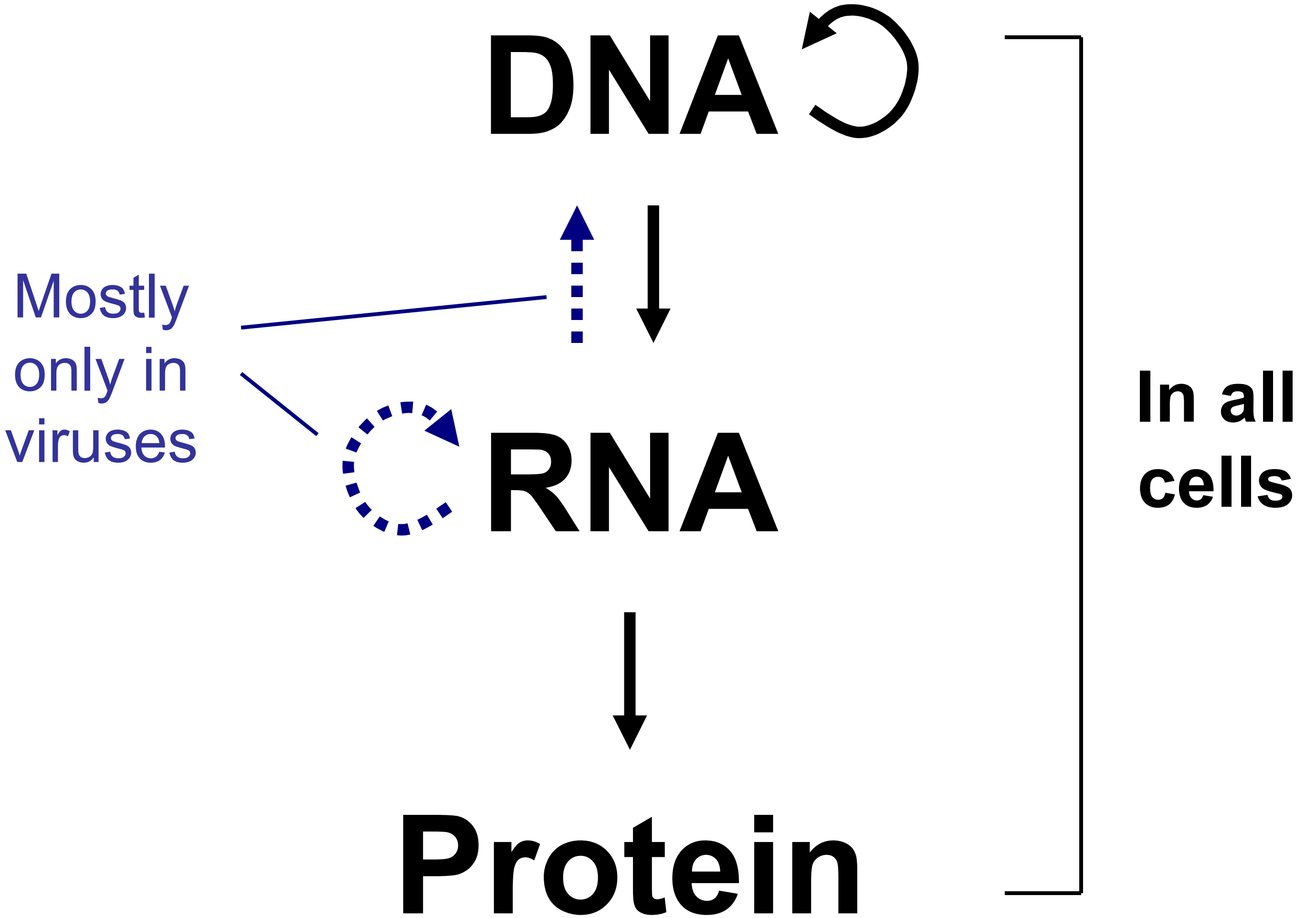
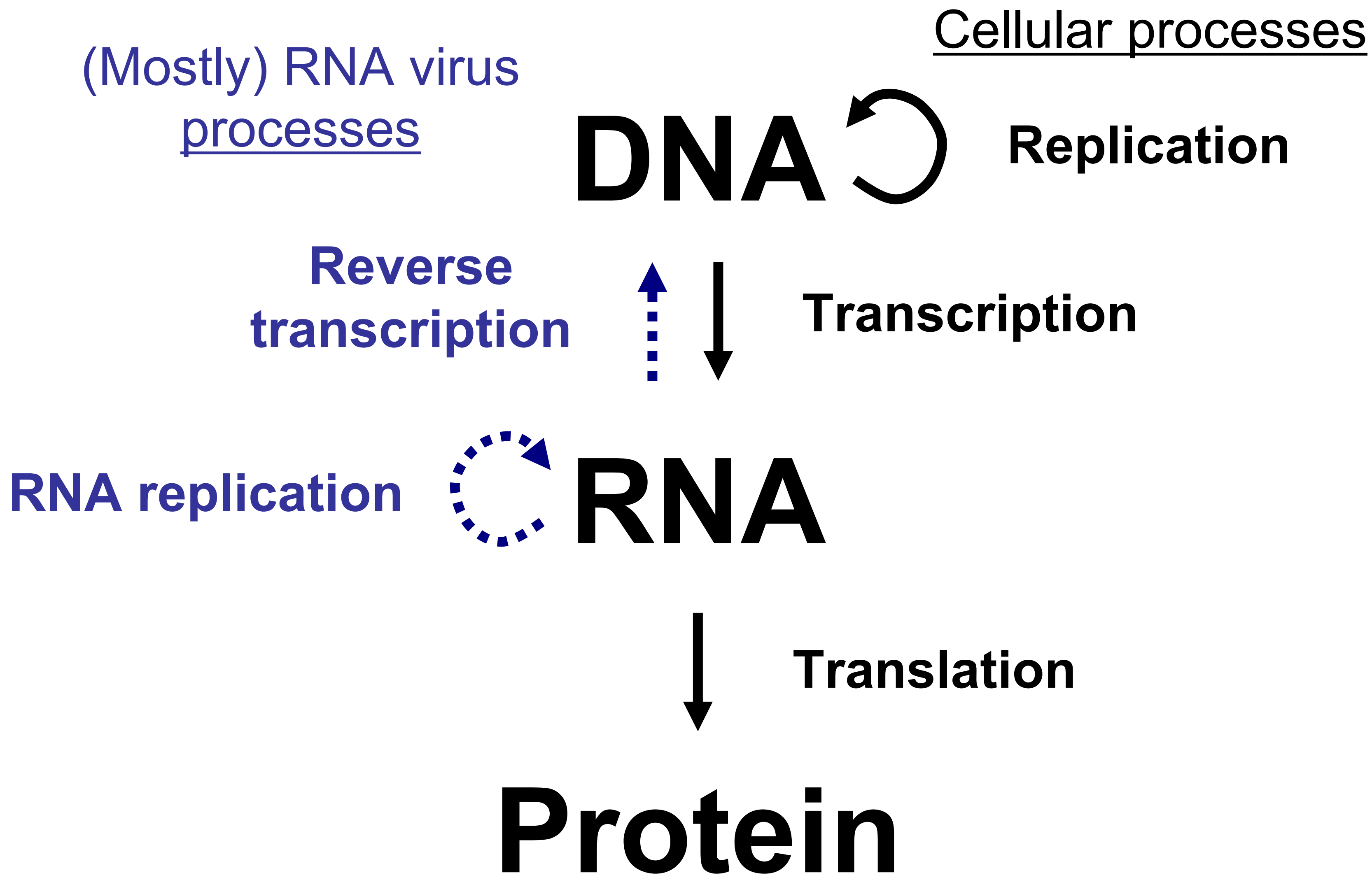
