

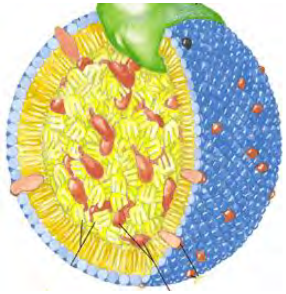


BIOCHEMISTRY REVIEW

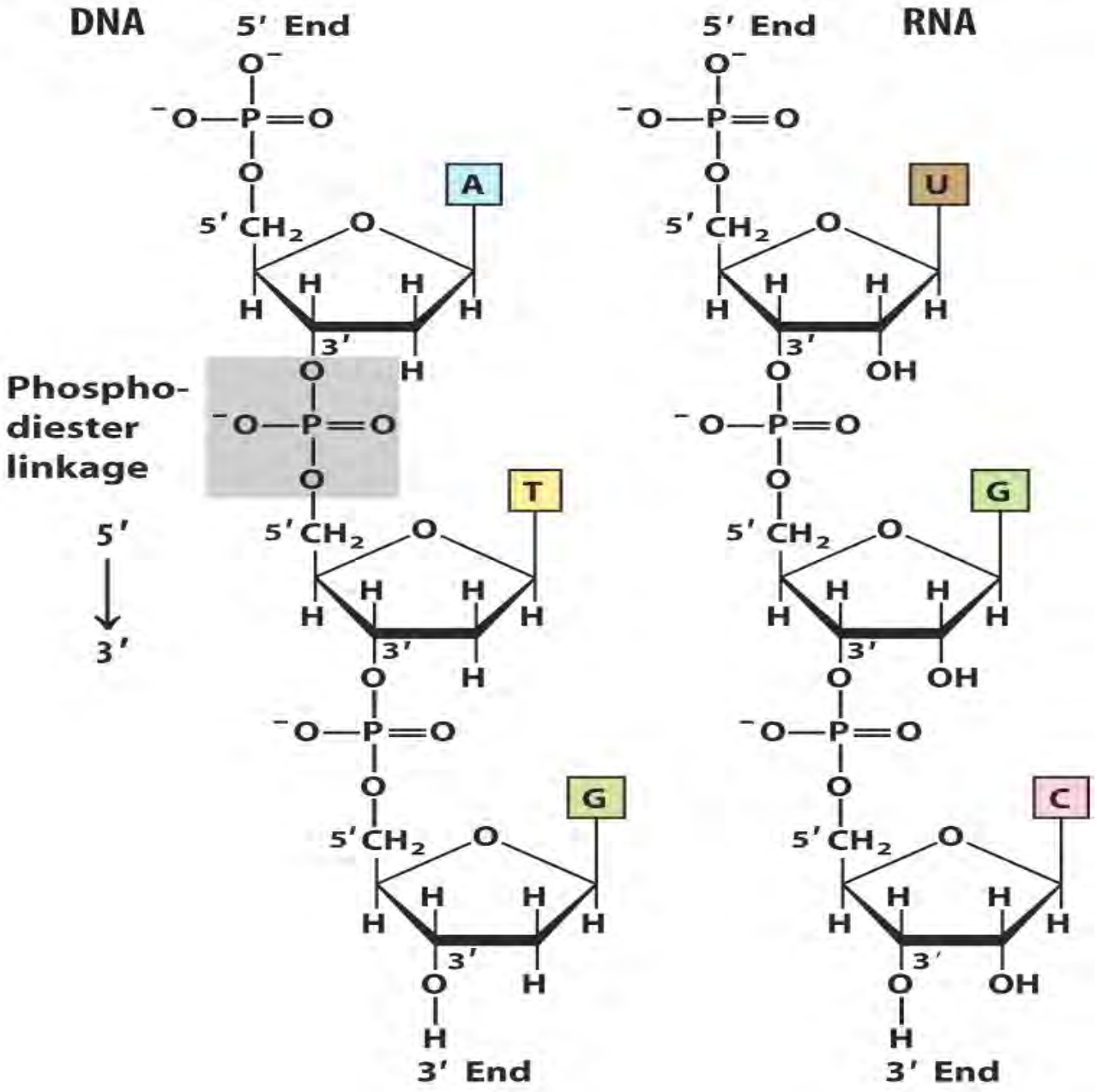
Overview of Biomolecules

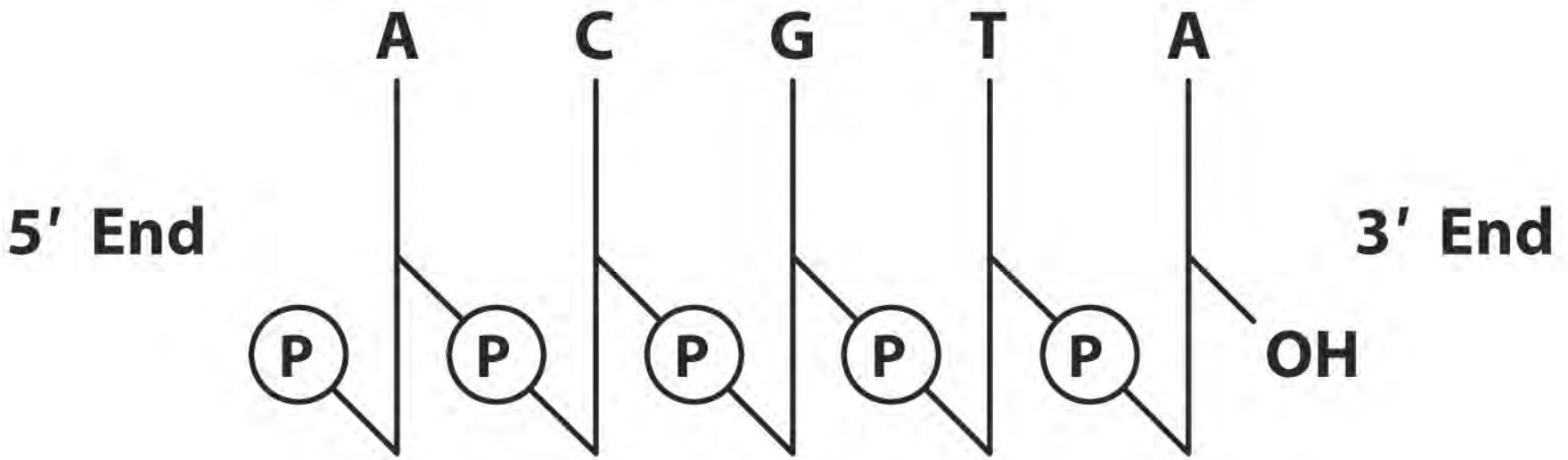
Chapter 10

Nucleic Acids






DNA
5′ End
RNA
5′ End
Phospho-
diester
linkage
5′
3′
A
T
G
G
U
G
C
3′ End
3′ End


A
C
G
T
A
5′ End
3′ End
P
P
P
P
P
OH

DNA vs RNA

DNA	RNA
deoxyribose	ribose
A, C, G, T	A, C, G, U
$10^3 – 10^8$ nucleotides	$10^2 – 10^4$ nucleotides
nucleus	cytoplasm
double-stranded	single-stranded
one type/ 1-2 copies	many types/ many copies
permanent	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.**



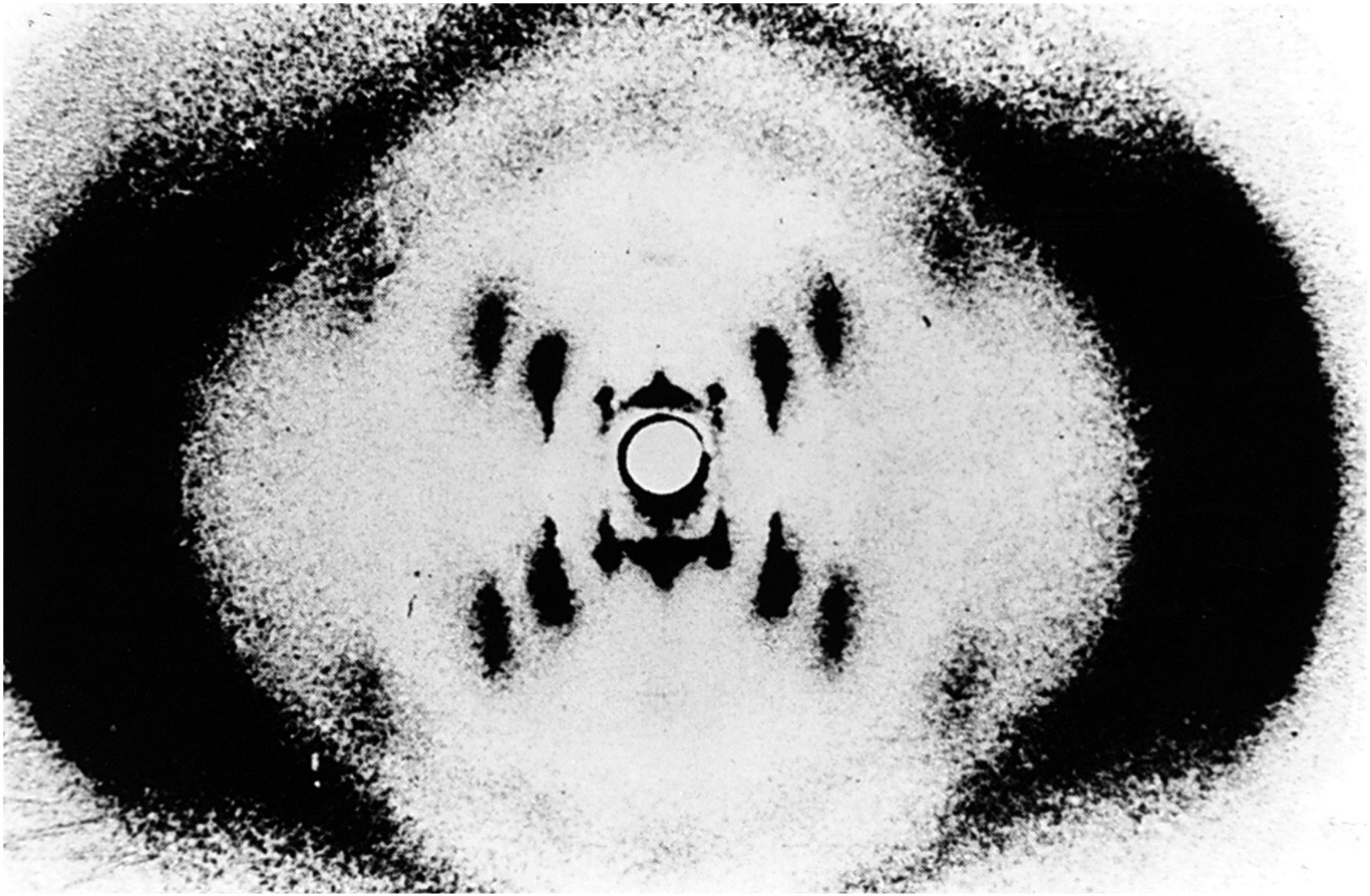
Are You Getting It??

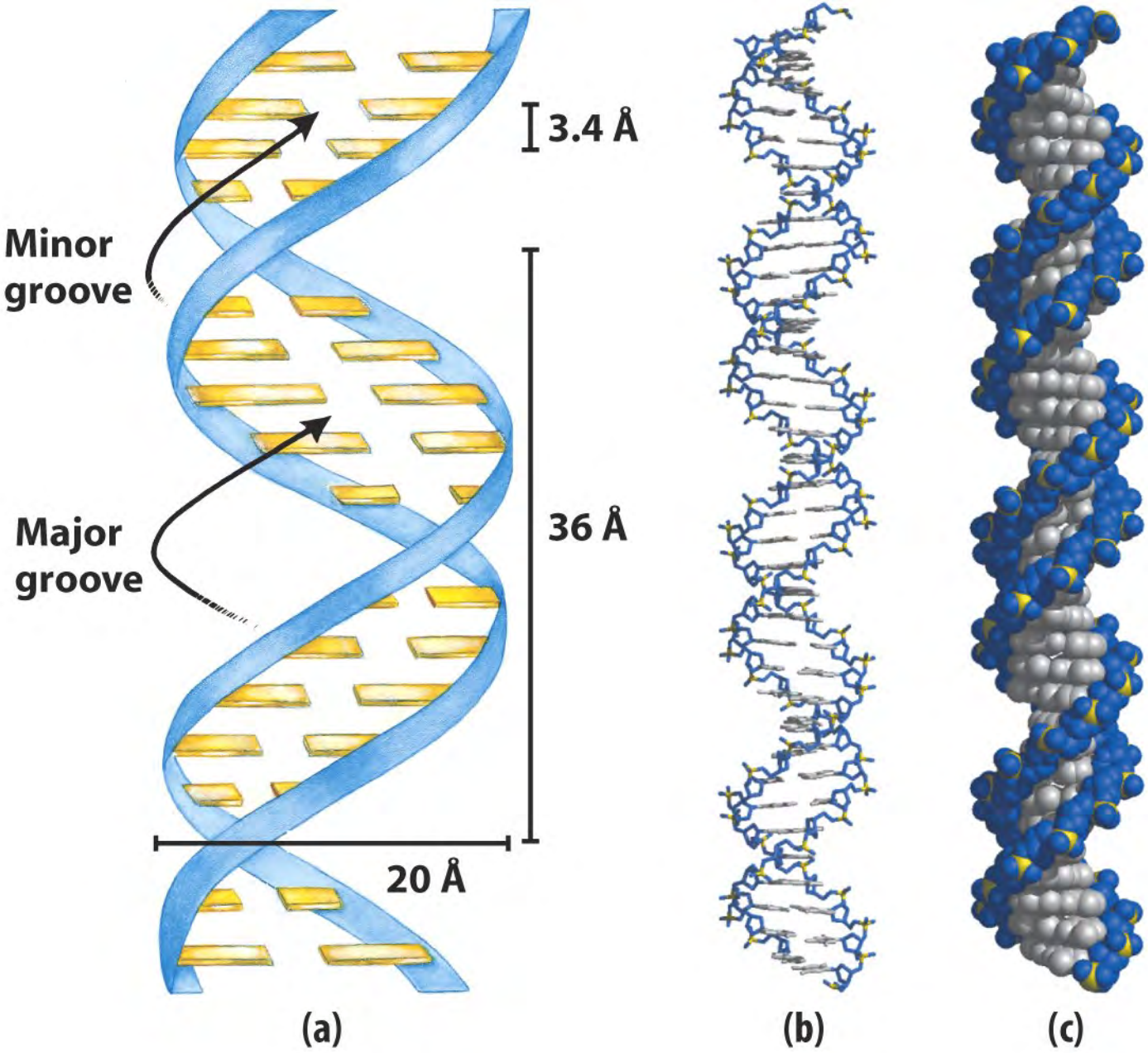


Answer

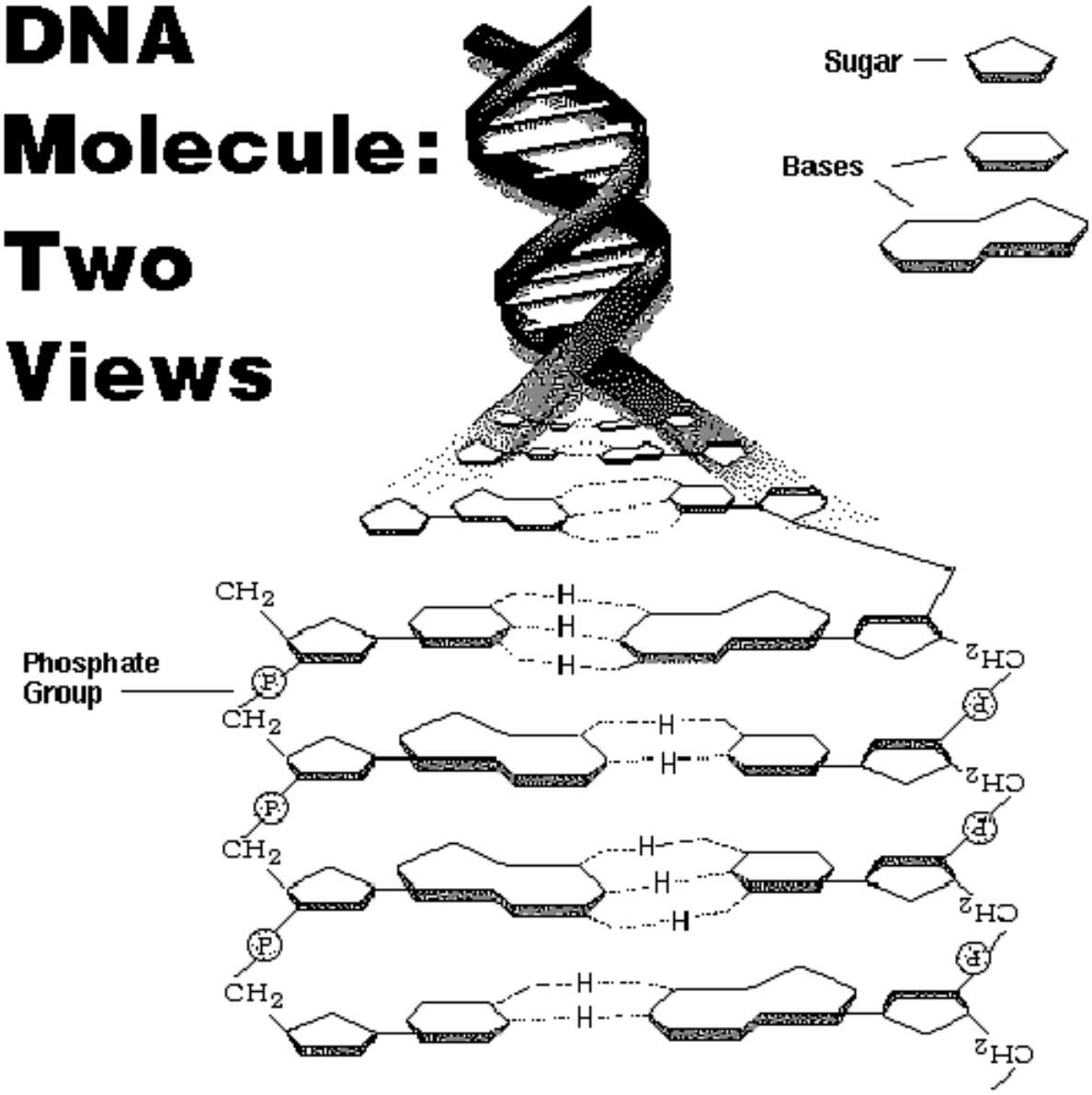
Which properties are shared by DNA and RNA?

