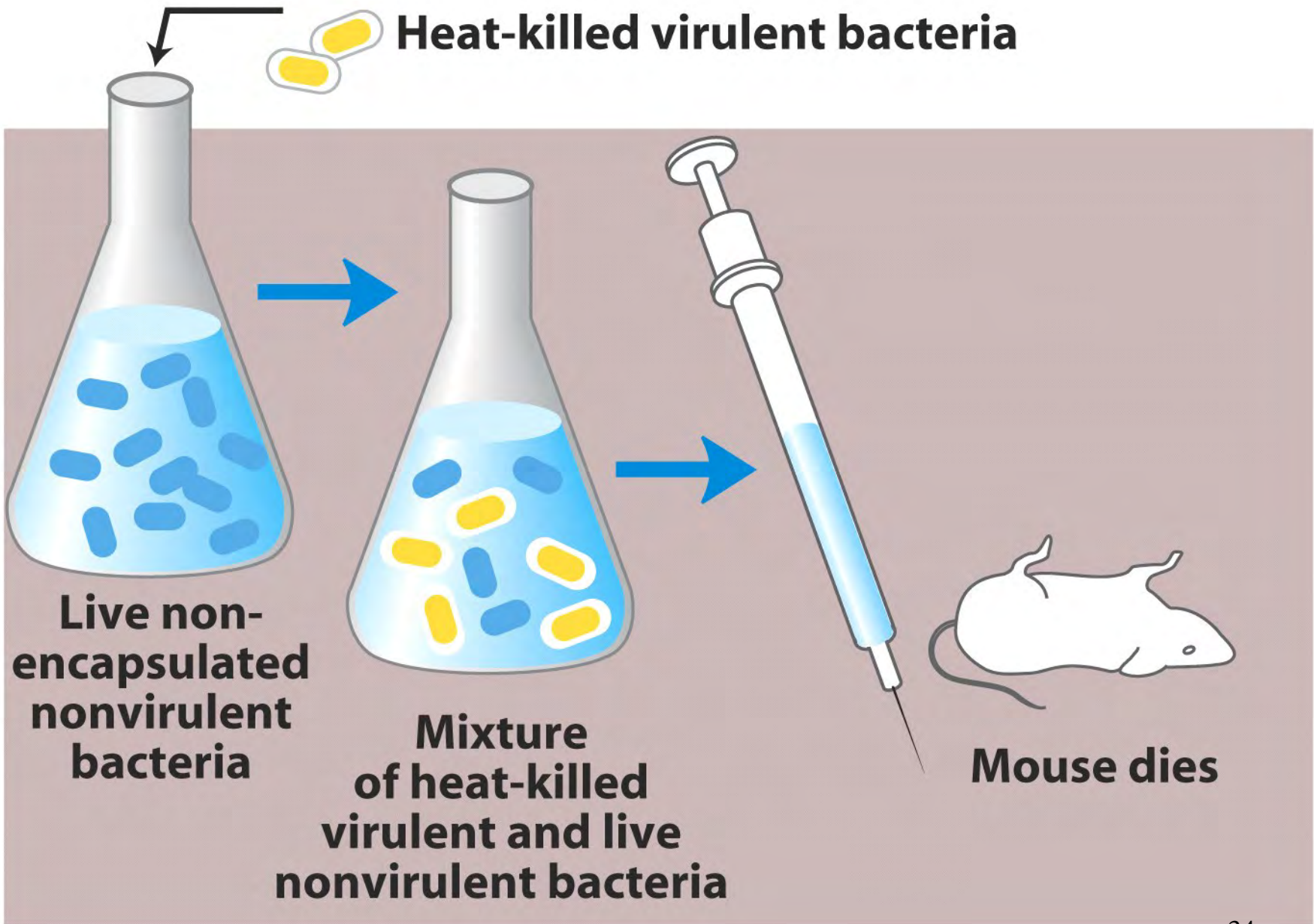


**Live nonencapsulated  
nonvirulent bacteria**

**Mouse lives**





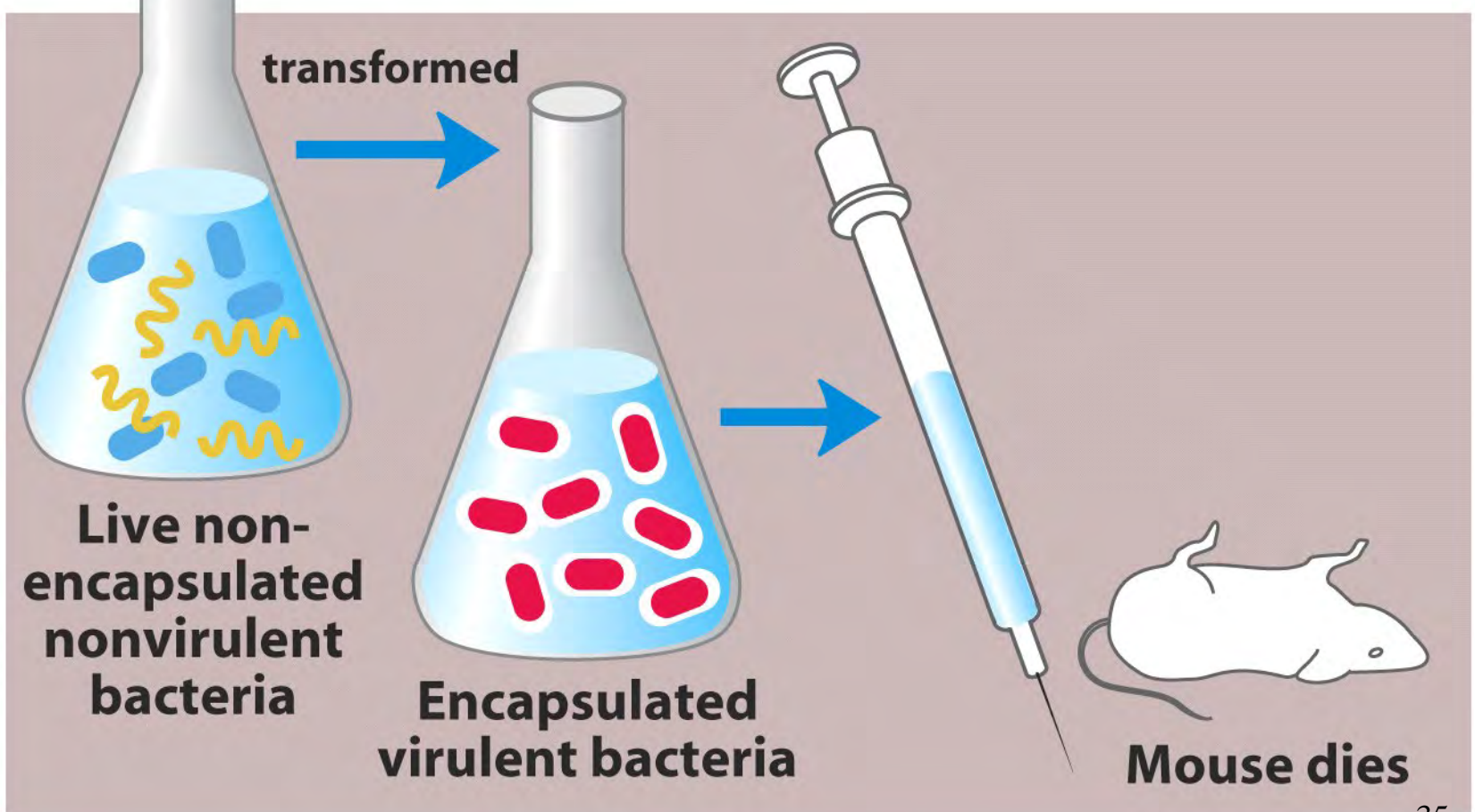


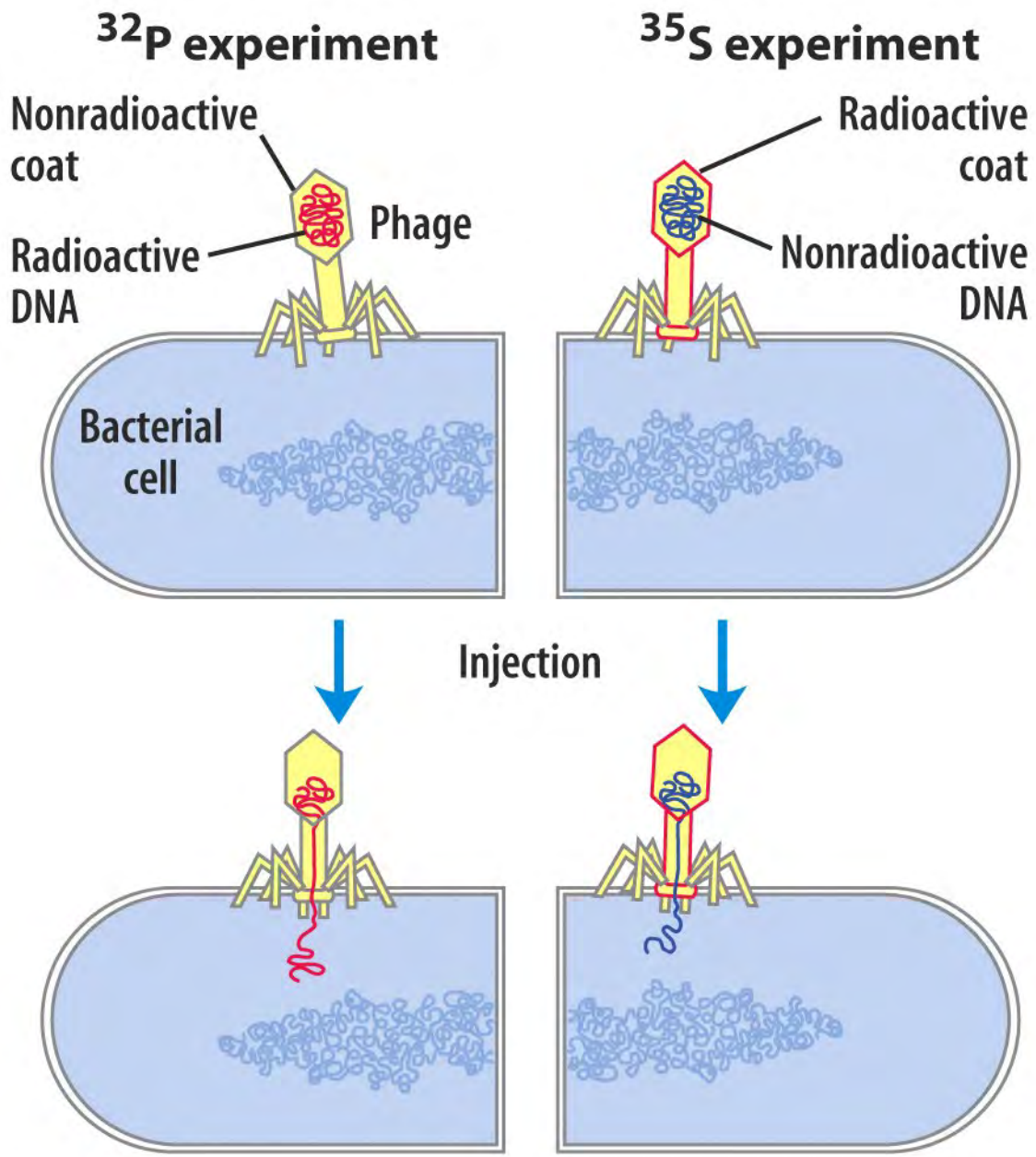


**Live nonvirulent bacteria**

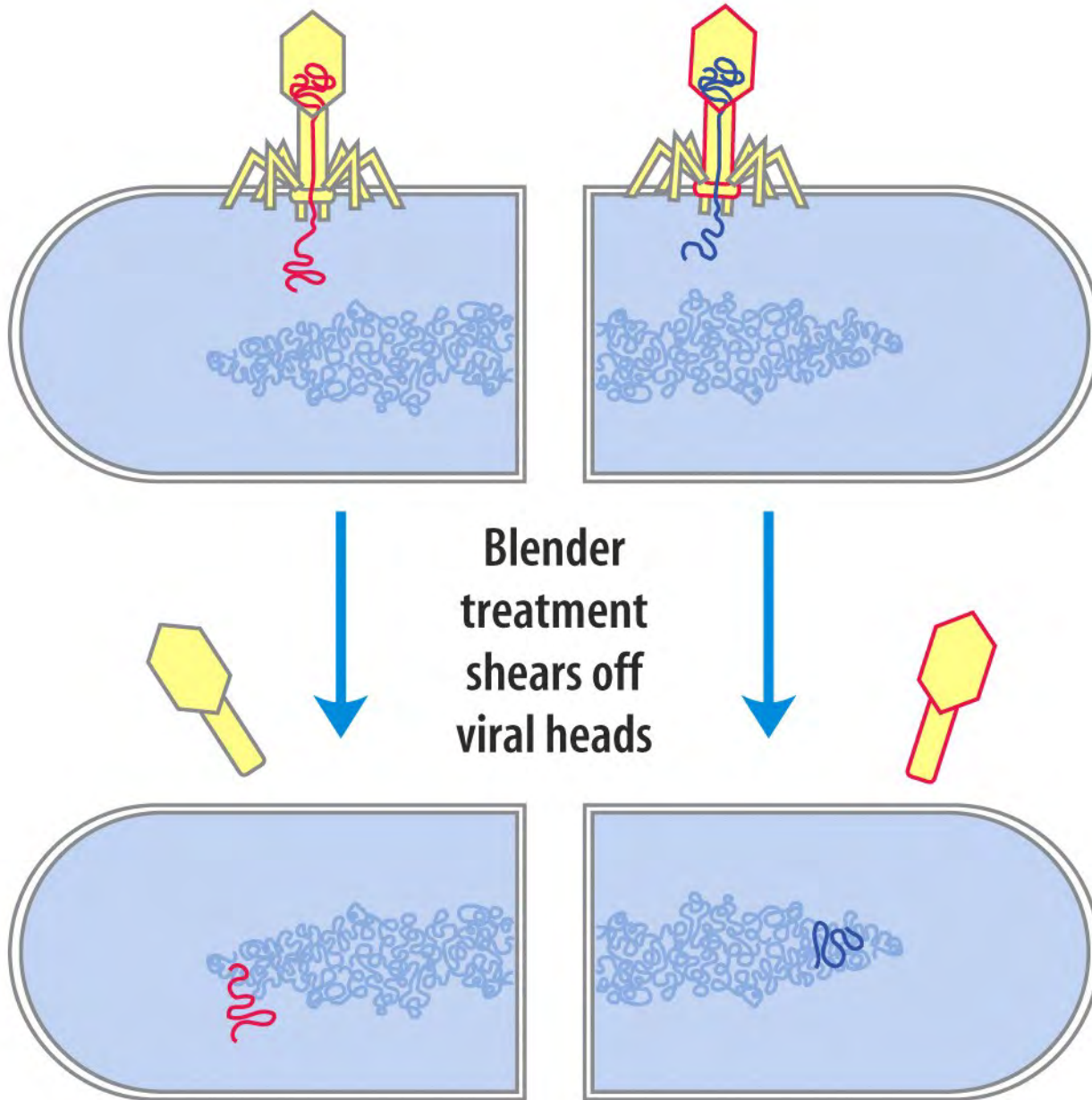


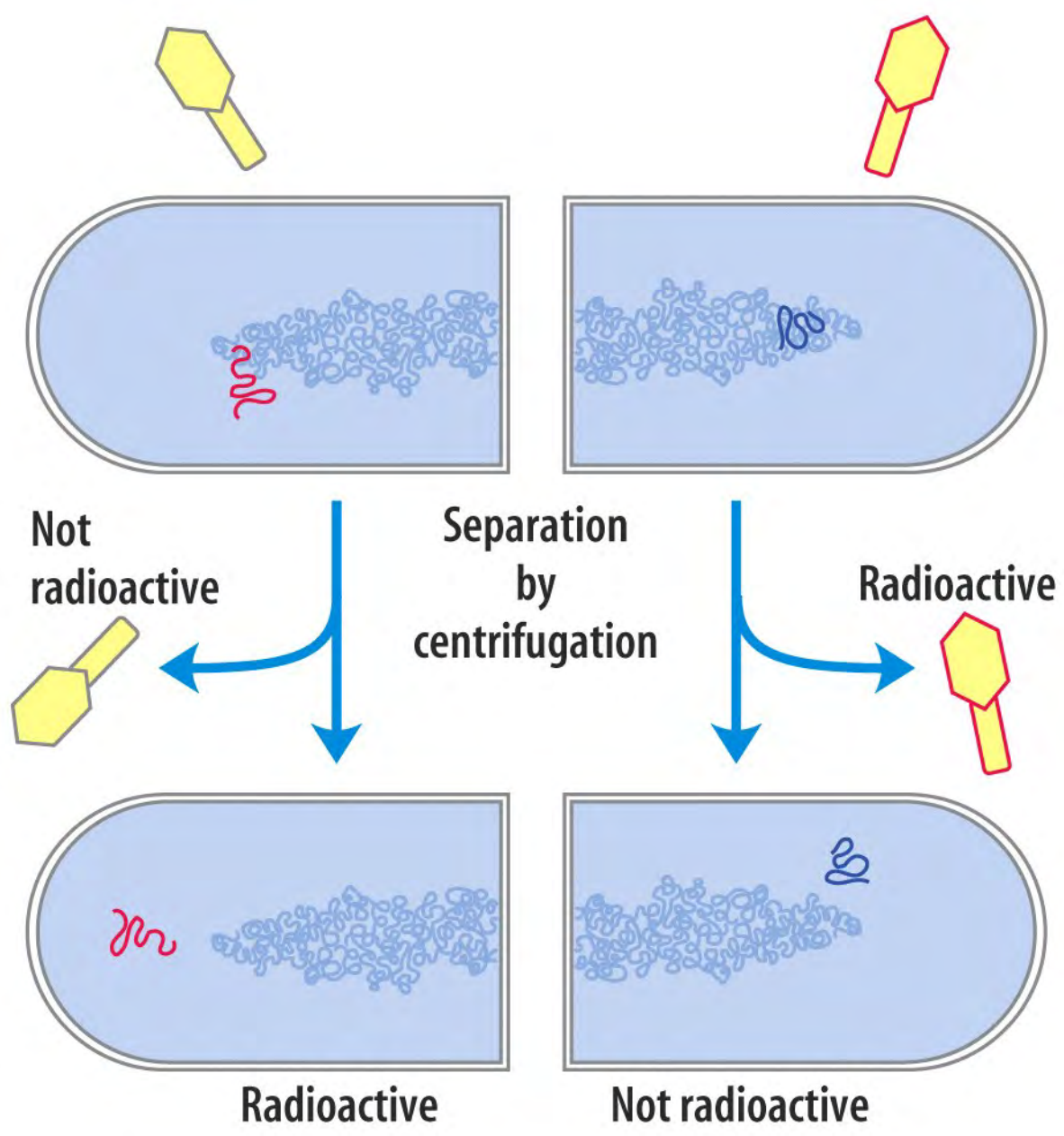
**DNA isolated from heat-killed virulent bacteria**











**Table 11-1. Molar Properties of Bases\* in DNAs from Various Sources**

Organism	Tissue	Adenine	Thymine	Guanine	Cytosine
<i>Escherichia coli</i> (K12)	—	26.0	23.9	24.9	25.2
<i>Diplococcus pneumoniae</i>	—	29.8	31.6	20.5	18.0
<i>Mycobacterium tuberculosis</i>	—	15.1	14.6	34.9	35.4
Yeast	—	31.3	32.9	18.7	17.1
<i>Paracentrotus lividus</i> (sea urchin)	Sperm	32.8	32.1	17.7	18.4
Herring	Sperm	27.8	27.5	22.2	22.6
Rat	Bone marrow	28.6	28.4	21.4	21.5
Human	Thymus	30.9	29.4	19.9	19.8
Human	Liver	30.3	30.3	19.5	19.9
Human	Sperm	30.7	31.2	19.3	18.8

\* Defined as moles of nitrogenous constituents per 100 g-atoms phosphate in hydrolysate.

SOURCE: E. Chargaff and J. Davidson, eds., *The Nucleic Acids*. Academic Press, 1955.