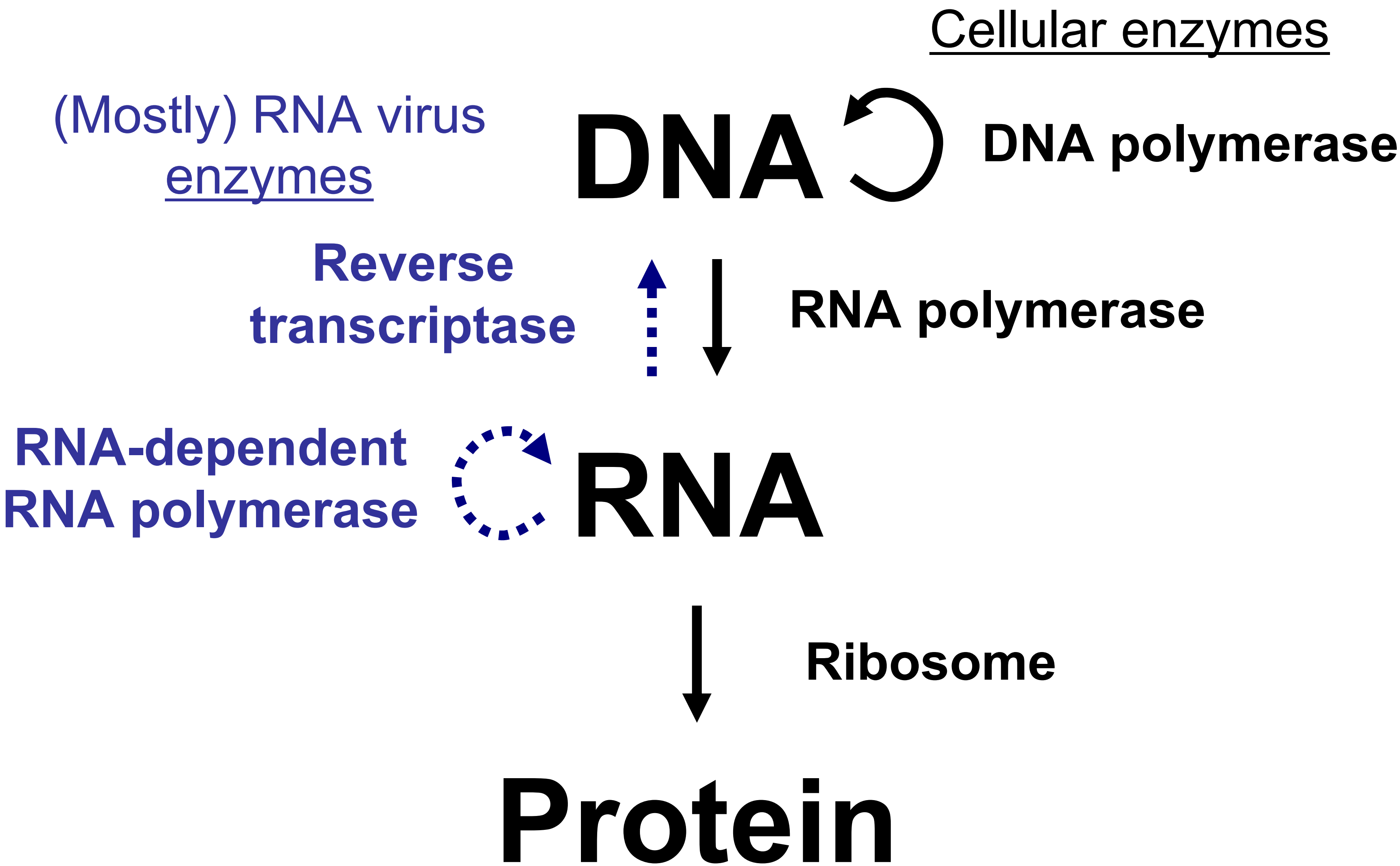
Central Dogma of Biology