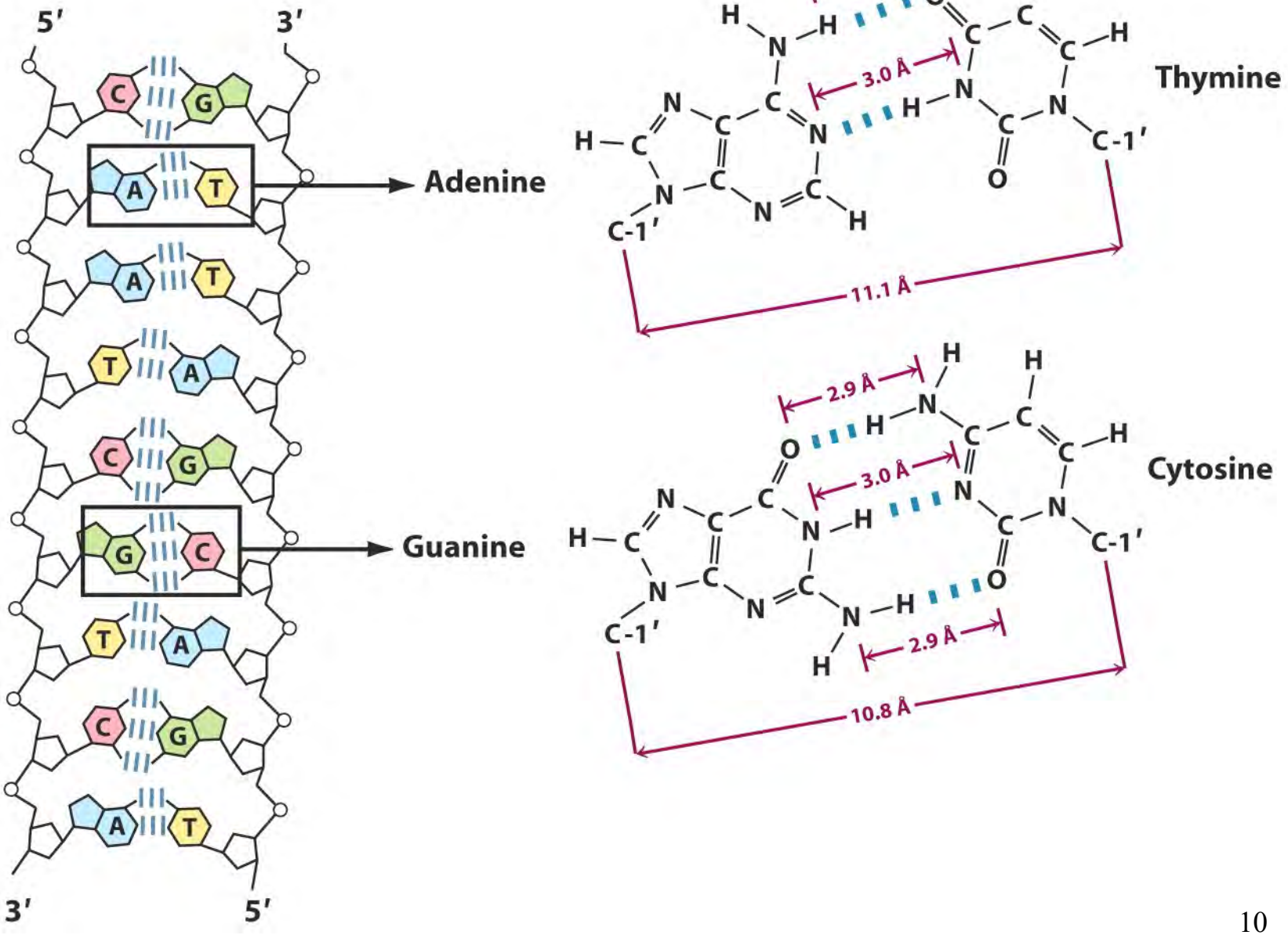
a) **Both contain the same sugar.**
b) ***Both contain the same purines.***
c) **Both contain the same pyrimidines.**
d) ***Both are negatively charged in the cell.***
e) ***Both contain phosphodiester bonds.***
f) ***Both have a sugar-phosphate backbone.***

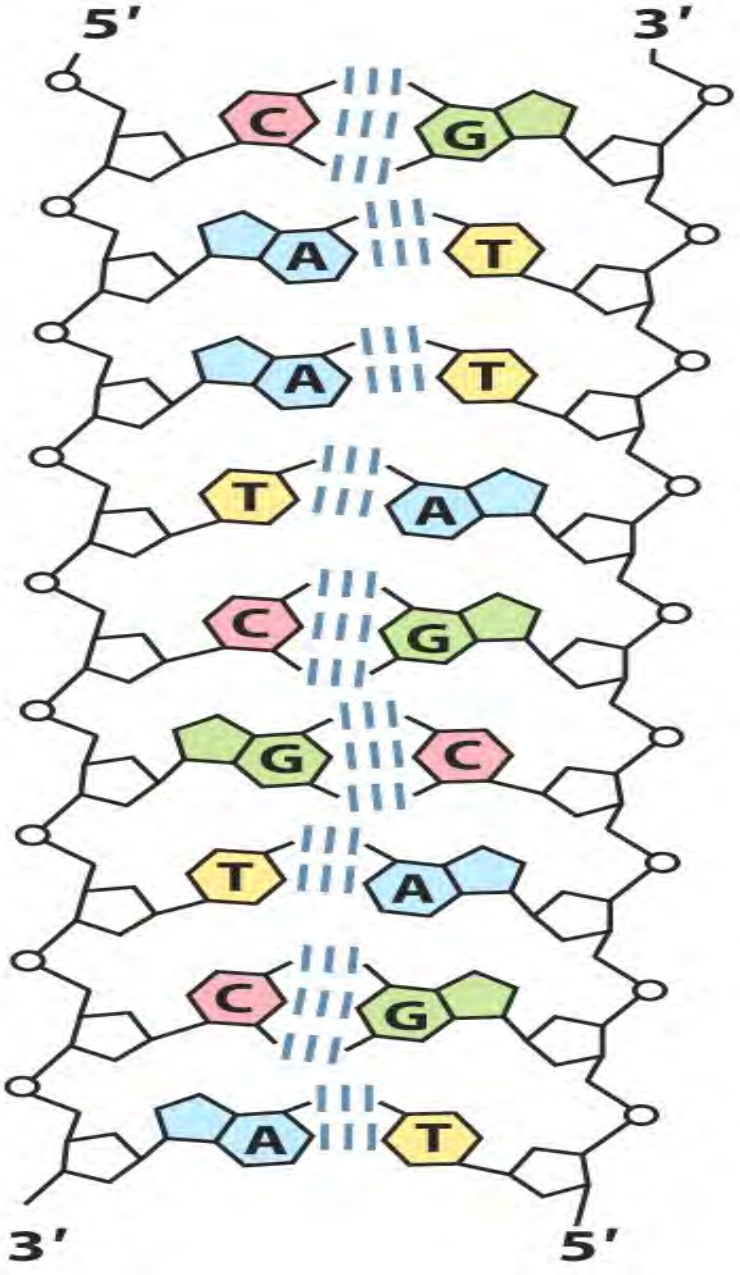



3.4 Å
Minor groove
Major groove
36 Å
20 Å
(a)
(b)
(c)

DNA Molecule: Two Views




5′
3′
C
G
A
T
Adenine
Guanine
3′
5′
2.8 Å
3.0 Å
11.1 Å
CH3
Thymine
C-1′
2.9 Å
3.0 Å
2.9 Å
10.8 Å
Cytosine


5′
3′
C
G
A
T
A
T
T
A
C
G
G
C
T
A
C
G
A
T
3′
5′



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

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

a) The complementary strand is 5'TTAAGGCCTTAAGG3'.

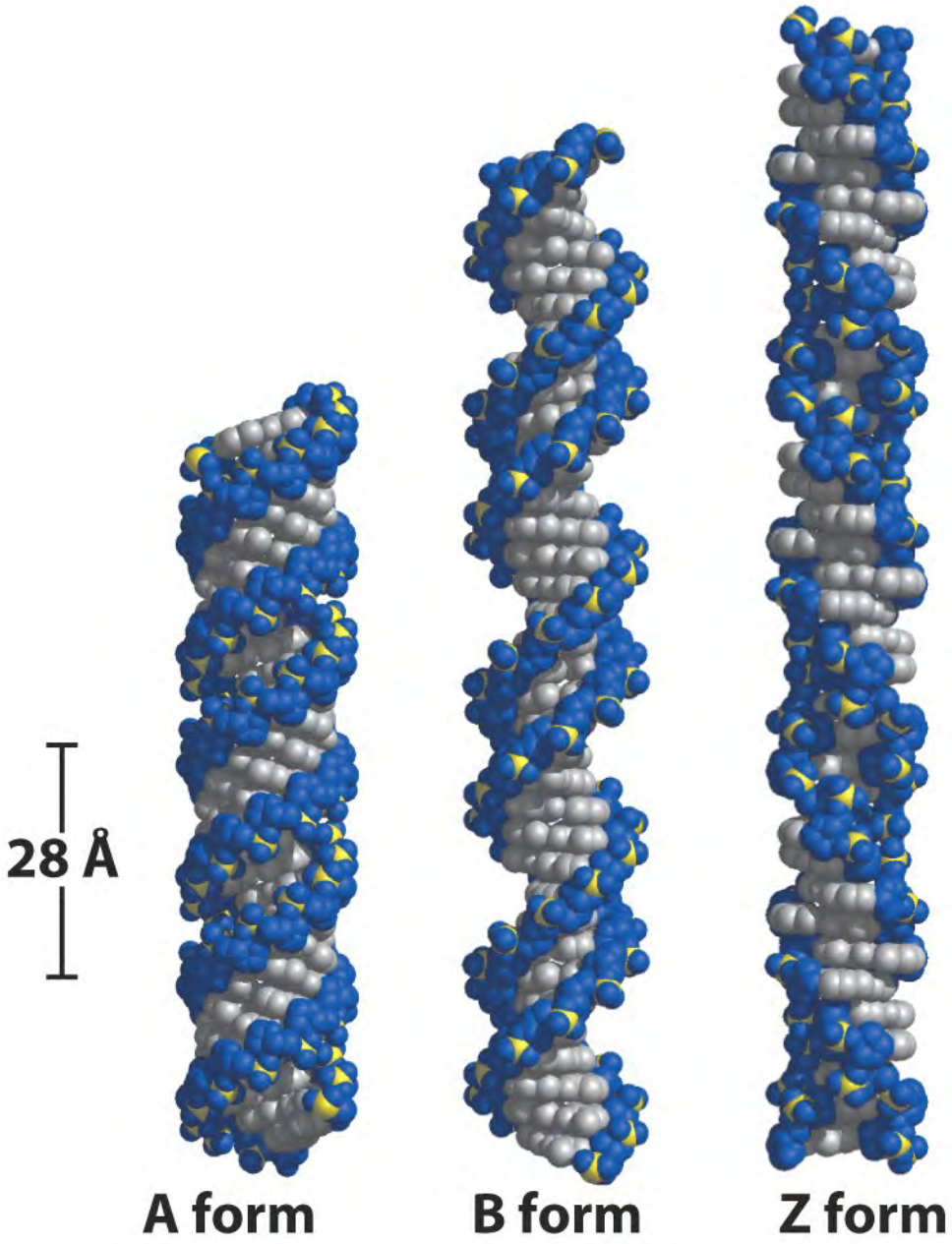
b) *The complementary strand is 5'GGAATTCCGGAATT3'.*

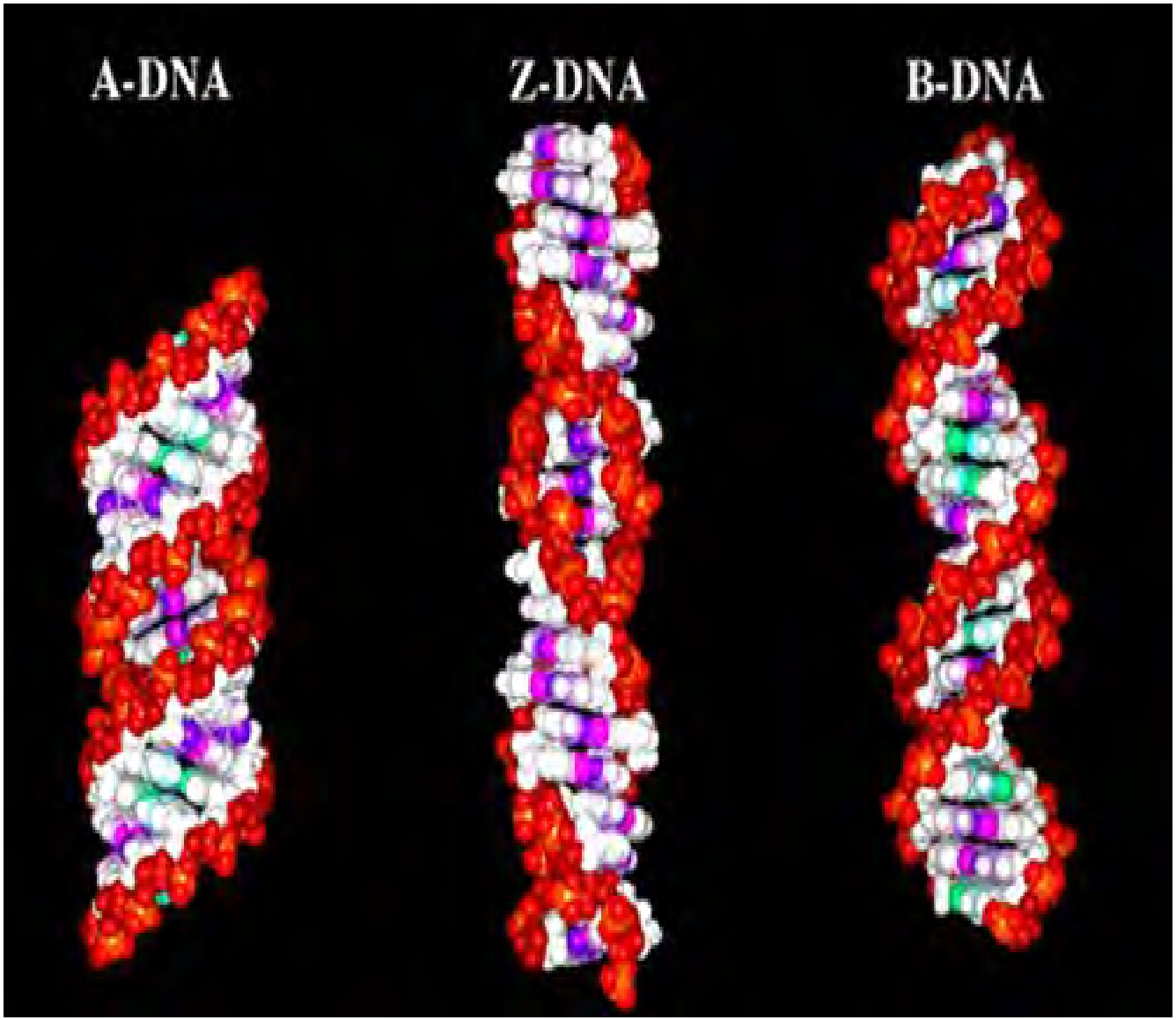
c) *A more stable helix is formed by 5'CCGGCCAATTGGCC3'.*

d) A more stable helix is formed by 5'AATTAAGGAATTAA3'.

e) The helix can be either left-handed or right-handed.