# Are You Getting It??



---

**Which properties are expected of genetic material?**  
*(multiple answers)*

- a) It is the same in all cells of an organism.
- b) It is the same in all organisms.
- c) It can control/transform the characteristics of an organism.
- d) It changes as an organism ages.
- e) It is double-stranded DNA.



# Are You Getting It??



---

## Answer

---

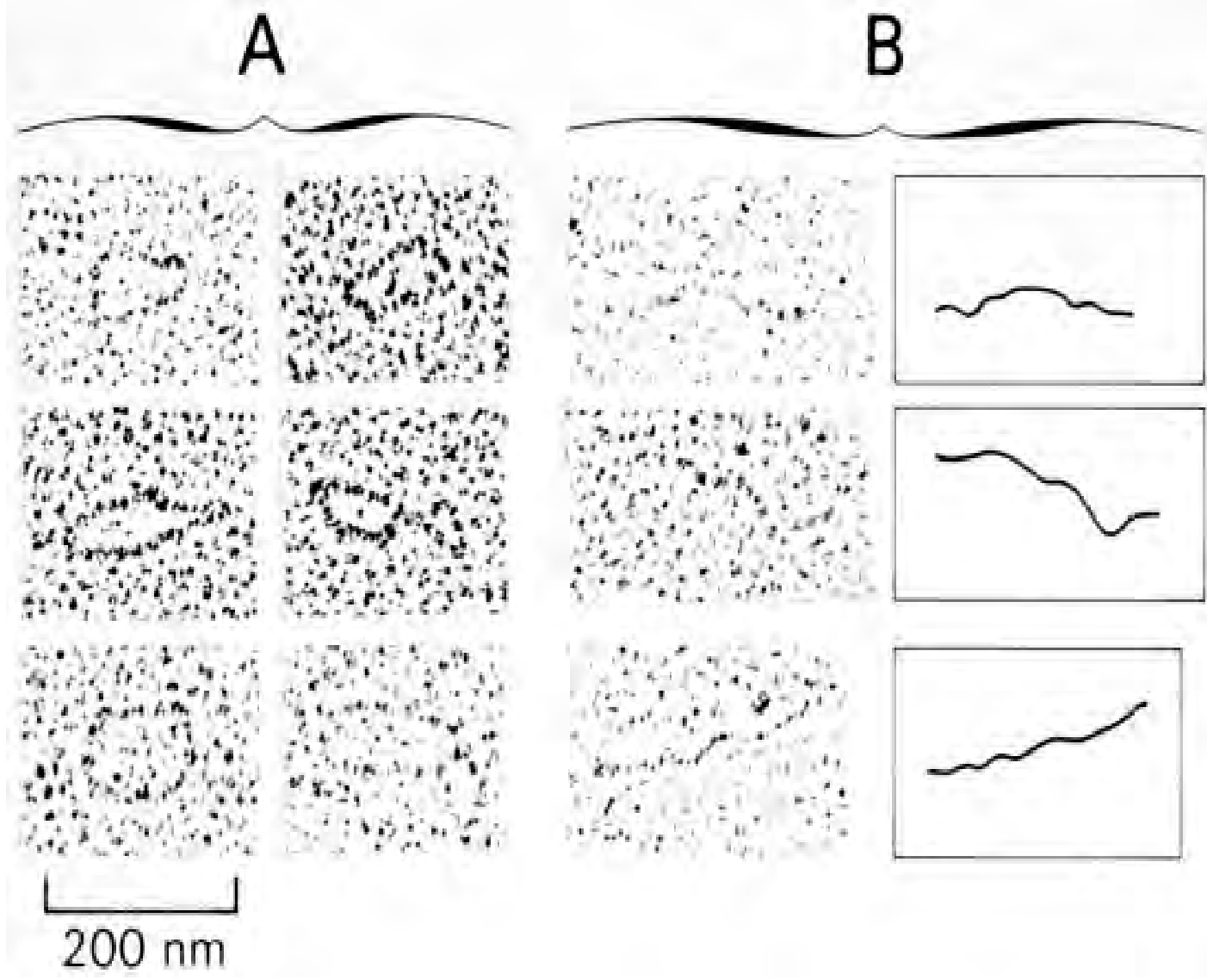
Which properties are expected of genetic material?

- a) *It is the same in all cells of an organism.*
- b) It is the same in all organisms.
- c) *It can control/transform the characteristics of an organism.*
- d) It changes as an organism ages.
- e) It is double-stranded DNA.

**TABLE 24-1** The Sizes of DNA and Viral Particles for Some Bacterial Viruses (Bacteriophages)

<i>Virus</i>	<i>Size of viral DNA (bp)</i>	<i>Length of viral DNA (nm)</i>	<i>Long dimension of viral particle (nm)</i>
$\phi$ X174	5,386	1,939	25
T7	39,936	14,377	78
$\lambda$ (lambda)	48,502	17,460	190
T4	168,889	60,800	210

**Note:** Data on size of DNA are for the replicative form (double-stranded). The contour length is calculated assuming that each base pair occupies a length of 3.4 Å (see Fig. 8-15).





**TABLE 24-2** DNA, Gene, and Chromosome Content in Some Genomes

	<i>Total DNA (bp)</i>	<i>Number of chromosomes*</i>	<i>Approximate number of genes</i>
Bacterium ( <i>Escherichia coli</i> )	4,639,221	1	4,405
Yeast ( <i>Saccharomyces cerevisiae</i> )	12,068,000	16 <sup>†</sup>	6,200
Nematode ( <i>Caenorhabditis elegans</i> )	97,000,000	12 <sup>‡</sup>	19,000
Plant ( <i>Arabidopsis thaliana</i> )	125,000,000	10	25,500
Fruit fly ( <i>Drosophila melanogaster</i> )	180,000,000	18	13,600
Plant ( <i>Oryza sativa</i> ; rice)	480,000,000	24	57,000
Mouse ( <i>Mus musculus</i> )	2,500,000,000	40	30,000–35,000
Human ( <i>Homo sapiens</i> )	3,200,000,000	46	30,000–35,000

**Note:** This information is constantly being refined. For the most current information, consult the websites for the individual genome projects.

\*The diploid chromosome number is given for all eukaryotes except yeast.