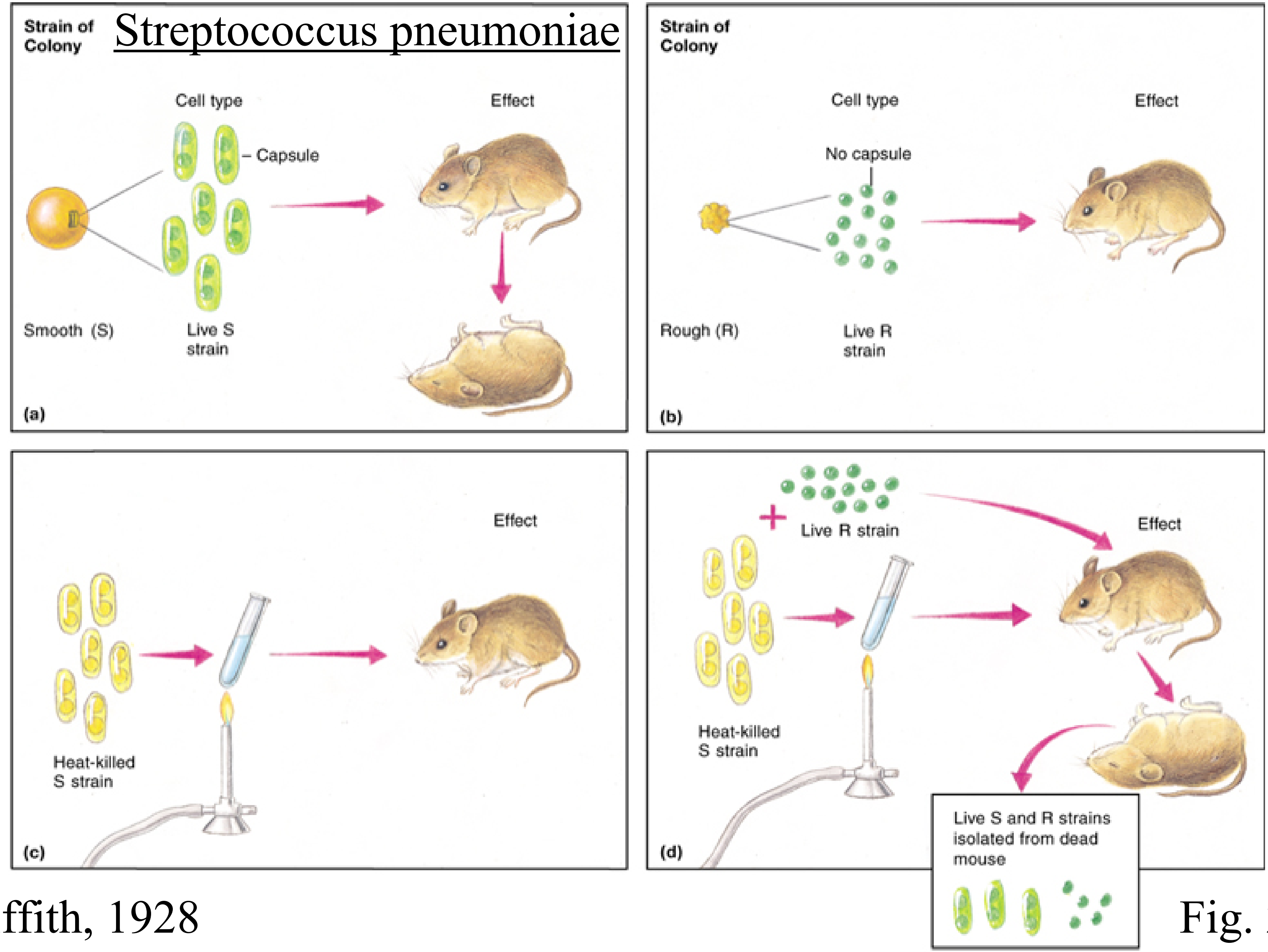
Processes in the central dogma



Enzymes in the central dogma



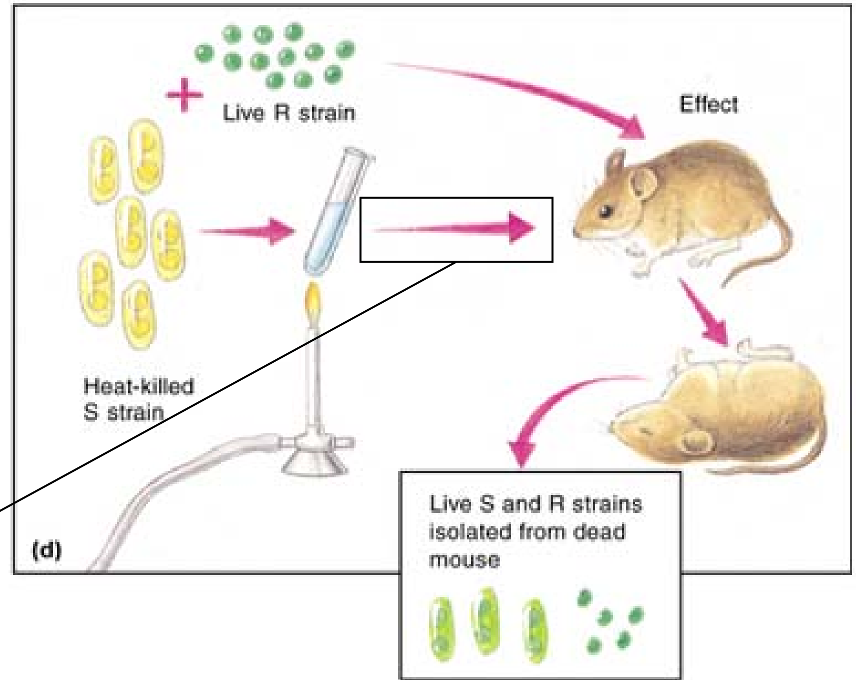
Genetic material is transferable between bacteria



Griffith, 1928

Fig. 2.2

The genetic material is DNA



<u>Heat killed S strain treated with</u>:

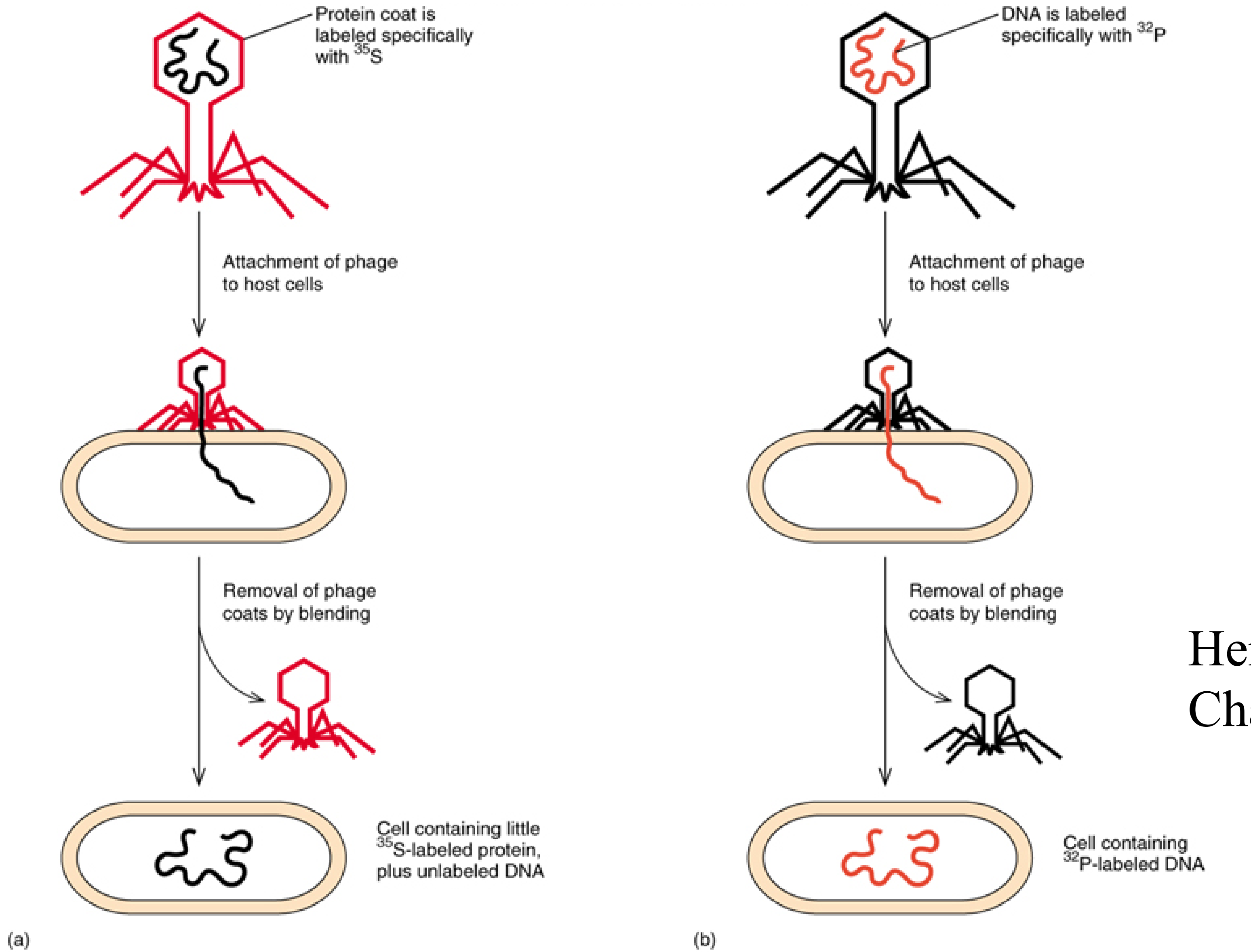
- Phenol => still infectious
- Proteinase (trypsin, chymotrypsin) => still infectious
- UV light => no longer infectious
- RNase => still infectious
- DNase => no longer infectious

Avery, MacLeod, McCarthy, 1944

=> <u>Genetic material is DNA</u>!