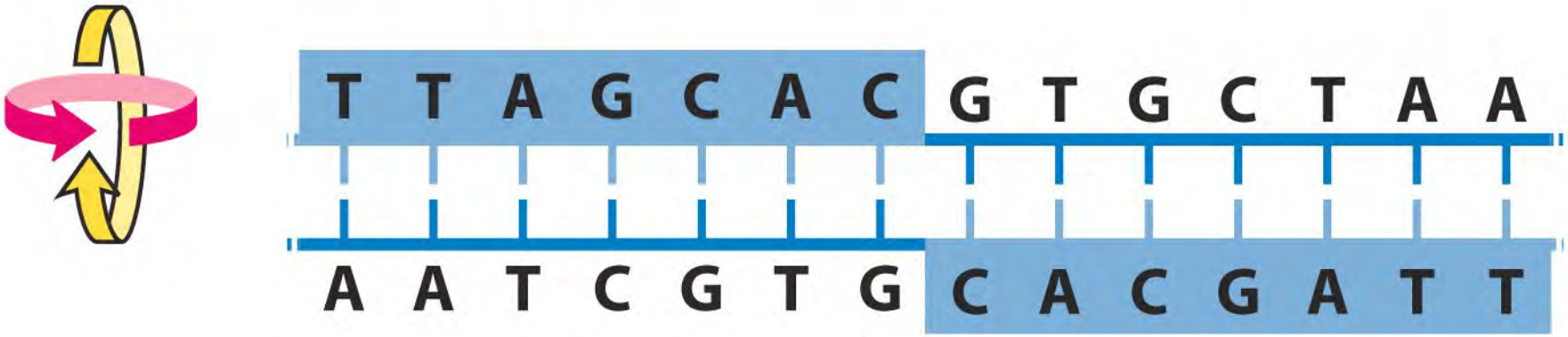
f) *The helix has both hydrophilic parts and hydrophobic parts.*


28 Å
A form
B form
Z form

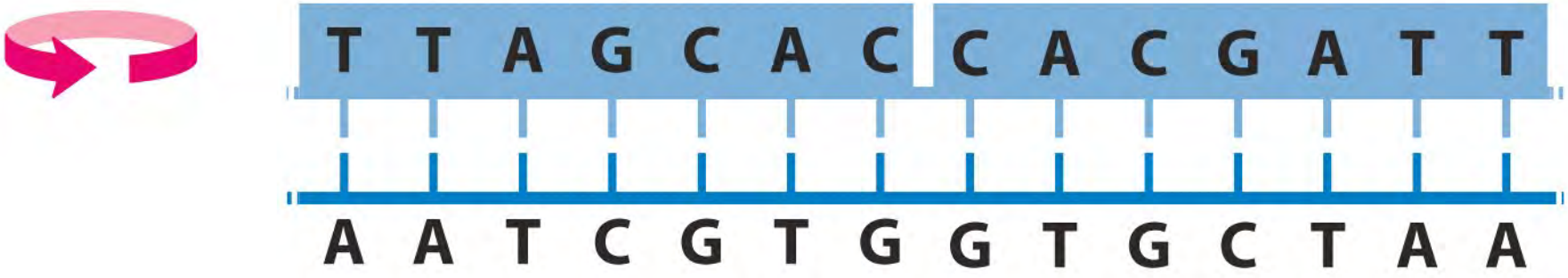

A-DNA
Z-DNA
B-DNA

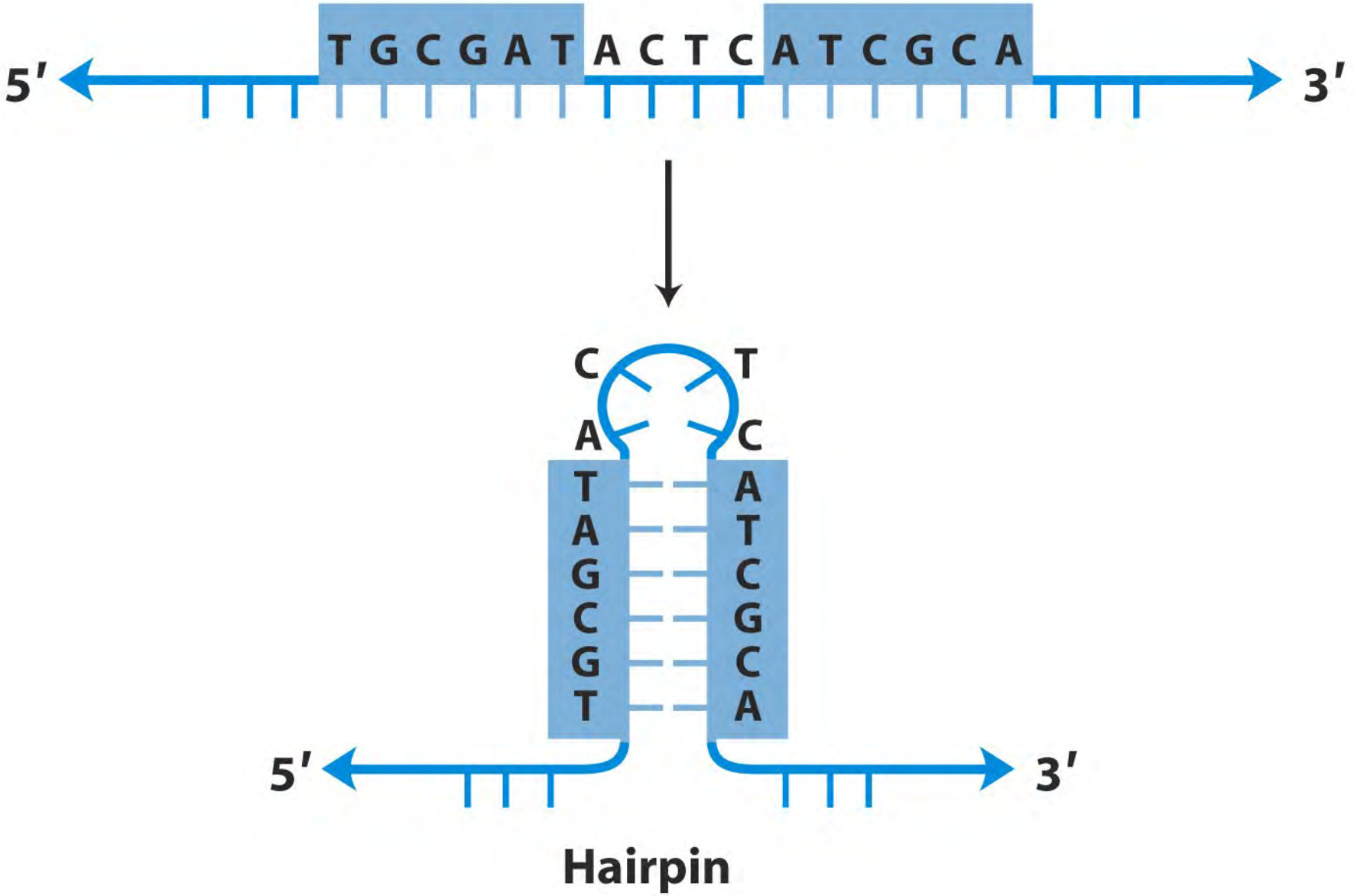
	A form	*B form*	*Z form*
Helical sense	Right handed	Right handed	Left handed
Diameter	~26 Å	~20 Å	~18 Å
Base pairs per helical turn	11	10.5	12
Helix rise per base pair	2.6 Å	3.4 Å	3.7 Å
Base tilt normal to the helix axis	20°	6°	7°
Sugar pucker conformation	C-3′ endo	C-2′ endo	C-2′ endo for pyrimidines;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