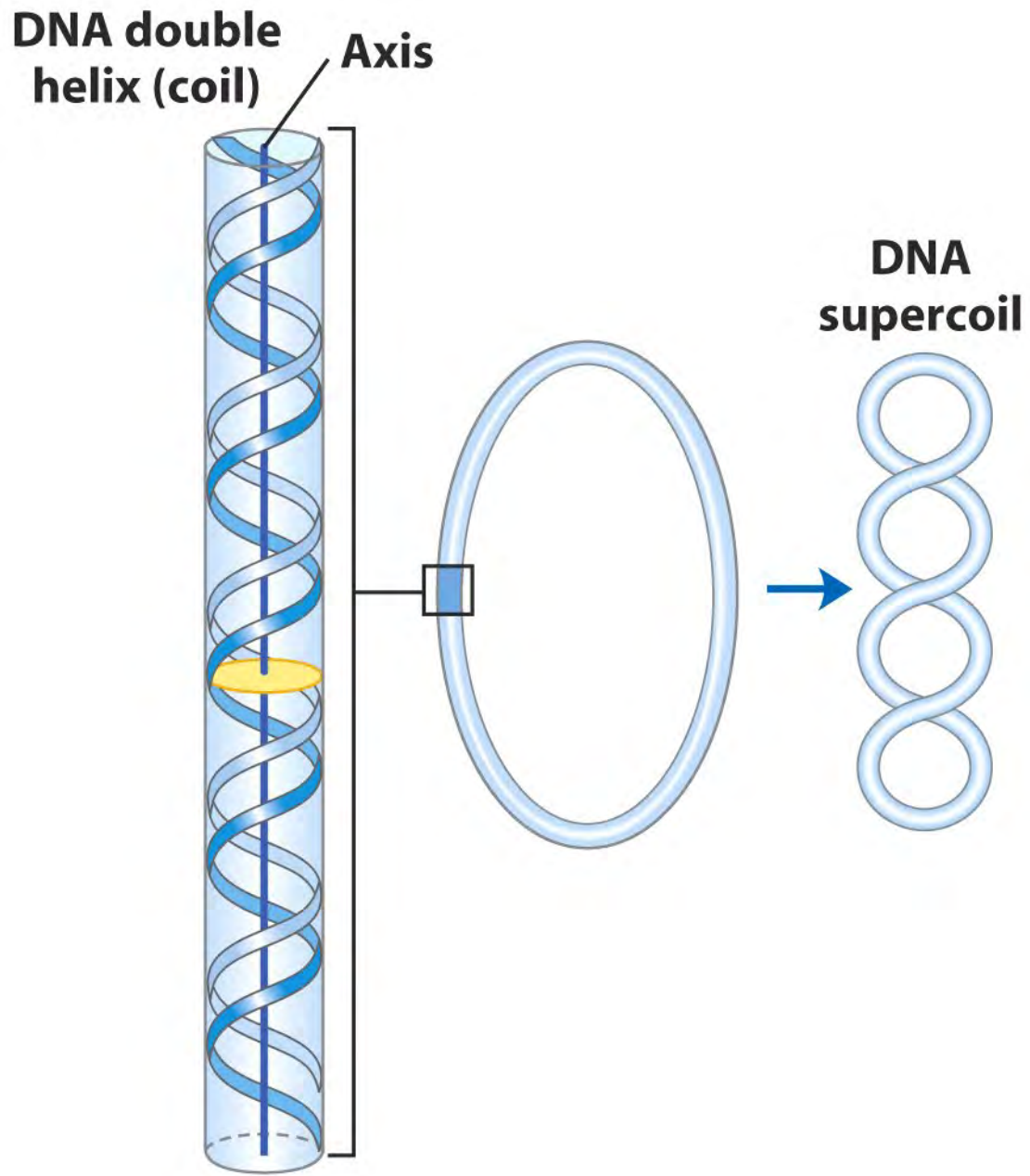
<sup>†</sup>Haploid chromosome number. Wild yeast strains generally have eight (octoploid) or more sets of these chromosomes.

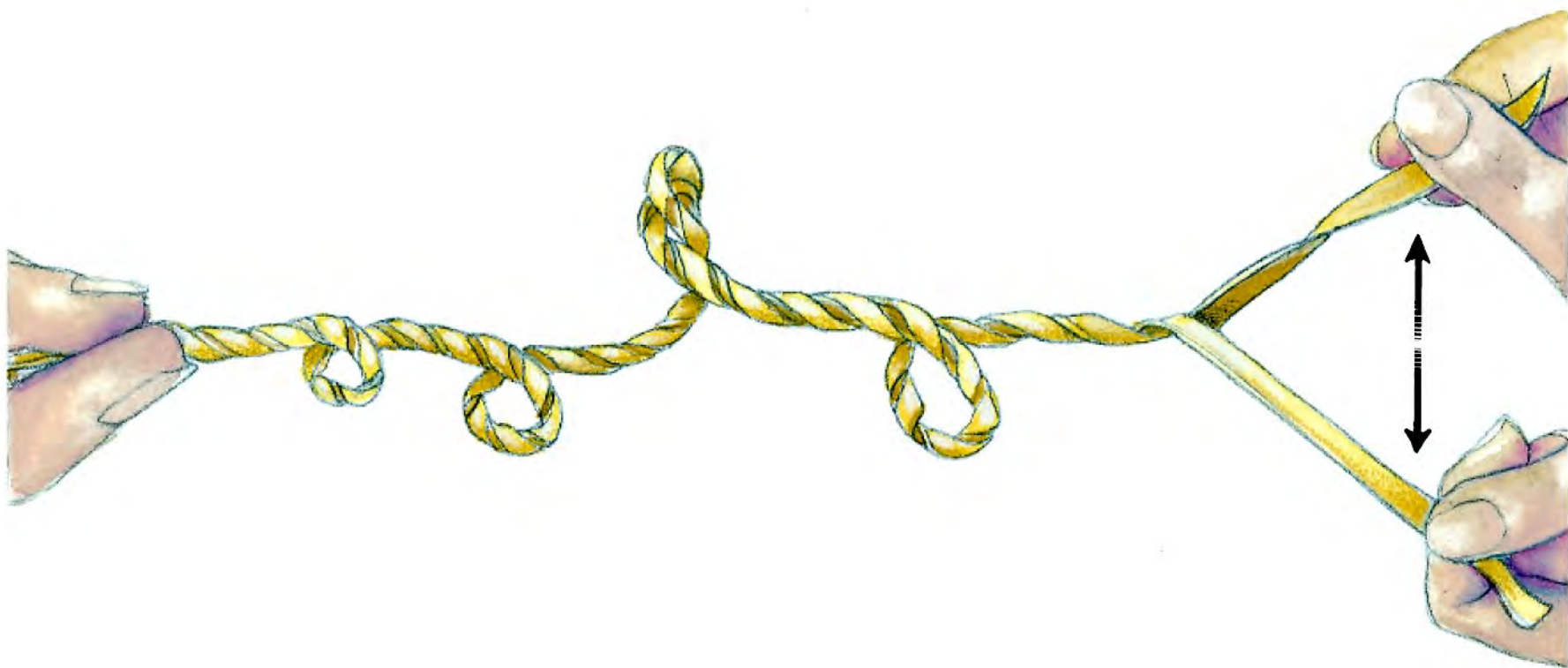
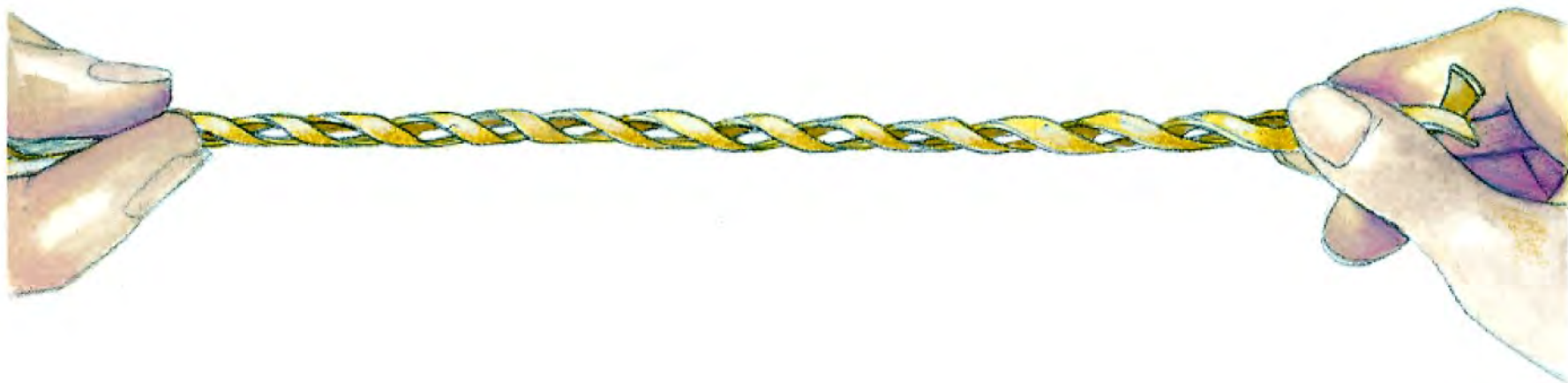
<sup>‡</sup>Number for females, with two X chromosomes. Males have an X but no Y, thus 11 chromosomes in all.