Based on Fig. 2.2

The genetic material of bacteriophage T2 is DNA



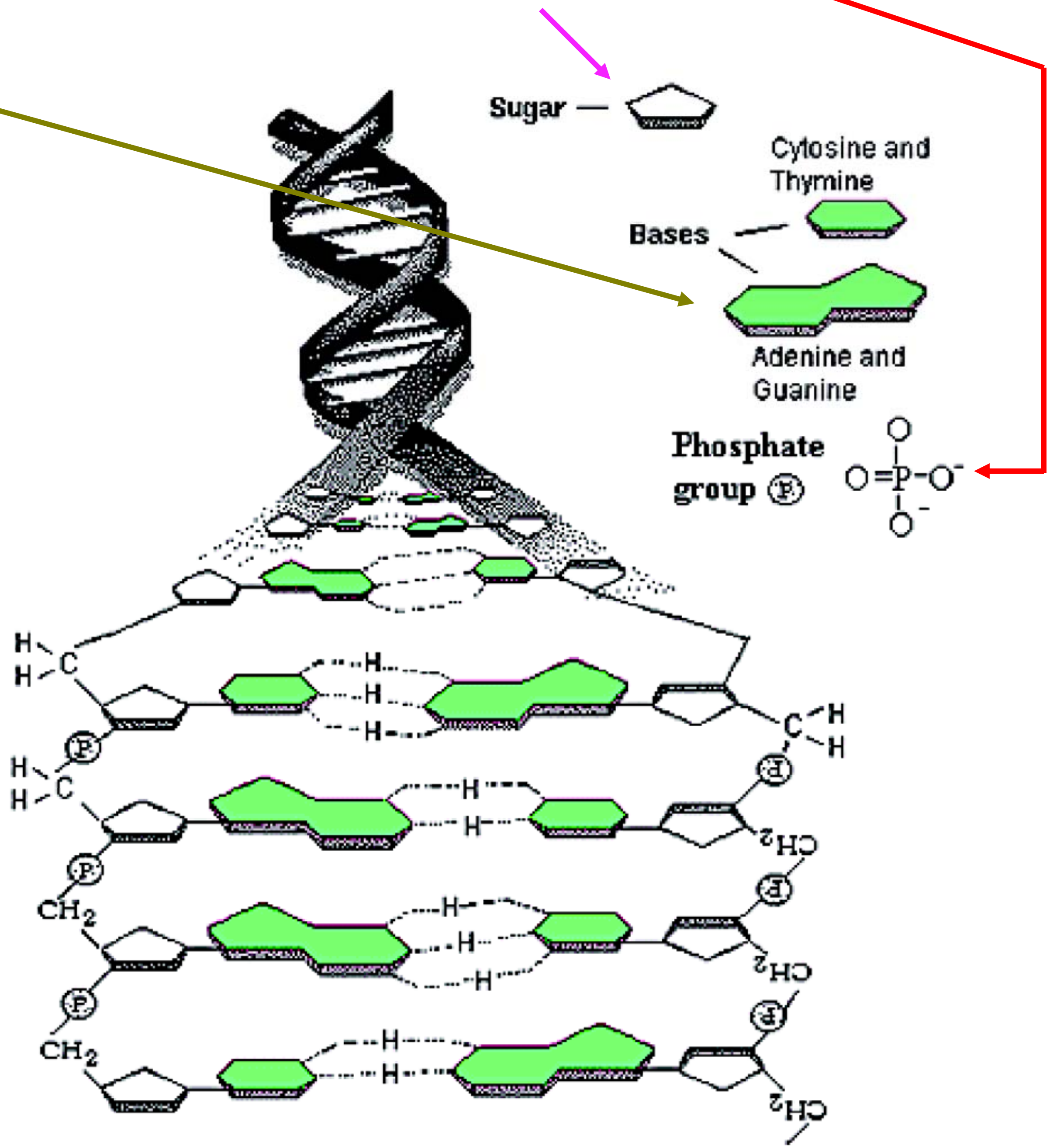
Hershey, Chase, 1952

Fig. 2.4

Some viruses use RNA as genetic material (e.g. HIV, herpesviruses etc)!

- Clicker Question -

A nucleotide is composed of a sugar, a phosphate and a base



The chemical nature of DNA and RNA

DNA

Nitrogenous bases:

Adenine (A)
Cytosine (C)
Guanine (G)
Thymine (T)

Phosphoric acid

Sugar: 2' deoxyribose

RNA

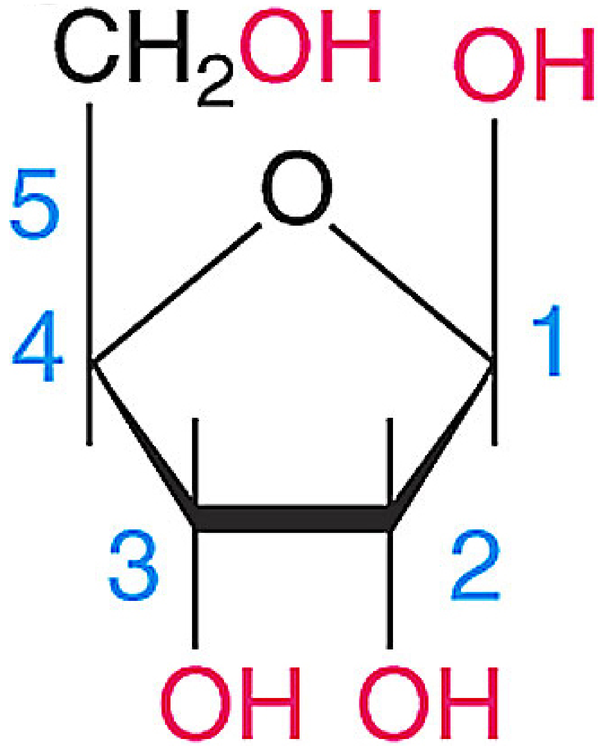
Nitrogenous bases:

Adenine (A)
Cytosine (C)
Guanine (G)
Uracil (U)

Phosphoric acid

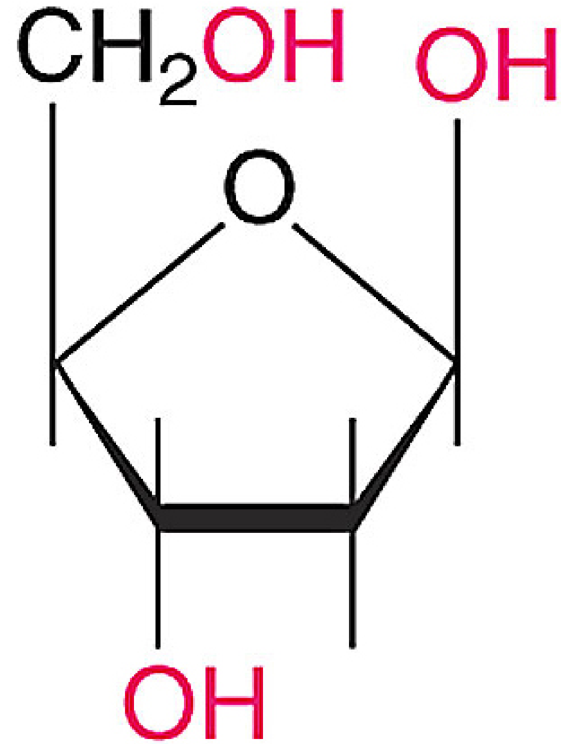
Sugar: ribose

The sugars



Ribose

(RNA)



2-deoxyribose

(DNA)