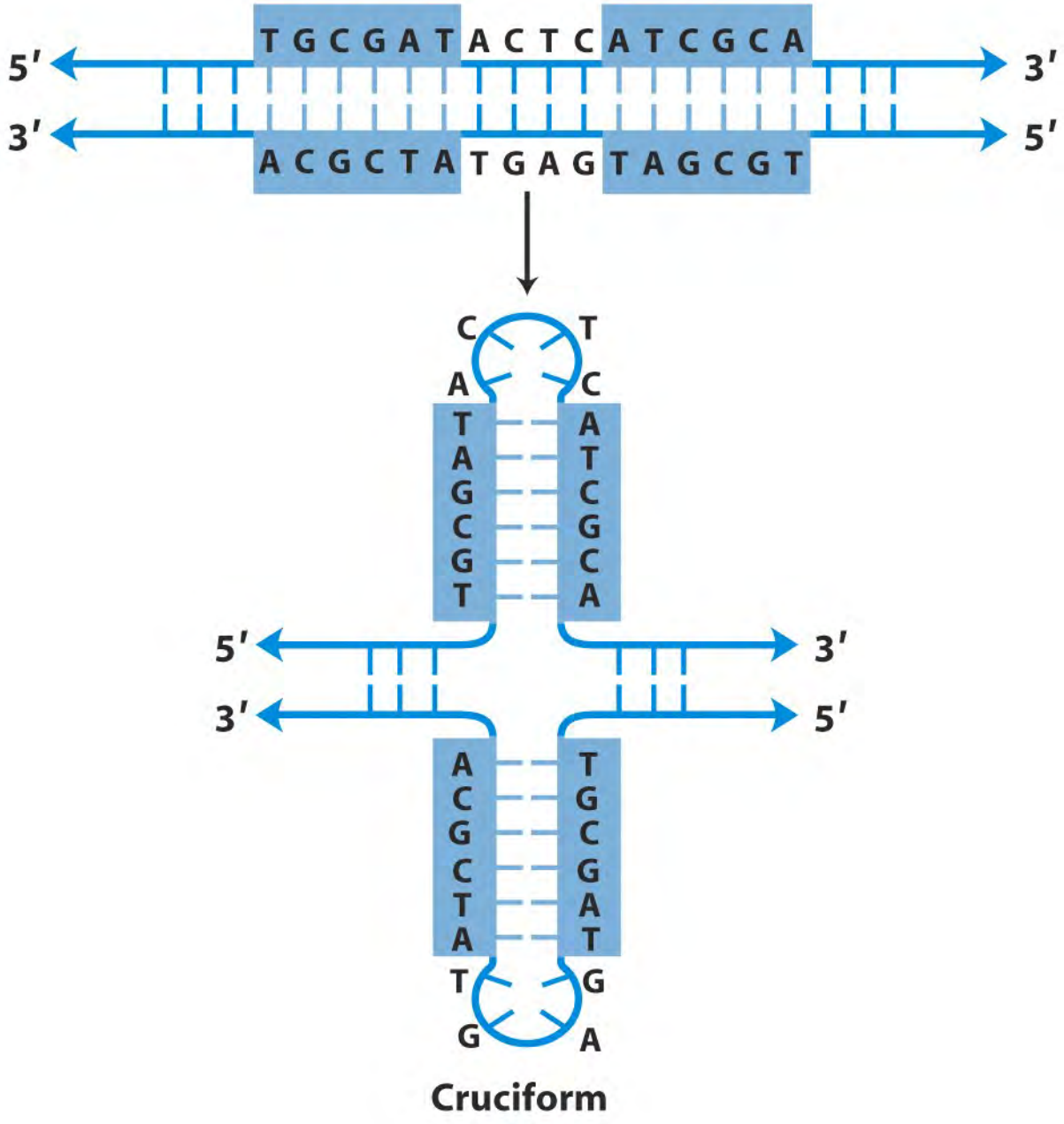
Palindrome



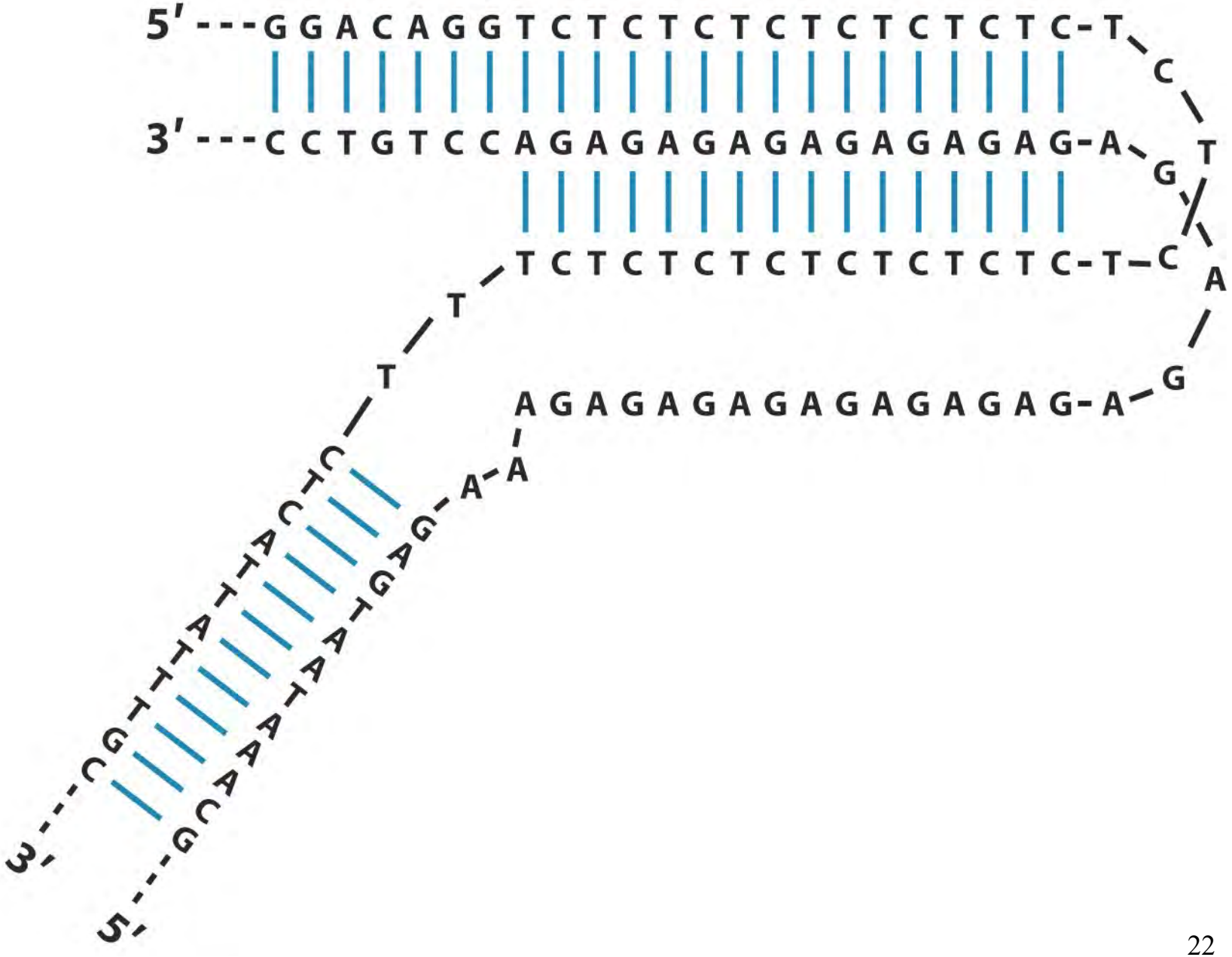
Mirror repeat

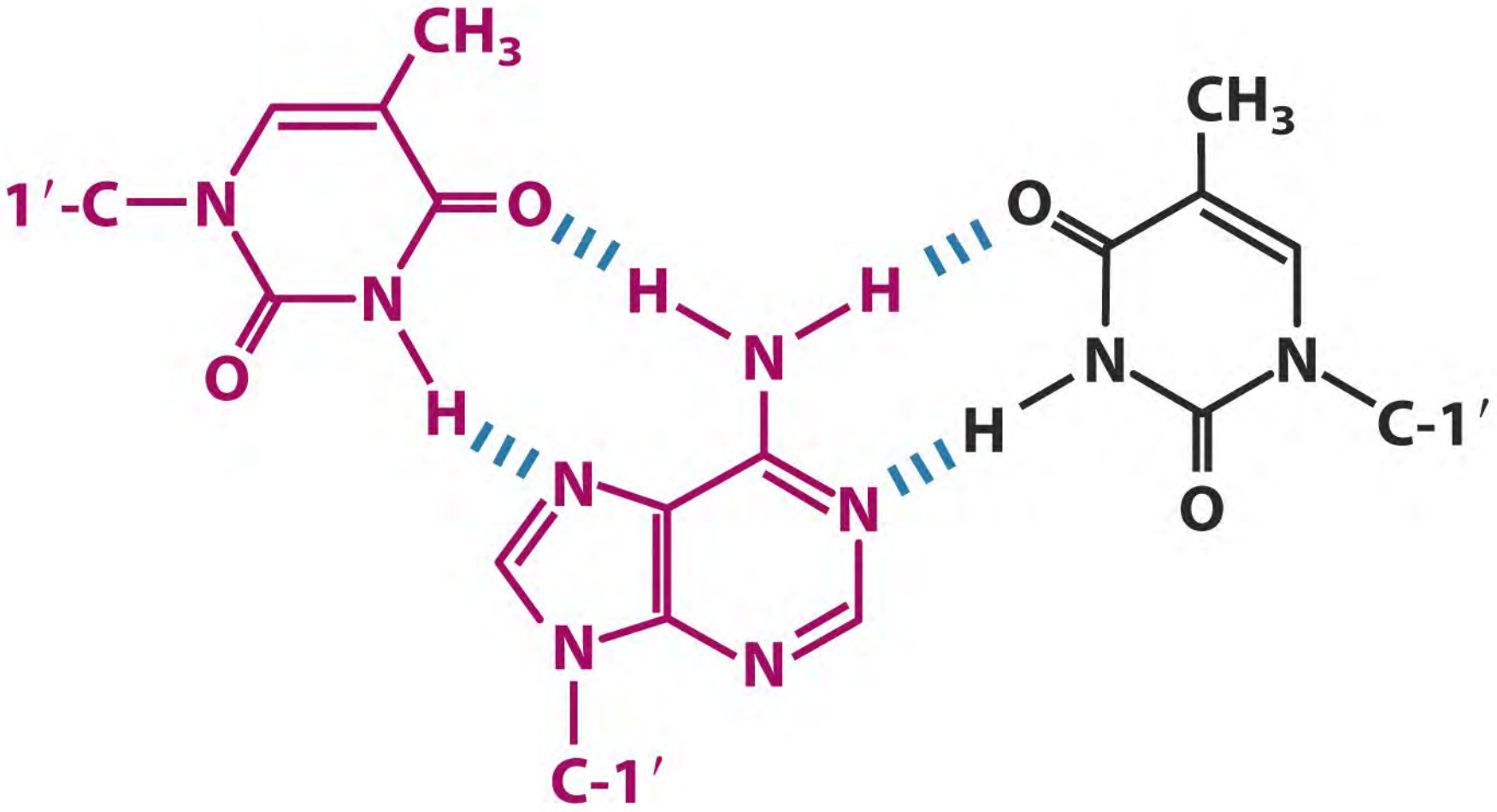



5′
T G C G A T A C T C A T C G C A
3′
C
T
A
C
T
A
G
C
G
T
A
T
C
G
C
A
5′
3′
Hairpin

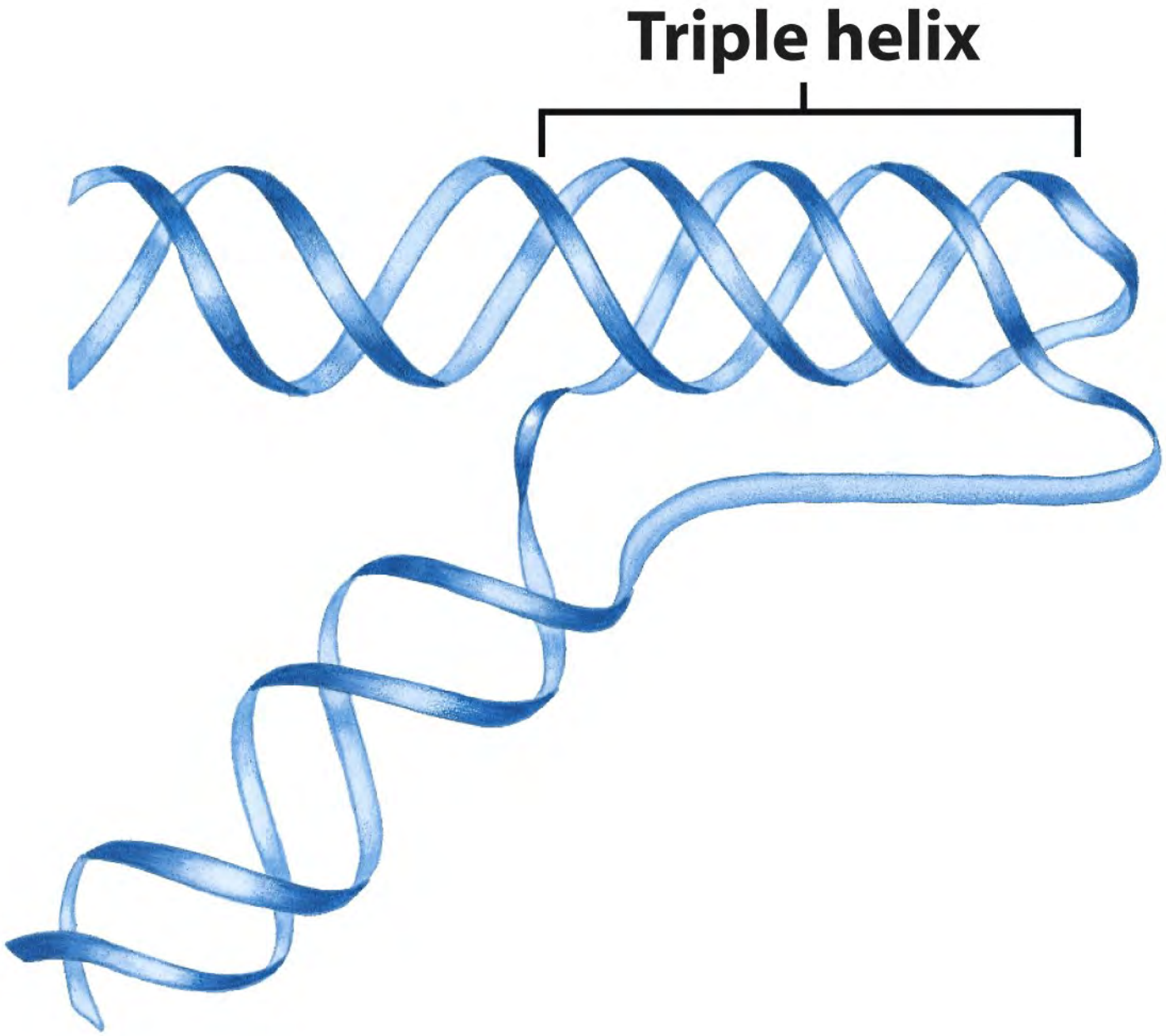

5′
3′
T G C G A T A C T C A T C G C A
A C G C T A T G A G T A G C G T
3′
5′
C
T
A
C
T A G C G T
A T C G C A
5′
3′
3′
5′
A C G C T A
T G C G A T
T
G
G
A

Cruciform


5′---GGACAGGTCTCTCTCTCTCTCTCTC-T
C
T
3′---CCTGTCCAGAGAGAGAGAGAGAGAG-A
G
TCTCTCTCTCTCTCTCTC-T-C
A
T
G
AGAGAGAGAGAGAGAGAG-A
A
3′---
5′---



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.



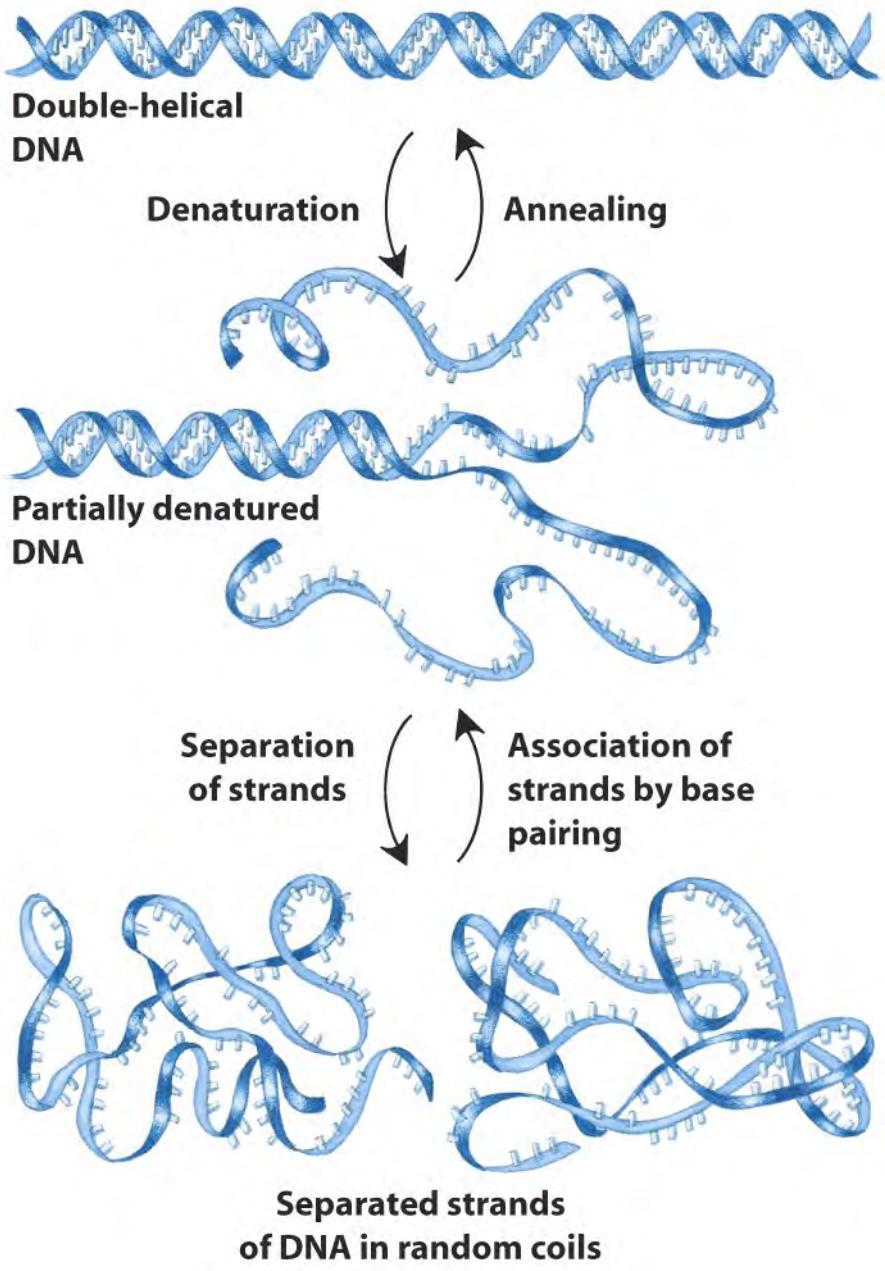
Are You Getting It??

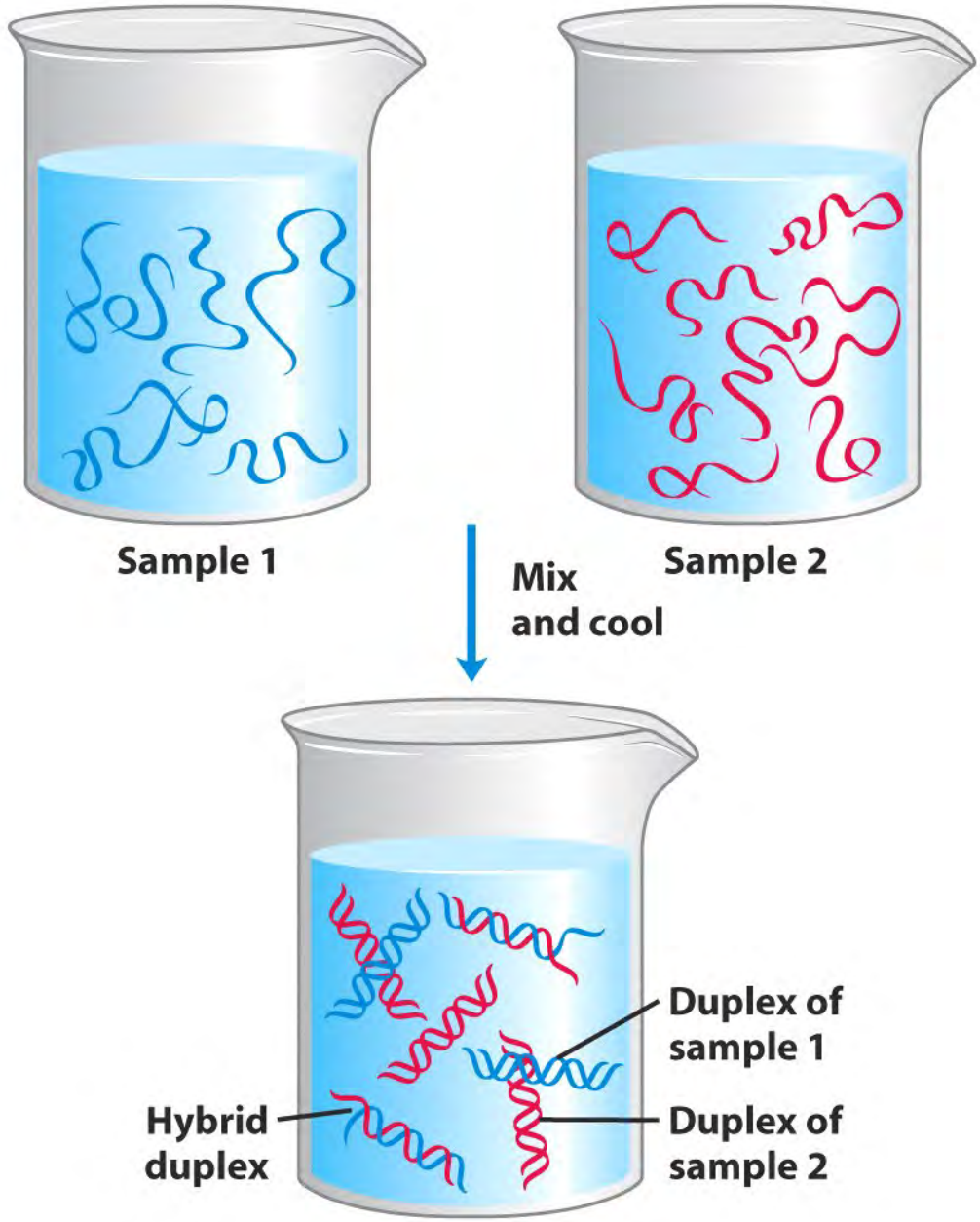


Answer

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


Sample 1
Sample 2
Mix
and cool
Duplex of
sample 1
Hybrid
duplex
Duplex of
sample 2



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??