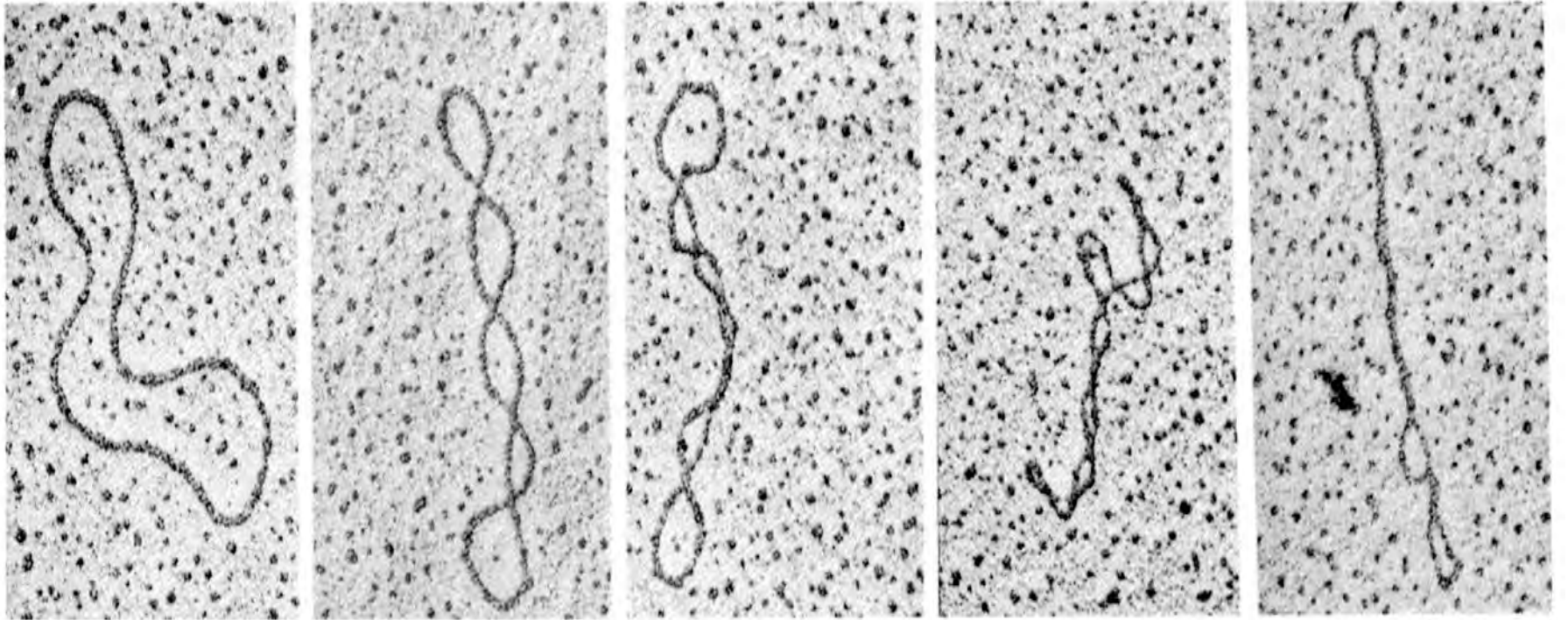
**E. coli**  
**E. coli DNA**



The diagram shows a large, circular, blue DNA molecule. On the left side, there is a small, multi-colored structure (possibly a protein or a small DNA fragment) attached to the main molecule. The main molecule is a single, continuous blue line that forms a large, irregular circle with several smaller loops and folds. The small structure is a small, multi-colored shape with a yellow dot above it, and a line connecting it to the main DNA molecule.







0.2  $\mu\text{m}$



# Are You Getting It??



---

Which properties can be characteristic of **viral genetic material** or **bacterial genetic material**?

- a) It is single-stranded.
- b) It is circular.
- c) It contains several million bases.
- d) It is compacted.
- e) It is found in the nucleus.