Fig. 2.6

The bases

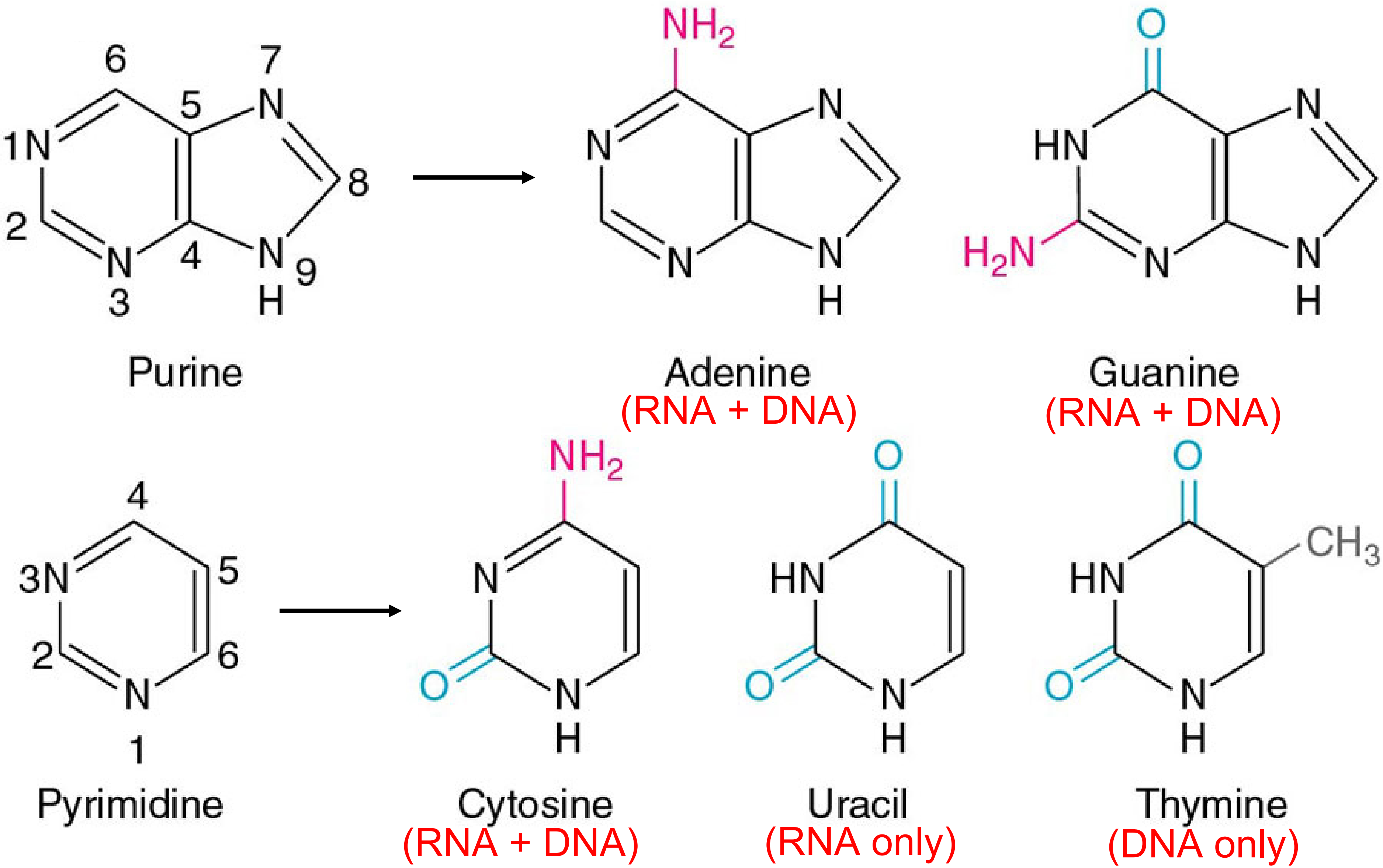
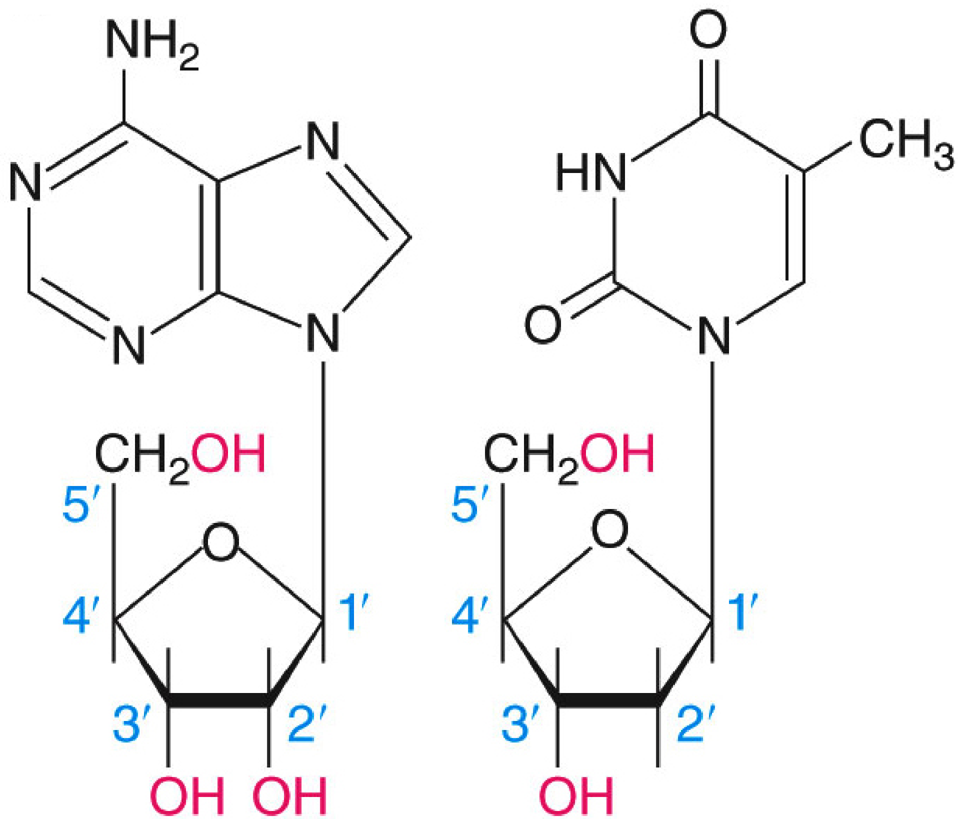


Fig. 2.5

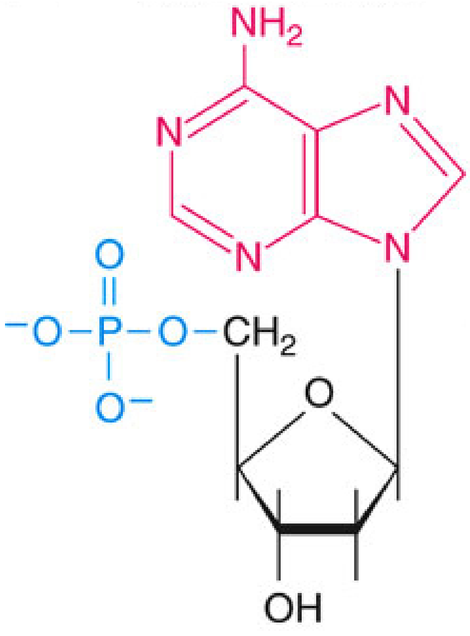
Nucleos<u>s</u>ides (=sugar+base, no phosphate)