Answer

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

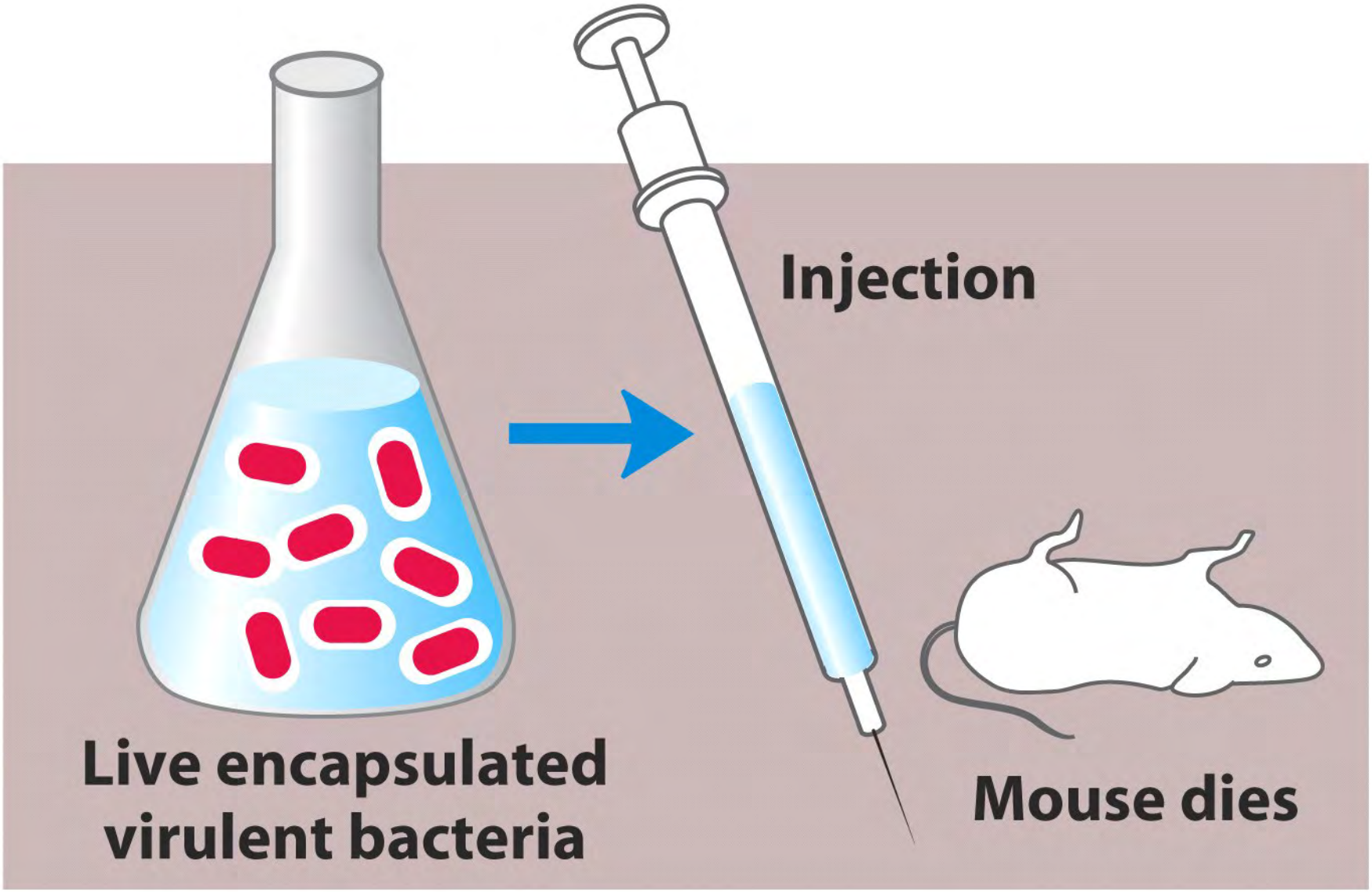
a) They all have the same amount of adenine.

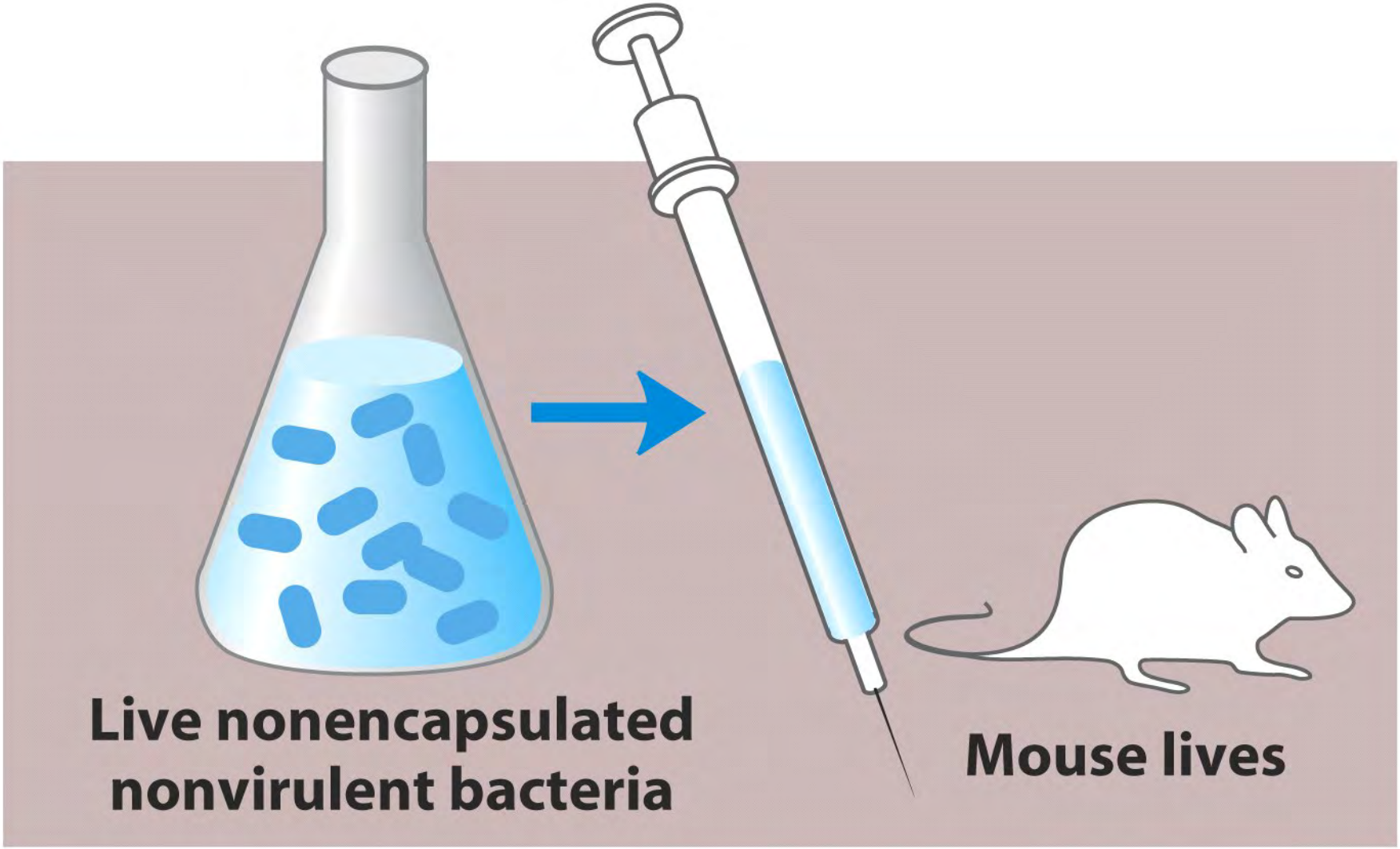
b) ***They all have a base composition where A=T.***

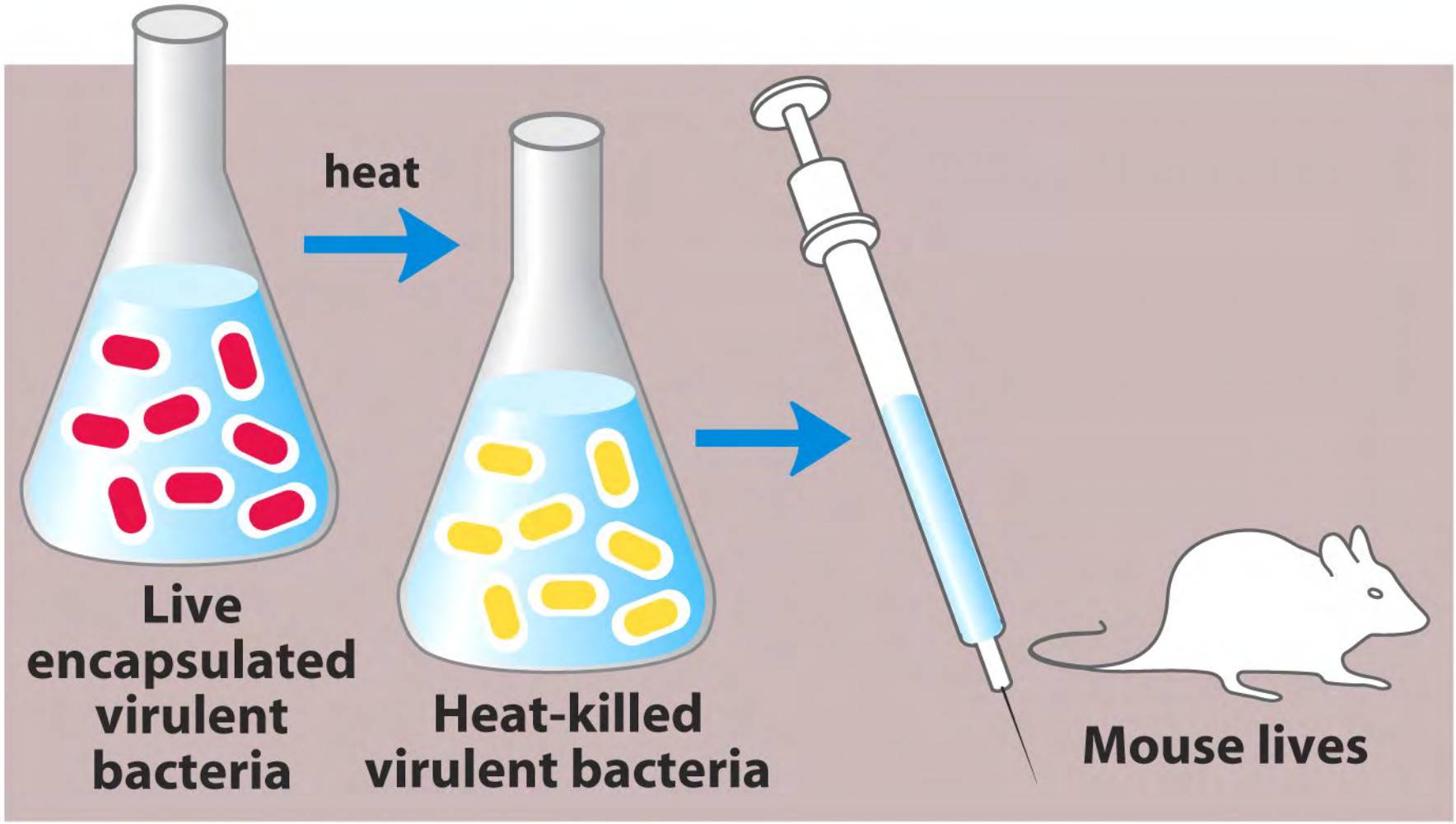
c) ***They all have two strands with complementary sequences.***

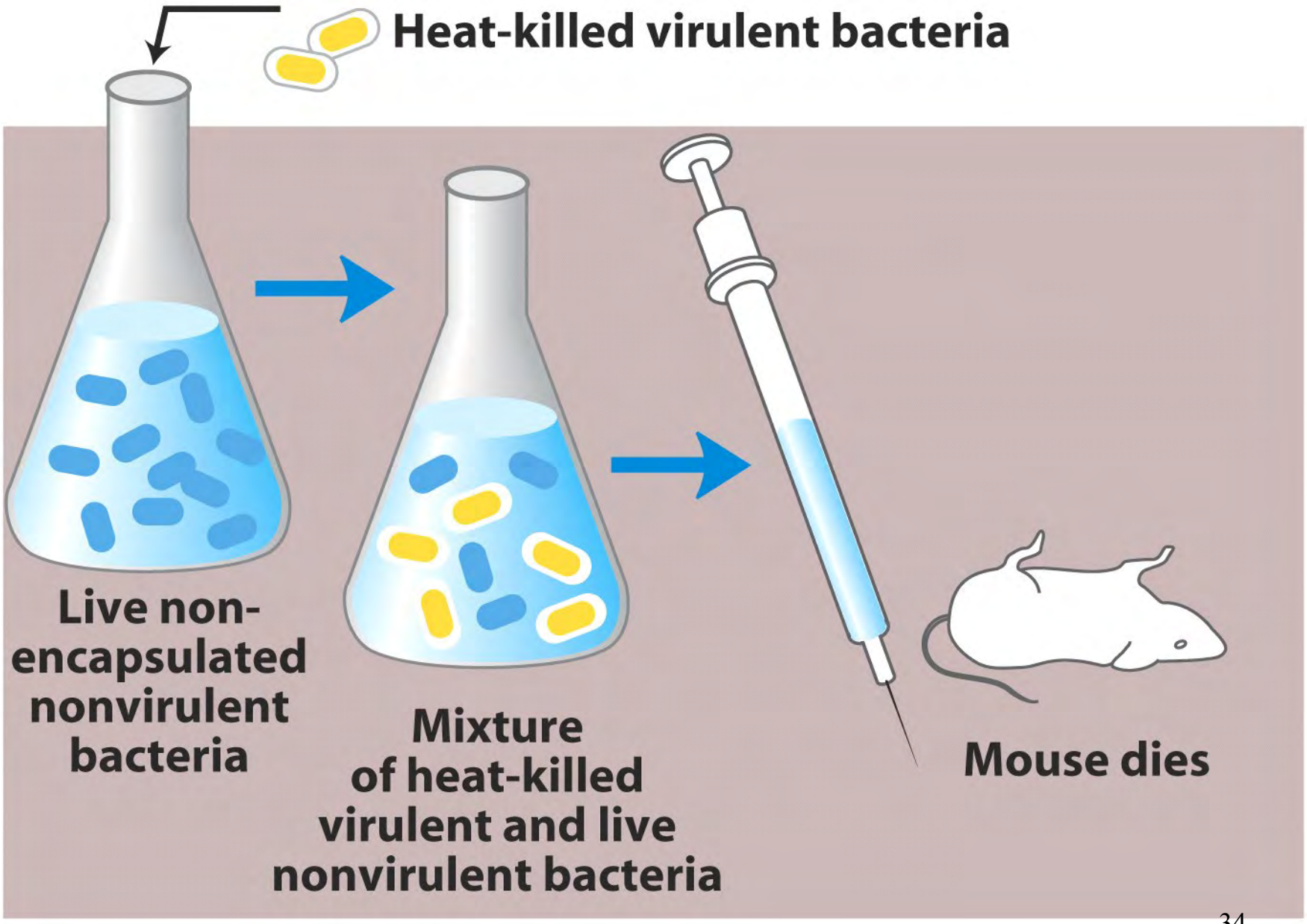
d) They all denature at the same temperature.