# Are You Getting It??



---

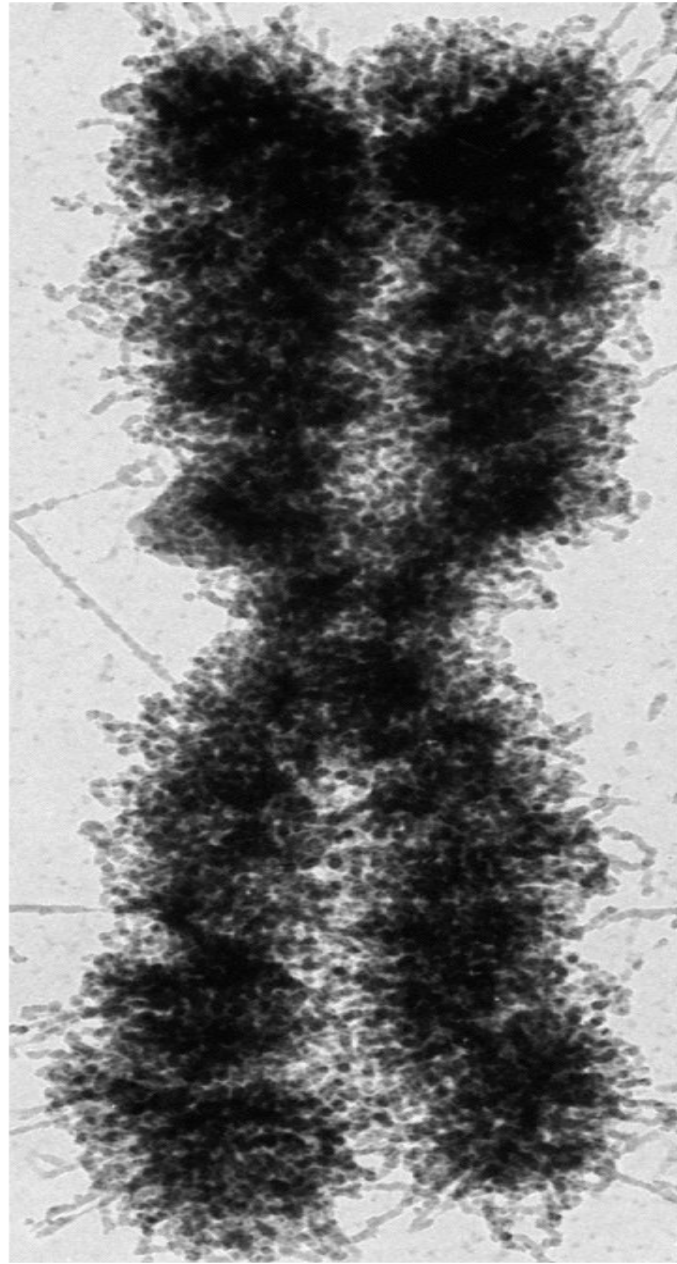
## Answer

---

Which properties can be characteristic of **viral genetic material** or **bacterial genetic material**?

- a) It is single-stranded. **viral**
- b) It is circular. **both**
- c) It contains several million bases. **bacterial**
- d) It is compacted. **both**
- e) It is found in the nucleus. **bacterial**



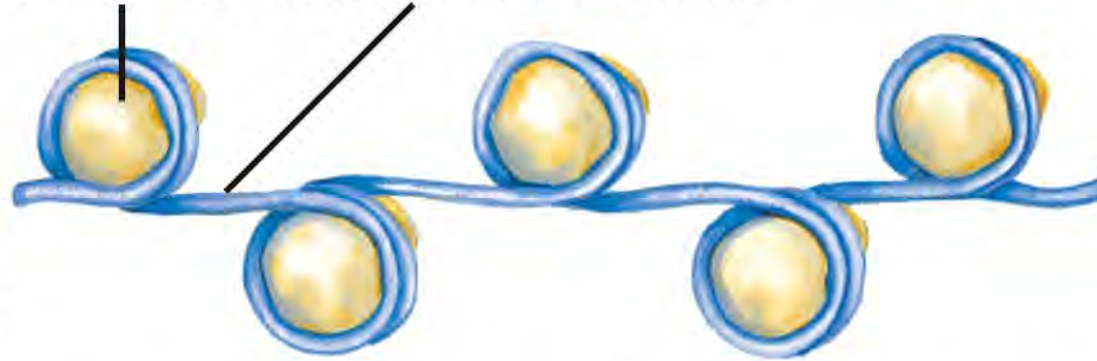


**TABLE 24-3** Types and Properties of Histones

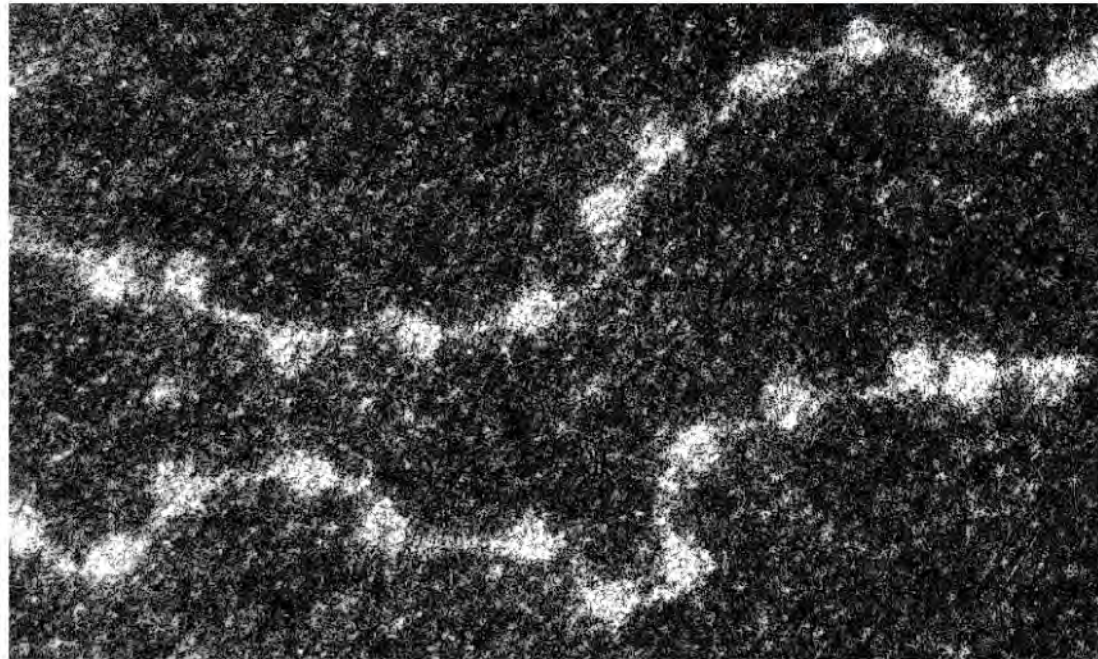
<i>Histone</i>	<i>Molecular weight</i>	<i>Number of amino acid residues</i>	<i>Content of basic amino acids (% of total)</i>	
			<i>Lys</i>	<i>Arg</i>
H1*	21,130	223	29.5	11.3
H2A*	13,960	129	10.9	19.3
H2B*	13,774	125	16.0	16.4
H3	15,273	135	19.6	13.3
H4	11,236	102	10.8	13.7

\*The sizes of these histones vary somewhat from species to species. The numbers given here are for bovine histones.