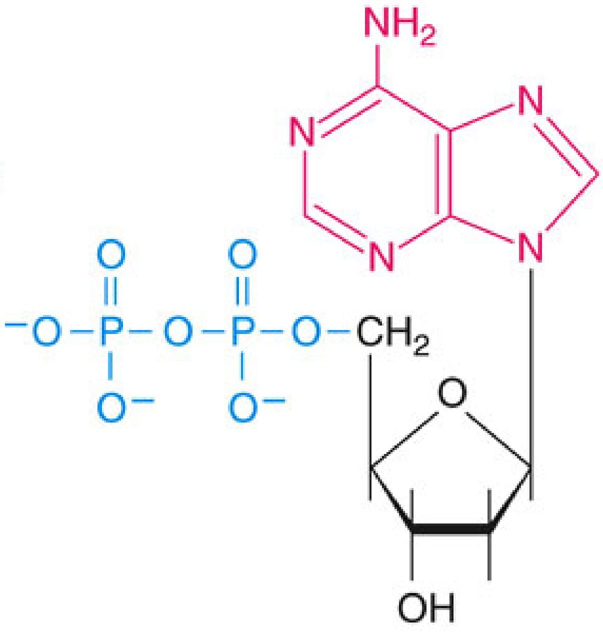
Adenosine   2′ -Deoxythymidine

Fig. 2.9

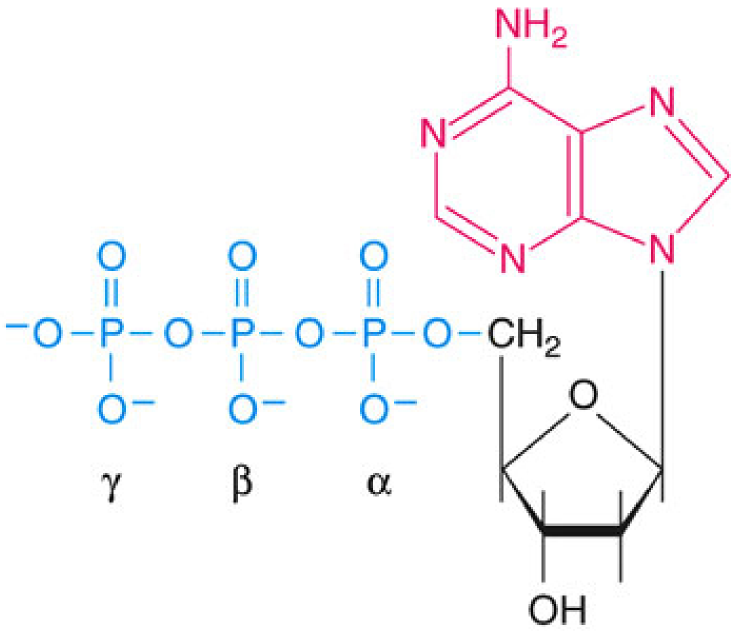
Nucleotides (= nucleoside phosphates)



Deoxyadenosine-5′-
monophosphate (dAMP)



Deoxyadenosine-5′-
diphosphate (dADP)



Deoxyadenosine-5′-
triphosphate (dATP)

- Clicker Question -

Nucleotide polymer

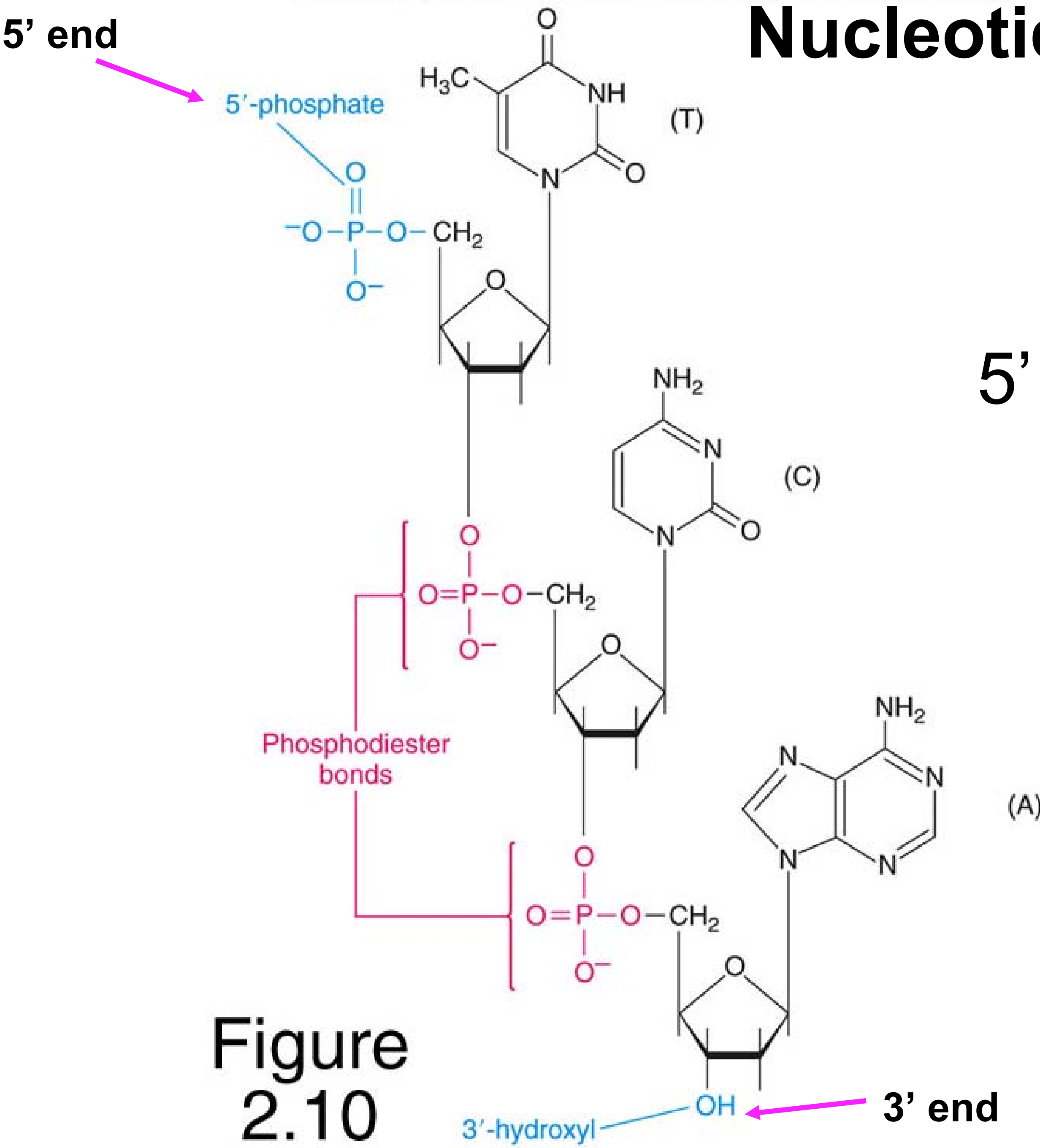
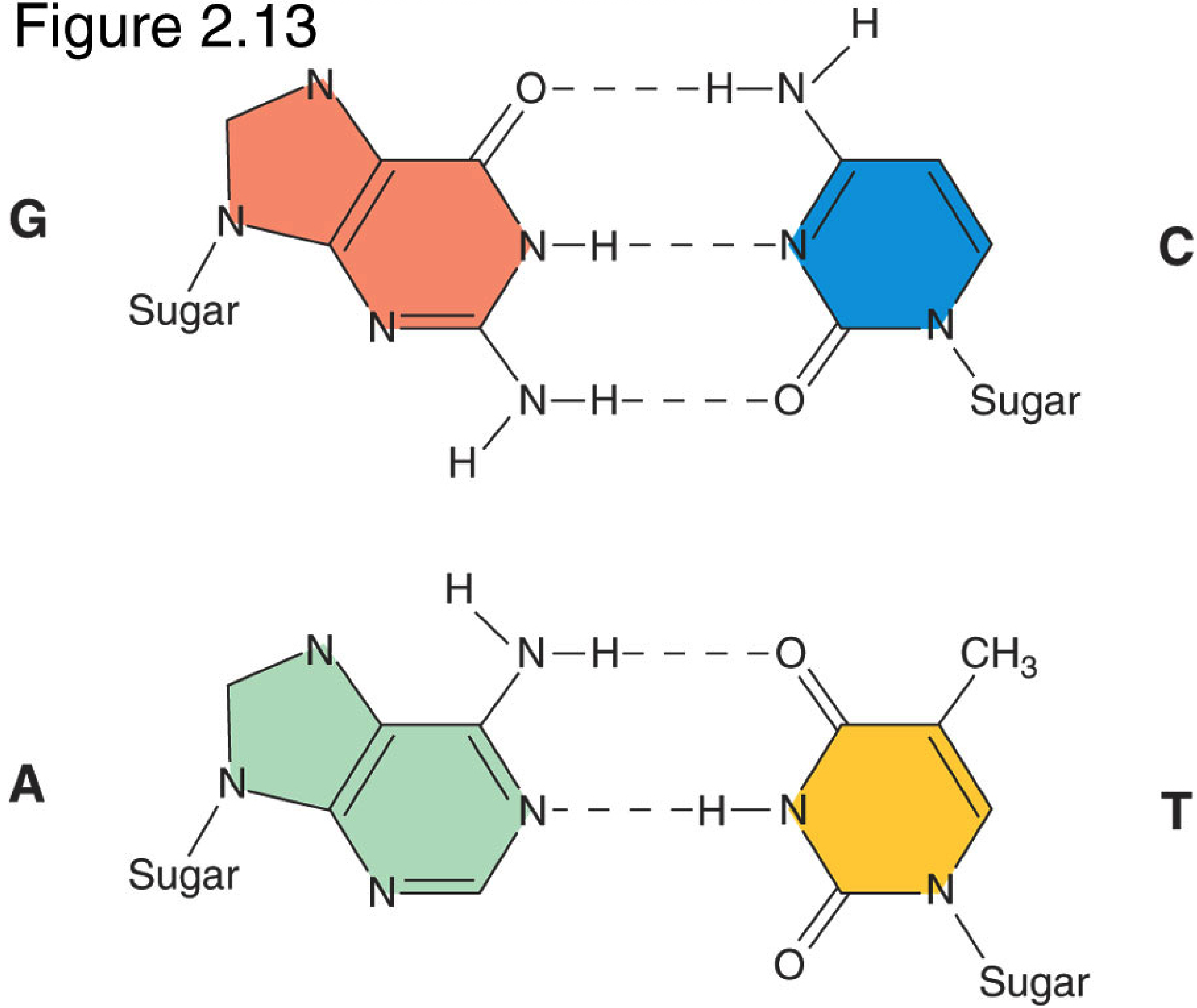