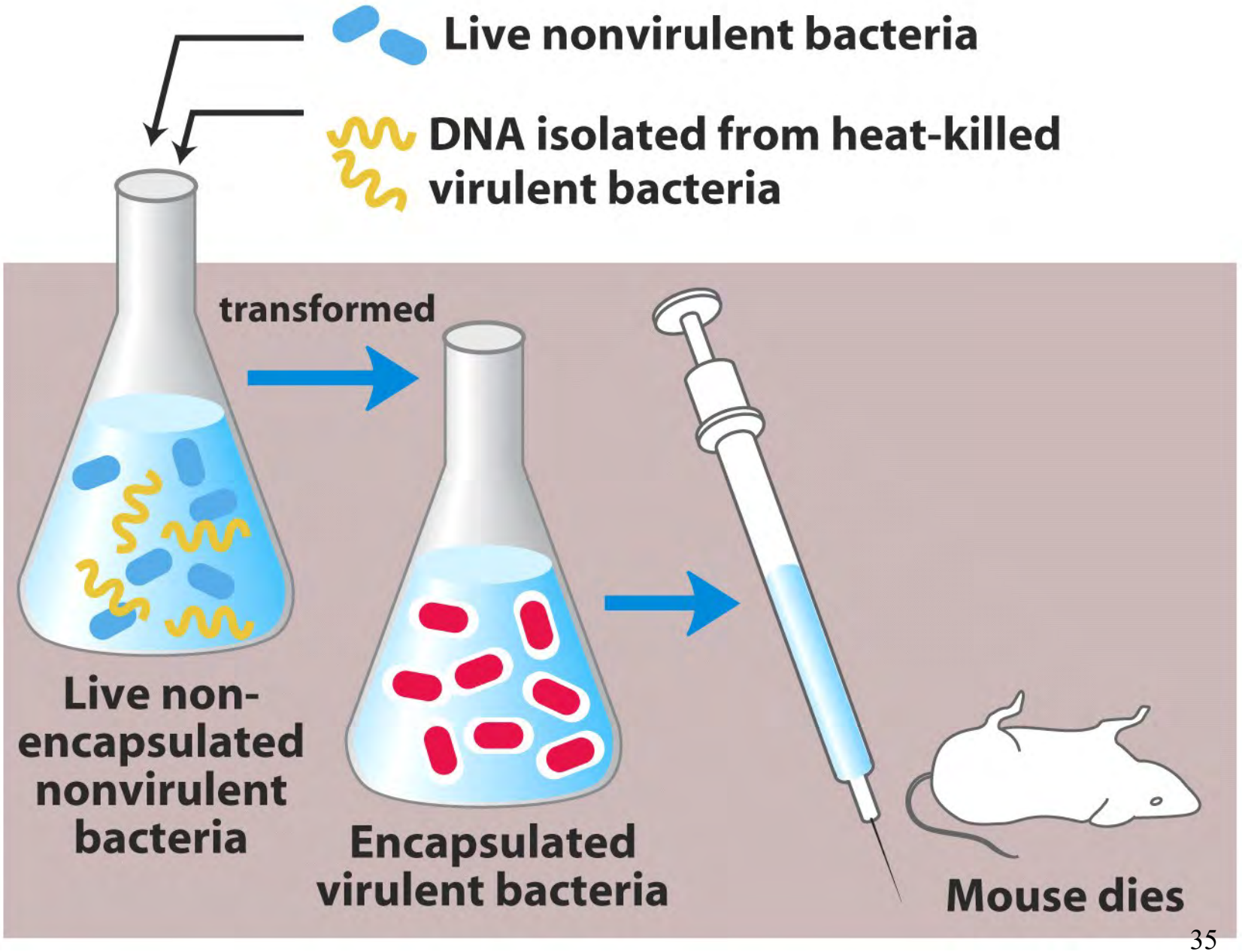
e) They all hybridize at high pH.

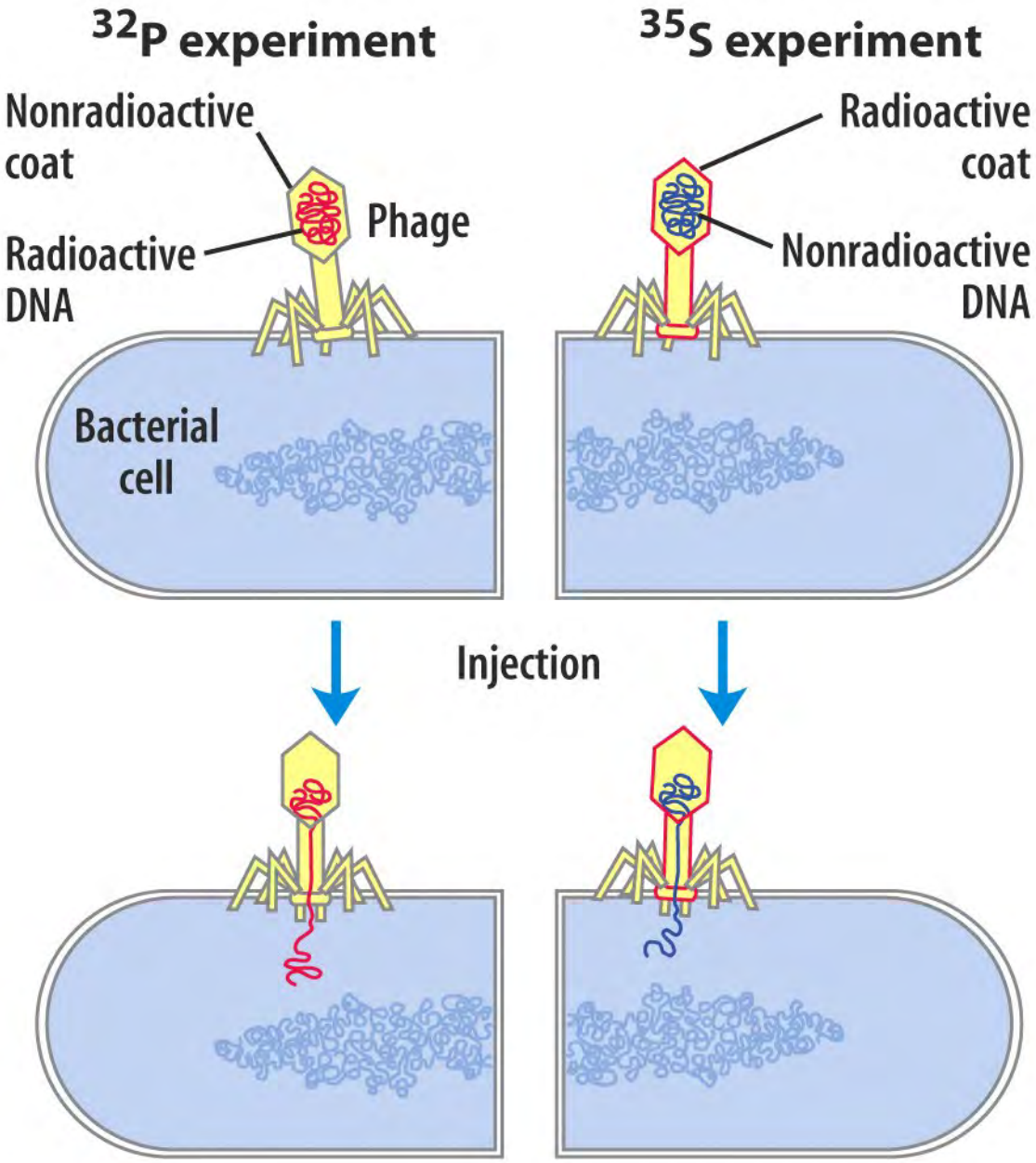

Injection
Live encapsulated virulent bacteria
Mouse dies

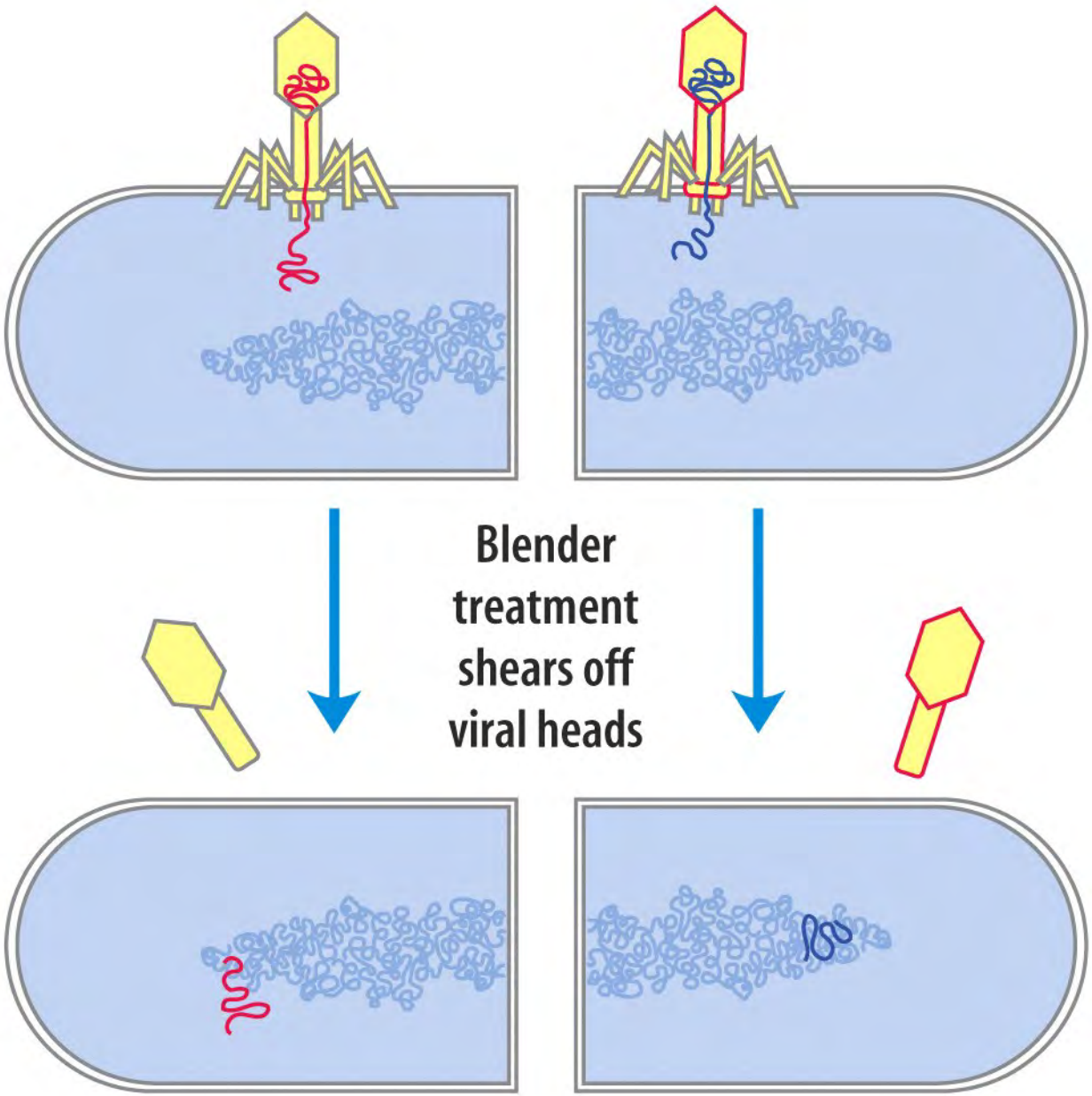

Live nonencapsulated
nonvirulent bacteria
Mouse lives


heat
Live encapsulated virulent bacteria
Heat-killed virulent bacteria
Mouse lives


Heat-killed virulent bacteria
Live non-encapsulated nonvirulent bacteria
Mixture of heat-killed virulent and live nonvirulent bacteria
Mouse dies


Live nonvirulent bacteria
DNA isolated from heat-killed virulent bacteria
transformed
Live non-encapsulated nonvirulent bacteria
Encapsulated virulent bacteria
Mouse dies


^{32}P experiment
^{35}S experiment
Nonradioactive coat
Radioactive DNA
Phage
Radioactive coat
Nonradioactive DNA
Bacterial cell
Injection


Blender
treatment
shears off
viral heads

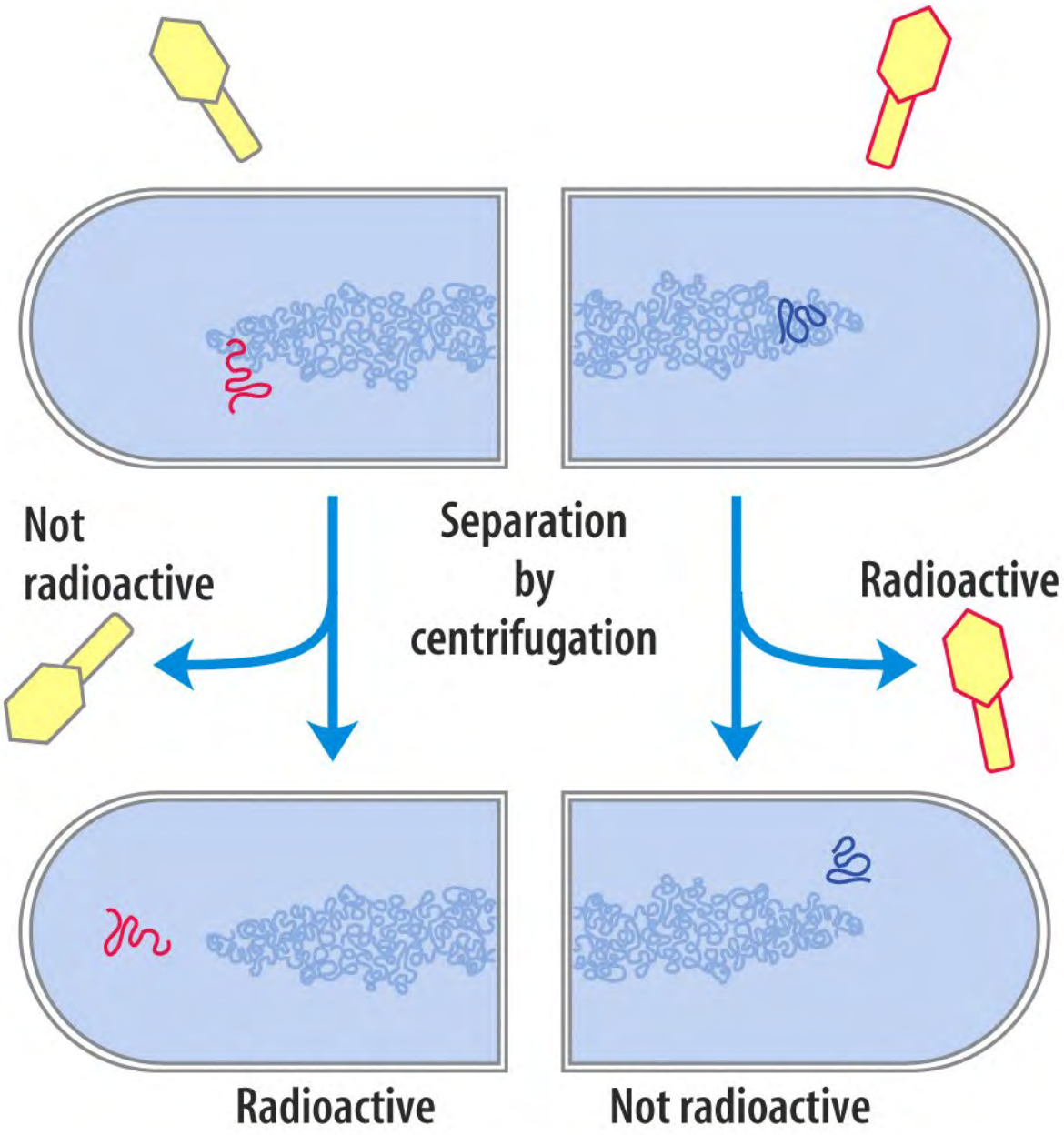

Not
radioactive
Separation
by
centrifugation
Radioactive
Radioactive
Not radioactive

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

Organism	Tissue	Adenine	Thymine	Guanine	Cytosine
Escherichia coli (K12)	—	26.0	23.9	24.9	25.2
Diplococcus pneumoniae	—	29.8	31.6	20.5	18.0
Mycobacterium tuberculosis	—	15.1	14.6	34.9	35.4
Yeast	—	31.3	32.9	18.7	17.1
Paracentrotus lividus (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)

Virus	*Size of viral DNA (bp)*	*Length of viral DNA (nm)*	*Long dimension of viral particle (nm)*
ϕX174	5,386	1,939	25
T7	39,936	14,377	78
λ (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).