Histone core  
of nucleosome      Linker DNA  
of nucleosome



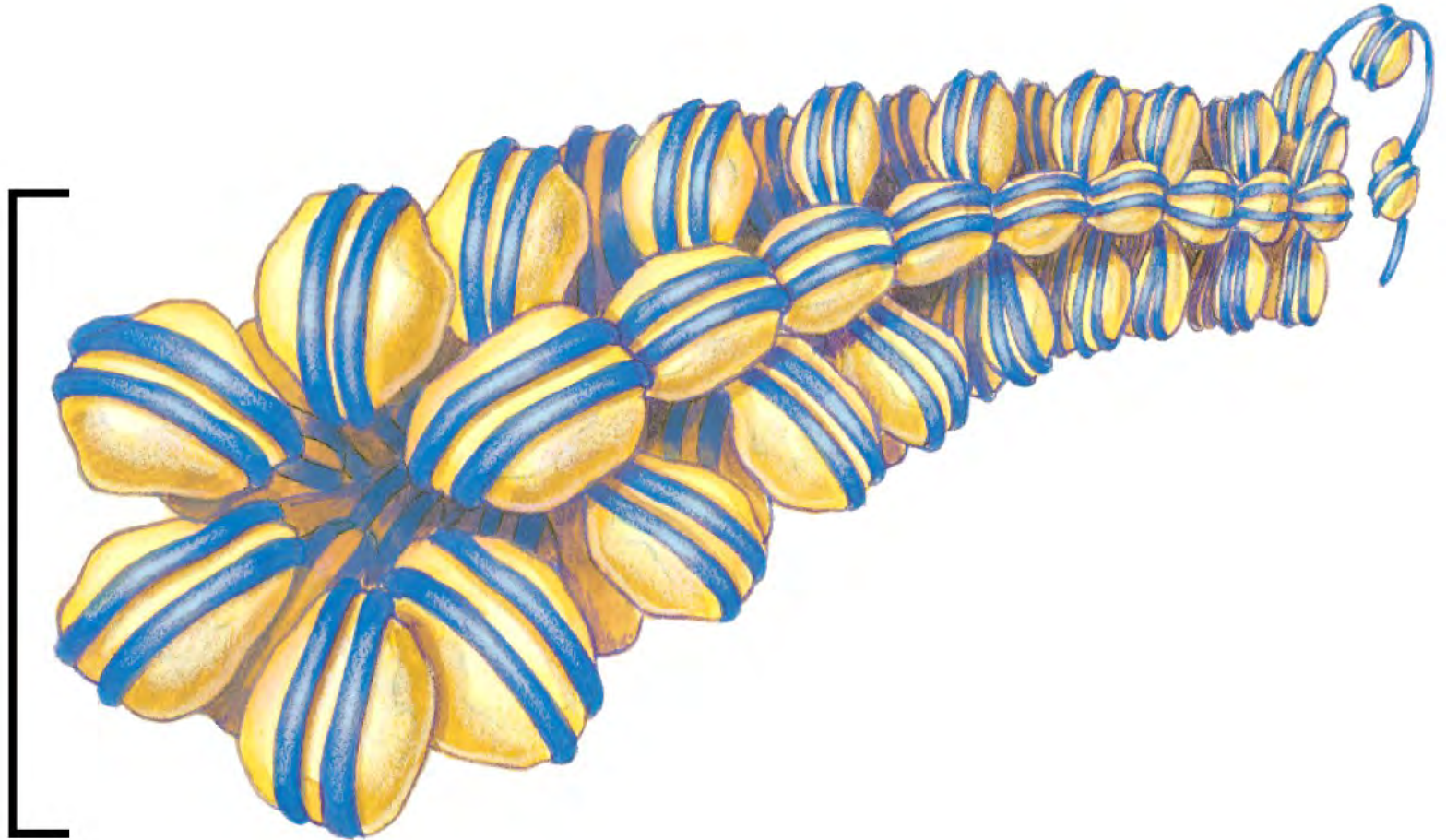
(a)



(b)

50 nm

**30  
nm**





**Two chromatids (10 coils each)**

**One coil (30 rosettes)**

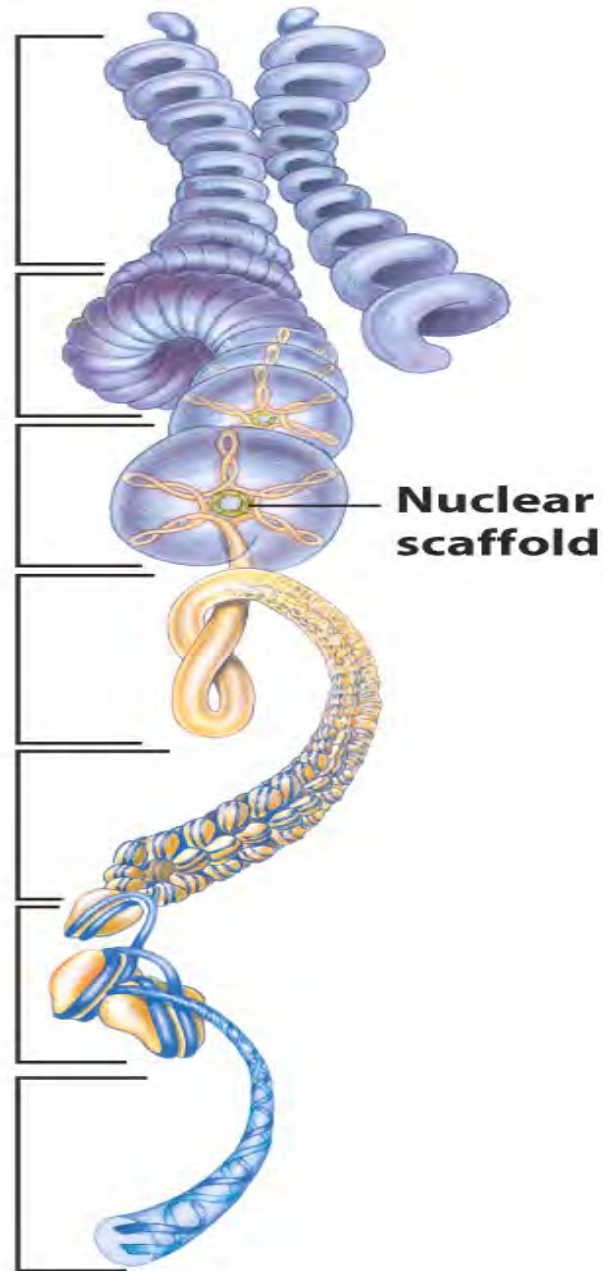
**One rosette (6 loops)**

**One loop (~75,000 bp)**

**30 nm Fiber**

**"Beads-on-a-string" form of chromatin**

**DNA**





# Are You Getting It??



---

Which properties are characteristic of eukaryotic genetic material? *(multiple answers)*

- a) It is contained in a single chromosome.
- b) It is complexed with protein.
- c) It is compacted about 10-fold.
- d) Each nucleosome contains several histone proteins.
- e) Each histone protein is negatively-charged.
- f) Nucleosomes are arranged into a helix.



# Are You Getting It??



---

## Answer

---

Which properties are characteristic of eukaryotic genetic material?

- a) It is contained in a single chromosome.
- b) *It is complexed with protein.***
- c) It is compacted about 10-fold.
- d) *Each nucleosome contains several histone proteins.***
- e) Each histone protein is negatively-charged.
- f) *Nucleosomes are arranged into a helix.***