Figure 2.10

5’ TCA 3’

Base pairs

Figure 2.13



The double-helix

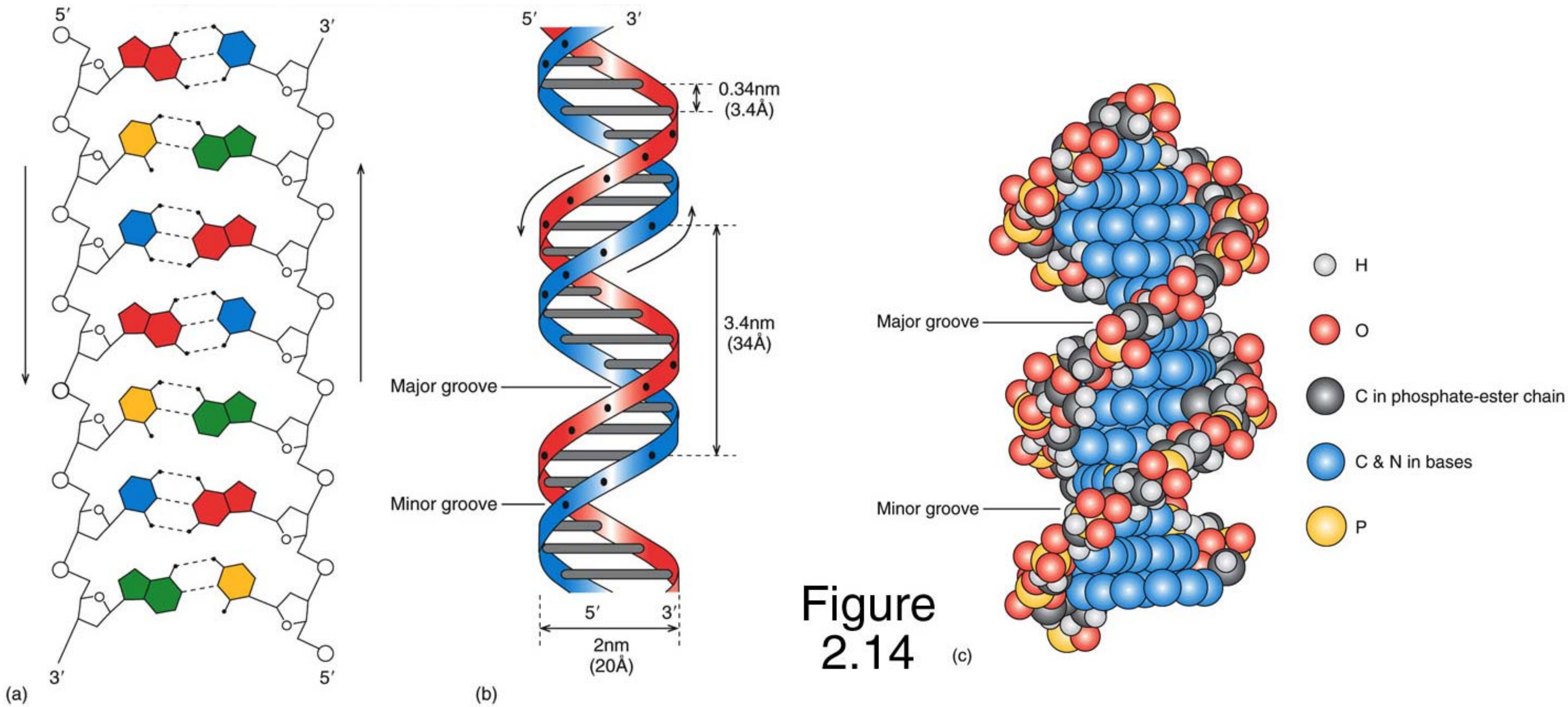
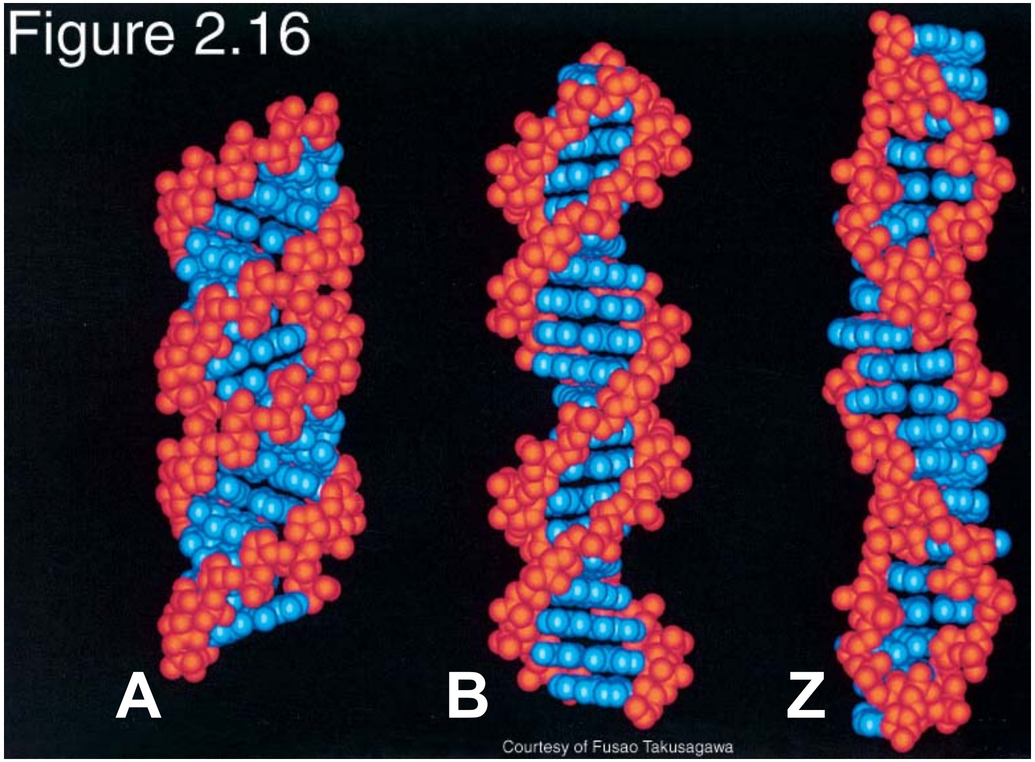