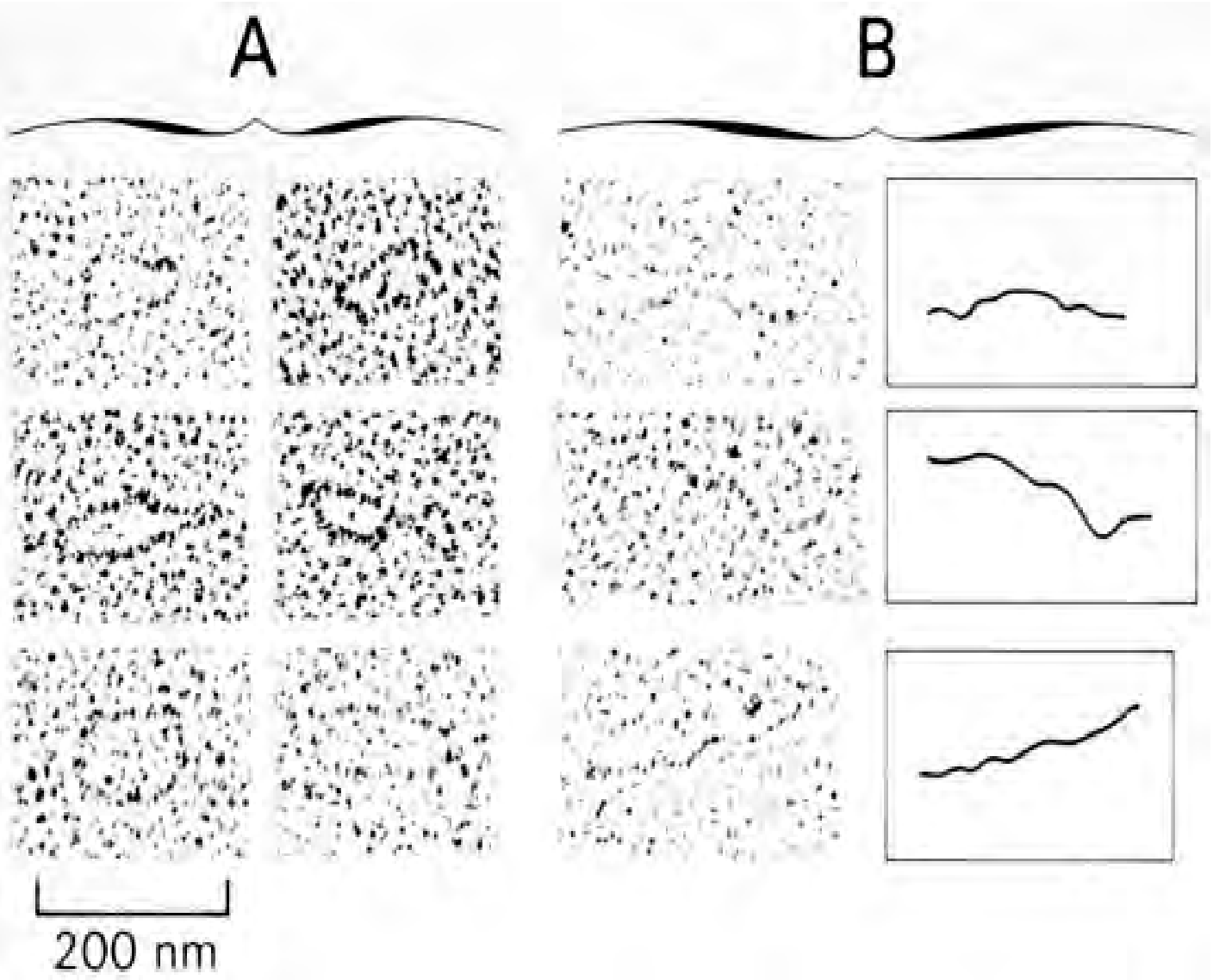

A
B
200 nm

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

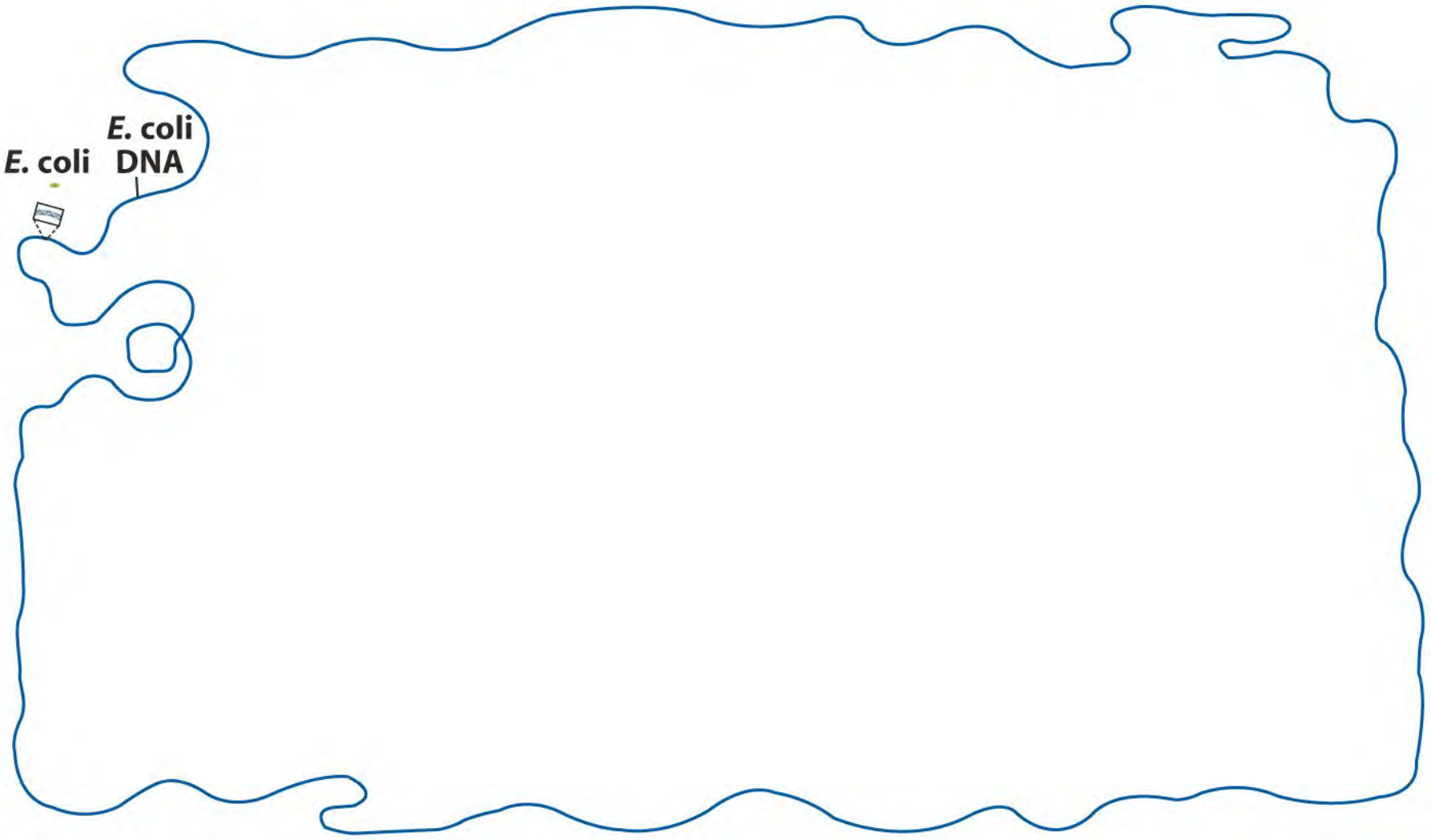
	Total DNA (bp)	*Number of chromosomes*[*]	*Approximate number of genes*
Bacterium (*Escherichia coli*)	4,639,221	1	4,405
Yeast (*Saccharomyces cerevisiae*)	12,068,000	16[†]	6,200
Nematode (*Caenorhabditis elegans*)	97,000,000	12[‡]	19,000
Plant (*Arabidopsis thaliana*)	125,000,000	10	25,500
Fruit fly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

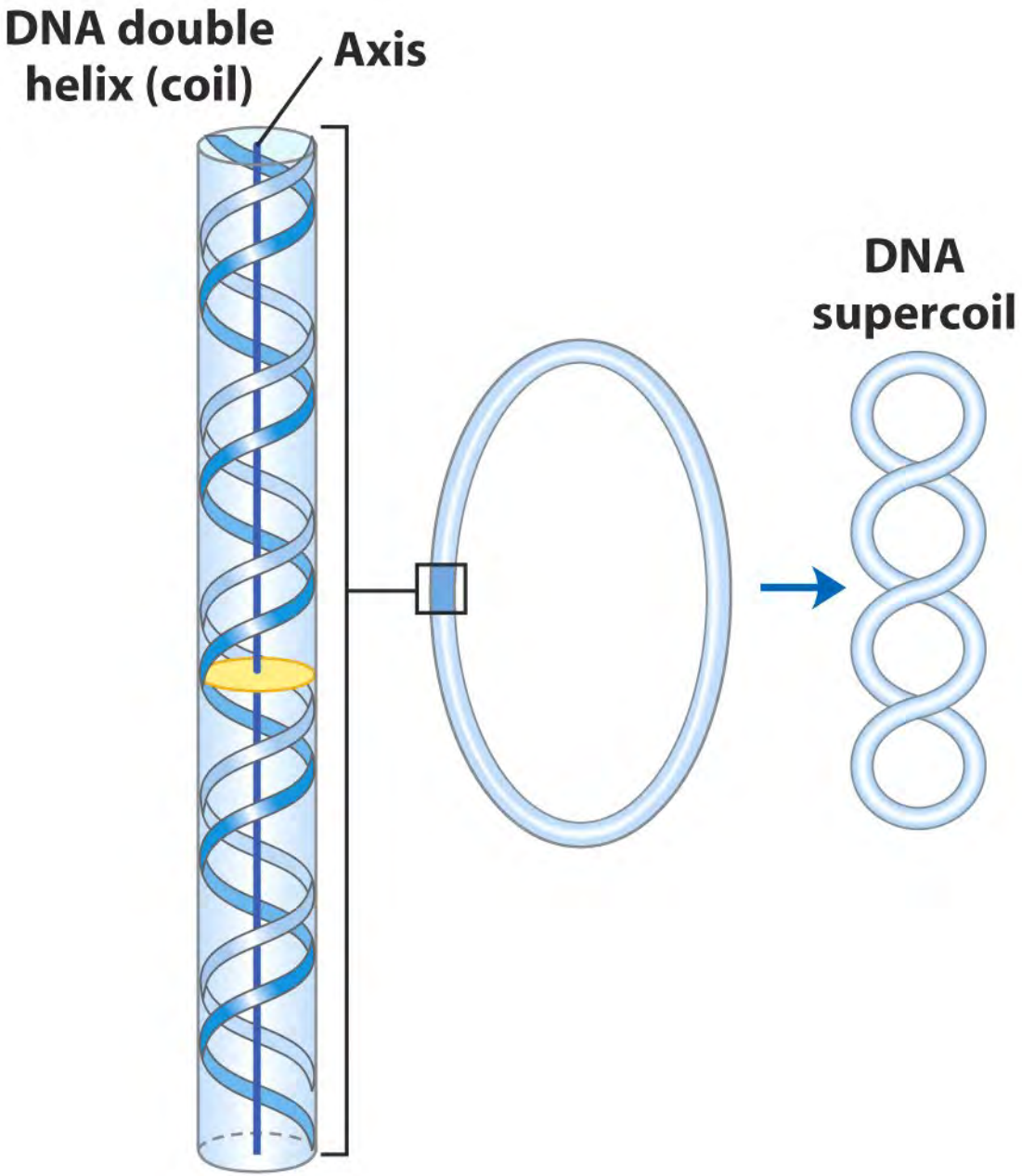
Note: This information is constantly being refined. For the most current information, consult the websites for the individual genome projects.

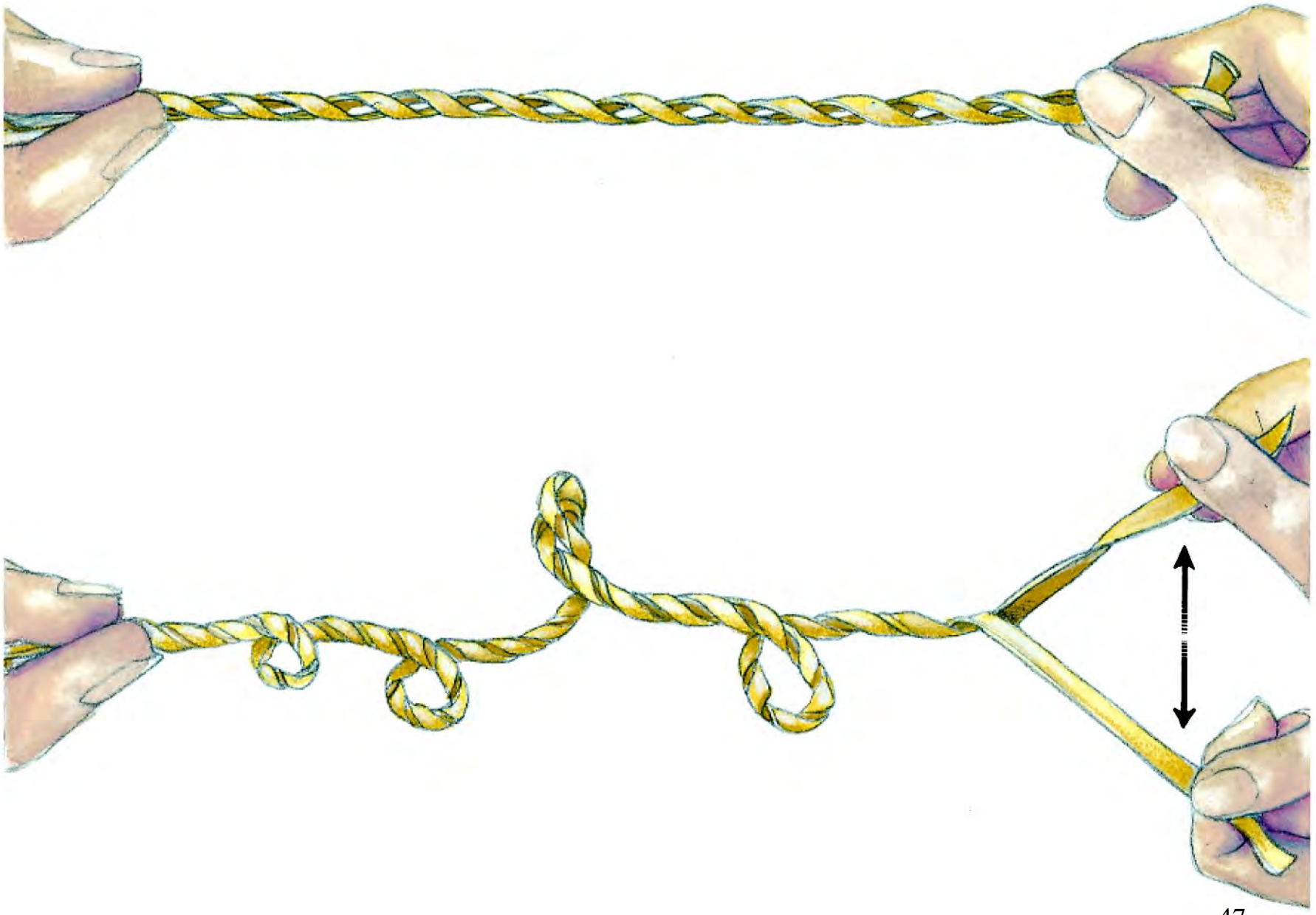
[*]The diploid chromosome number is given for all eukaryotes except yeast.

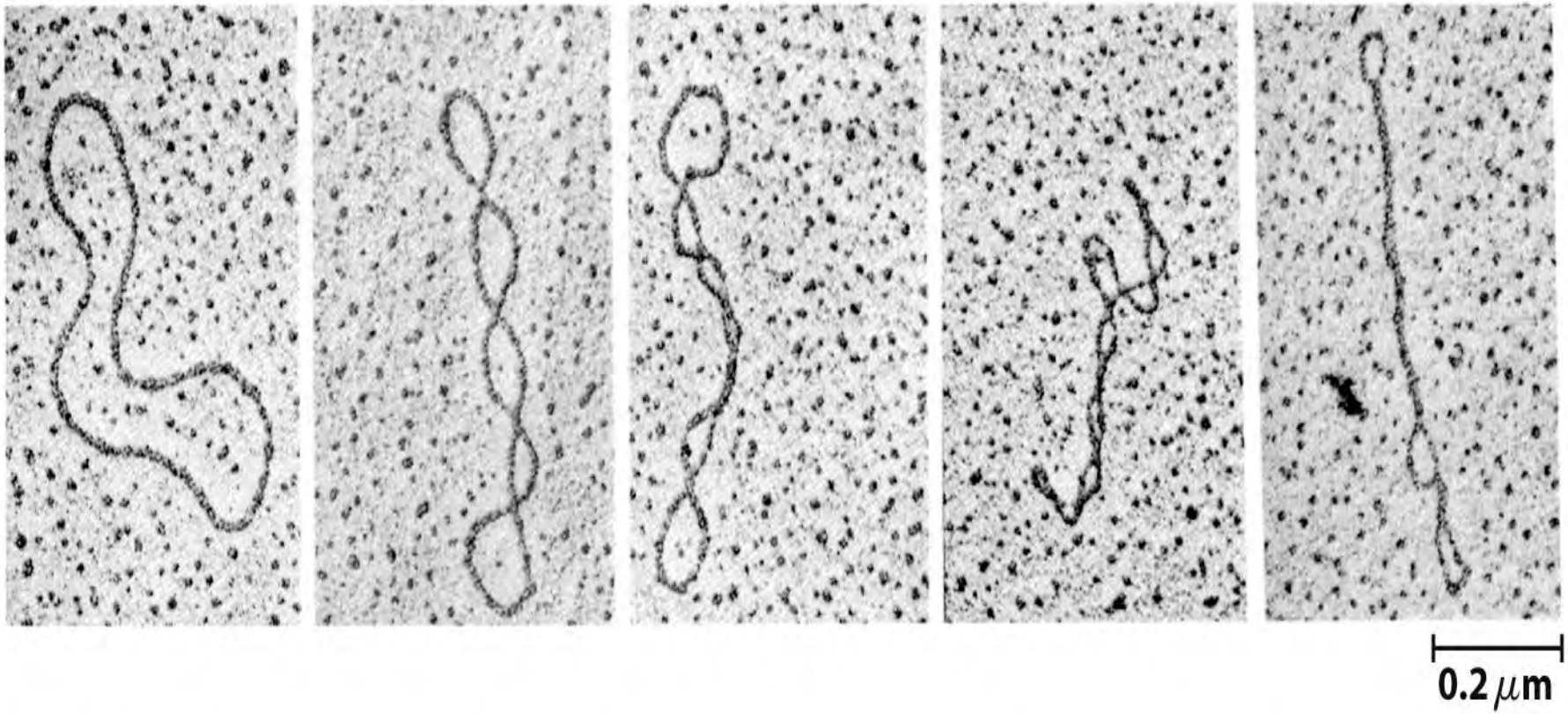
[†]Haploid chromosome number. Wild yeast strains generally have eight (octoploid) or more sets of these chromosomes.

[‡]Number for females, with two X chromosomes. Males have an X but no Y, thus 11 chromosomes in all.


E. coli
E. coli
DNA


DNA double helix (coil)
Axis
DNA supercoil




0.2 μm



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*

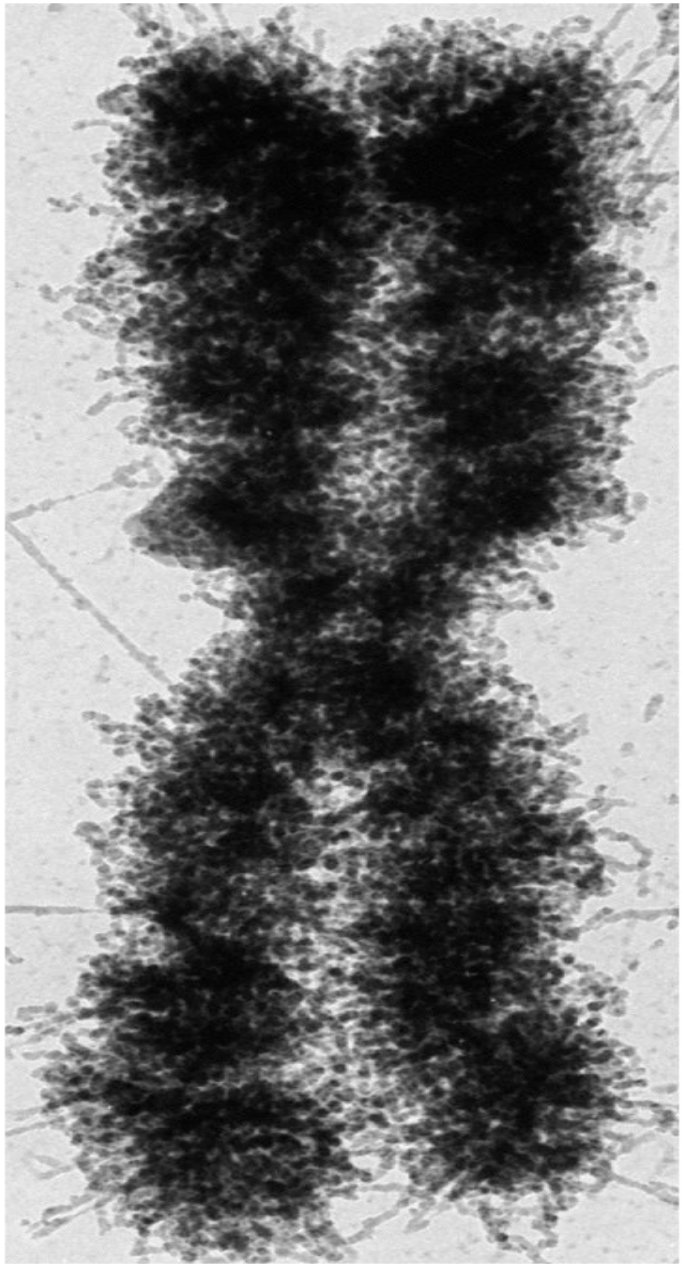
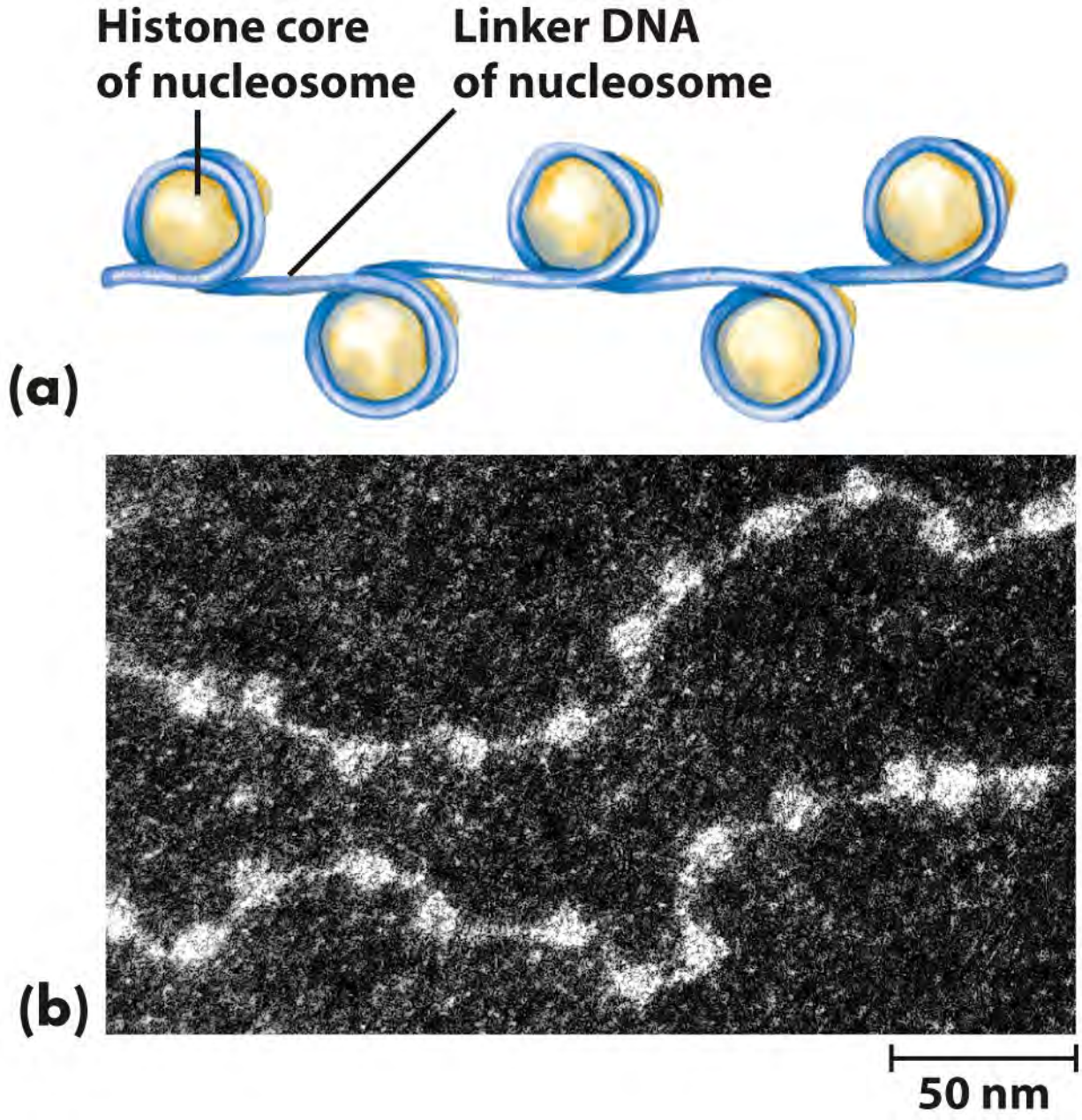
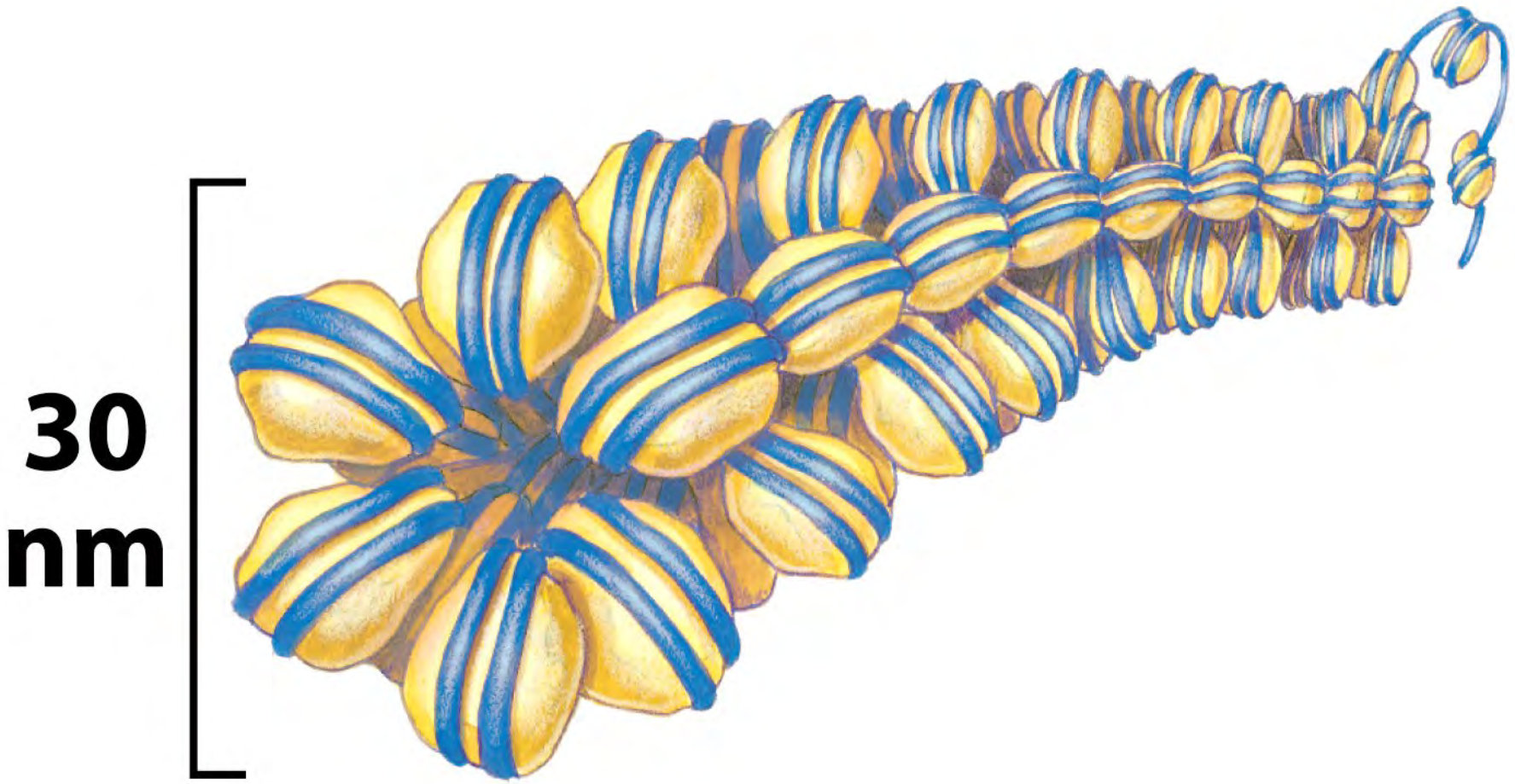


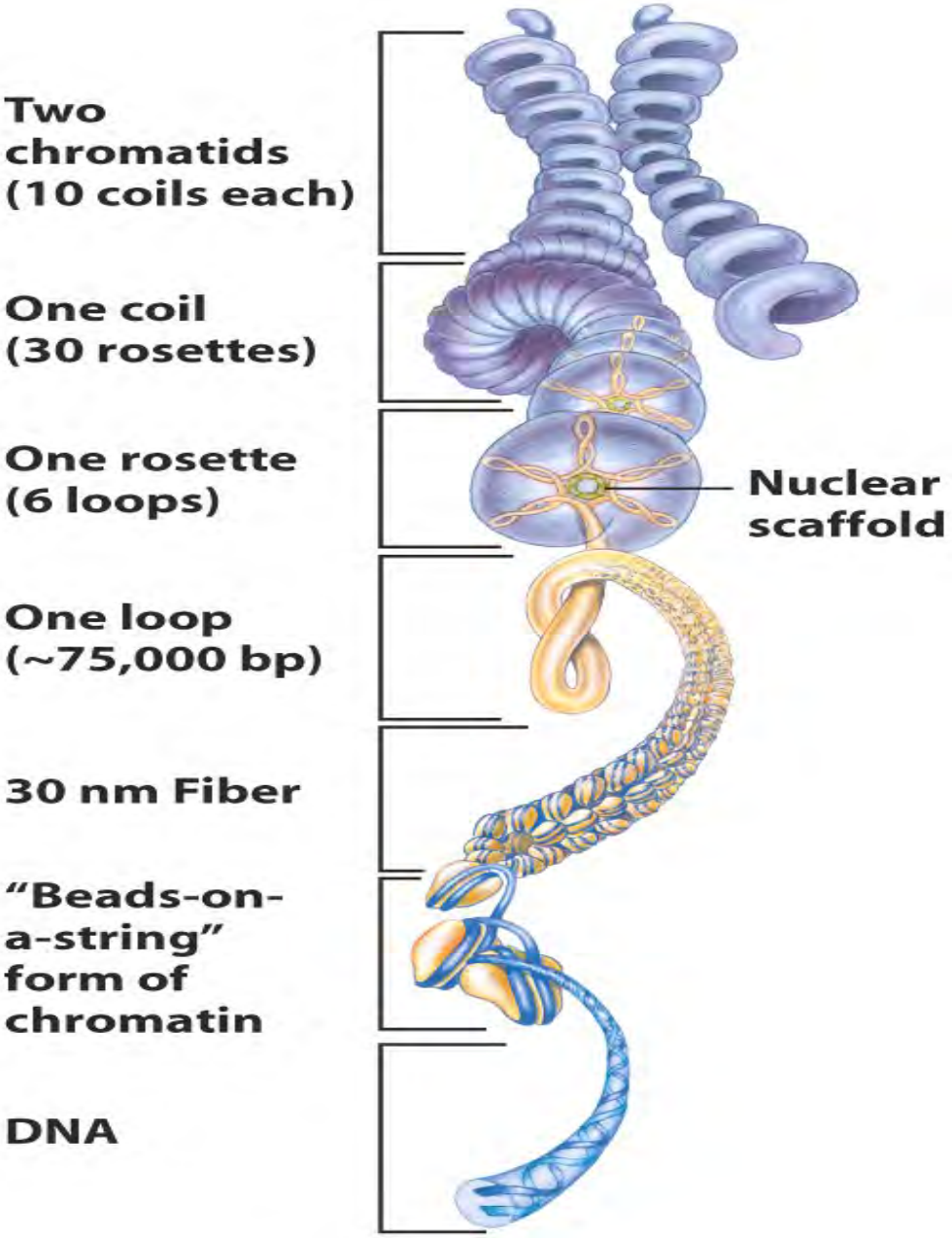
TABLE 24–3 Types and Properties of Histones

Histone	Molecular weight	Number of amino acid residues	Content of basic amino acids (% of total)	
			Lys	Arg
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)
Nuclear scaffold
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.***