Figure 2.14

Different polynucleotide double-helix structures



	Form	Pitch (Å)	Residues per turn	Inclination of base pair from horizontal
Most dsRNA →	A	24.6	~11	+19º
Most DNA →	B	33.2	~10	-1.2º
Rare →	Z	45.6	12	-9º

- Clicker Question -

Although G=C and A=T are true for every organism, the ratio of G+C versus A+T vary from organism to organism

Table 2.3 Relative G + C Contents of Various DNAs

Sources of DNA	Percent (G + C)
Dictyostelium (slime mold)	22
Streptococcus pyogenes	34
Vaccinia virus	36
Bacillus cereus	37
B. megaterium	38
Hemophilus influenzae	39
Saccharomyces cerevisiae	39
Calf thymus	40
Rat liver	40
Bull sperm	41
Streptococcus pneumoniae	42
Wheat germ	43
Chicken liver	43
Mouse spleen	44
Salmon sperm	44
B. subtilis	44
T1 bacteriophage	46
Escherichia coli	51
T7 bacteriophage	51
T3 bacteriophage	53
Neurospora crassa	54
Pseudomonas aeruginosa	68
Sarcina lutea	72
Micrococcus lysodeikticus	72
Herpes simplex virus	72
Mycobacterium phlei	73

Source: From Davidson, *The Biochemistry of the Nucleic Acids*, 8th edition revised by Adams et al. Lippencott.

The DNA content varies between organisms

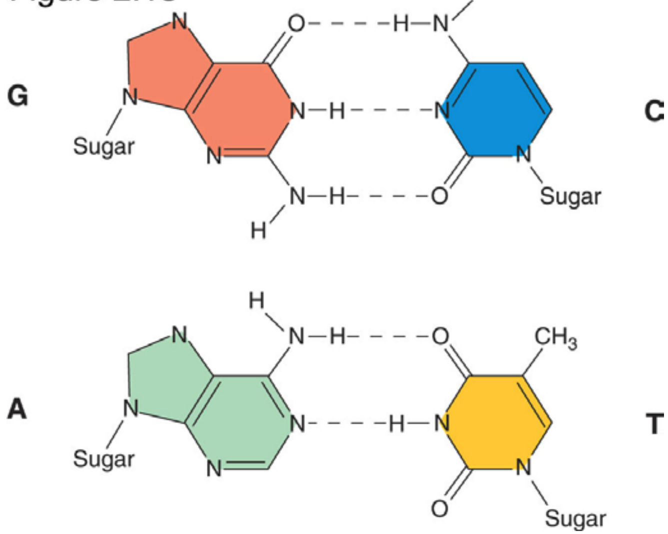
Figure T2.4

Table 2.4 Sizes of various DNAs

Source	Molecular weight	Base pairs	Length
Subcellular Genetic Systems:			
SV40 (mammalian tumor virus)	3.5×10^6	5226	1.7 µm
Bacteriophage ϕX174 (double-stranded form)	3.2×10^6	5386	1.8 µm
Bacteriophage λ	3.3×10^6	5×10^4	13 µm
Bacteriophage T2 or T4	1.3×10^8	2×10^5	50 µm
Human mitochondria *	9.5×10^6	16,596	5 µm
Prokaryotes:			
Hemophilus influenzae *	1.2×10^9	1.83×10^6	620 µm
Escherichia coli	3.1×10^9	4.65×10^6	1.6 mm
Salmonella typhimurium	8×10^9	1.1×10^7	3.8 mm
Eukaryotes (content per haploid nucleus):			
Saccharomyces cerevisiae (yeast)	7.9×10^9	1.2×10^7	4.1 mm
Neurospora crassa (pink bread mold)	$\sim 1.9 \times 10^{10}$	$\sim 2.7 \times 10^7$	~9.2 mm
Drosophila melanogaster (fruit fly)	$\sim 1.2 \times 10^{11}$	$\sim 1.8 \times 10^8$	~6.0 cm
Rana pipiens (frog) *	$\sim 1.4 \times 10^{13}$	$\sim 2.3 \times 10^{10}$	~7.7 m
Mus musculus (mouse)	$\sim 1.5 \times 10^{12}$	$\sim 2.2 \times 10^9$	~75 cm
Homo sapiens (human) *	$\sim 2.3 \times 10^{12}$	$\sim 3.5 \times 10^9$	~120 cm
Zea mays (corn, or maize)	$\sim 4.4 \times 10^{12}$	$\sim 6.6 \times 10^9$	~2.2 m
Lilium longiflorum (lily) *	$\sim 2 \times 10^{14}$	$\sim 3 \times 10^{11}$	~100 m

Two DNA strands can be separated by heating, a process called DNA denaturation or DNA melting

Figure 2.13



The temperature at which the DNA strands are half denatured is called the melting temperature, or T_m.

T_m of a DNA is largely determined by its G/C% (The more G/C the higher T_m) and the length (the longer the higher T_m) (Think of it as the more total hydrogen bonds, the higher temp to denature).

Other ways of denaturing DNA?

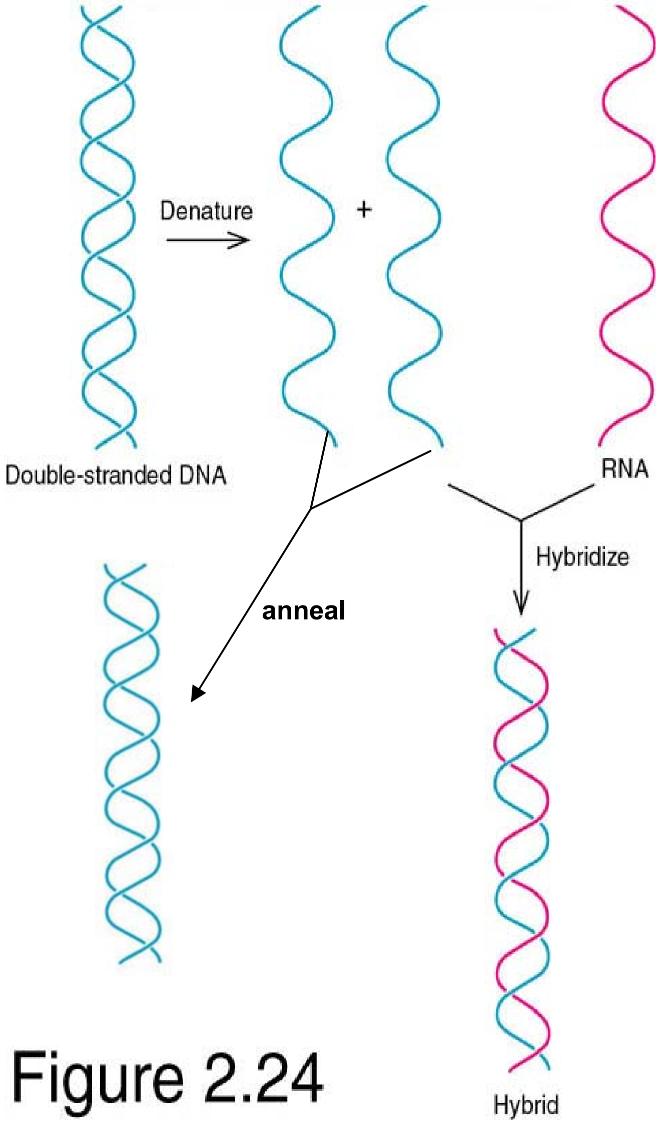


Figure 2.24

Annealing: **The process of reuniting separated DNA strands (also called renaturation).**

Hybridization: **The process of annealing a DNA strand with a complementary RNA strand or DNA strand from a different origin.**

- Clicker Question -