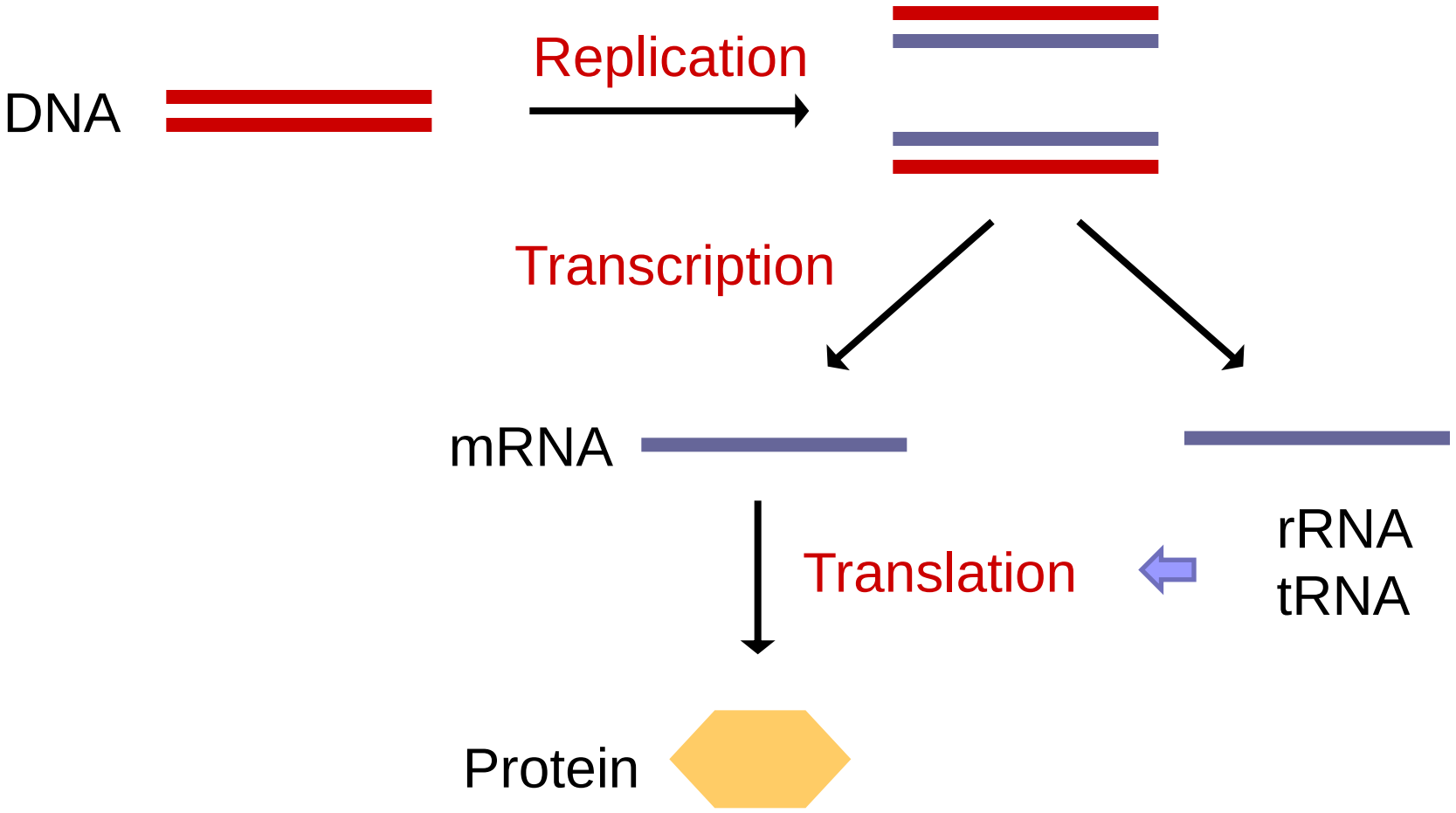
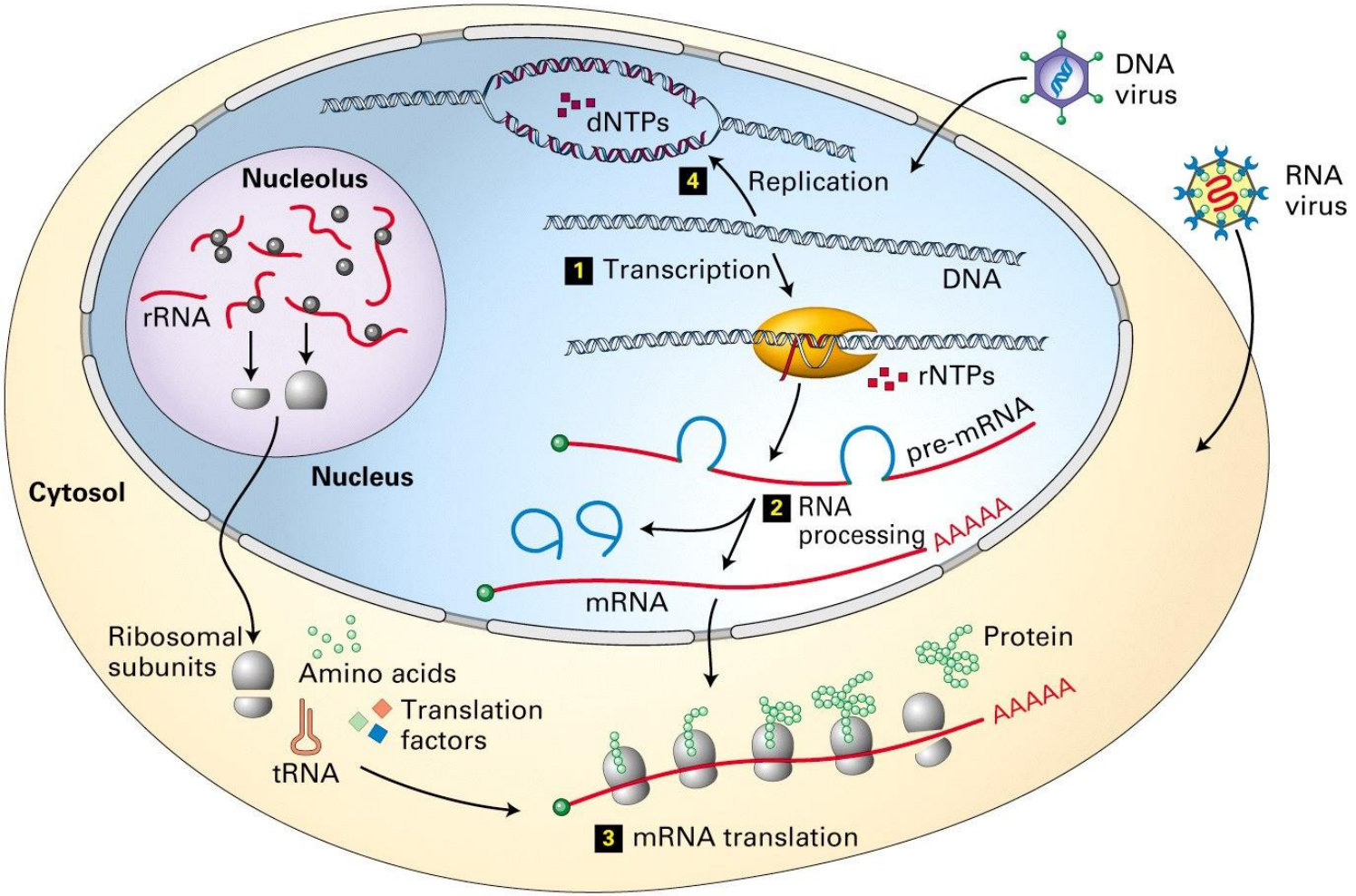
Chapter 3.
DNA, RNA, and Protein Synthesis

Processing of Genetic Information

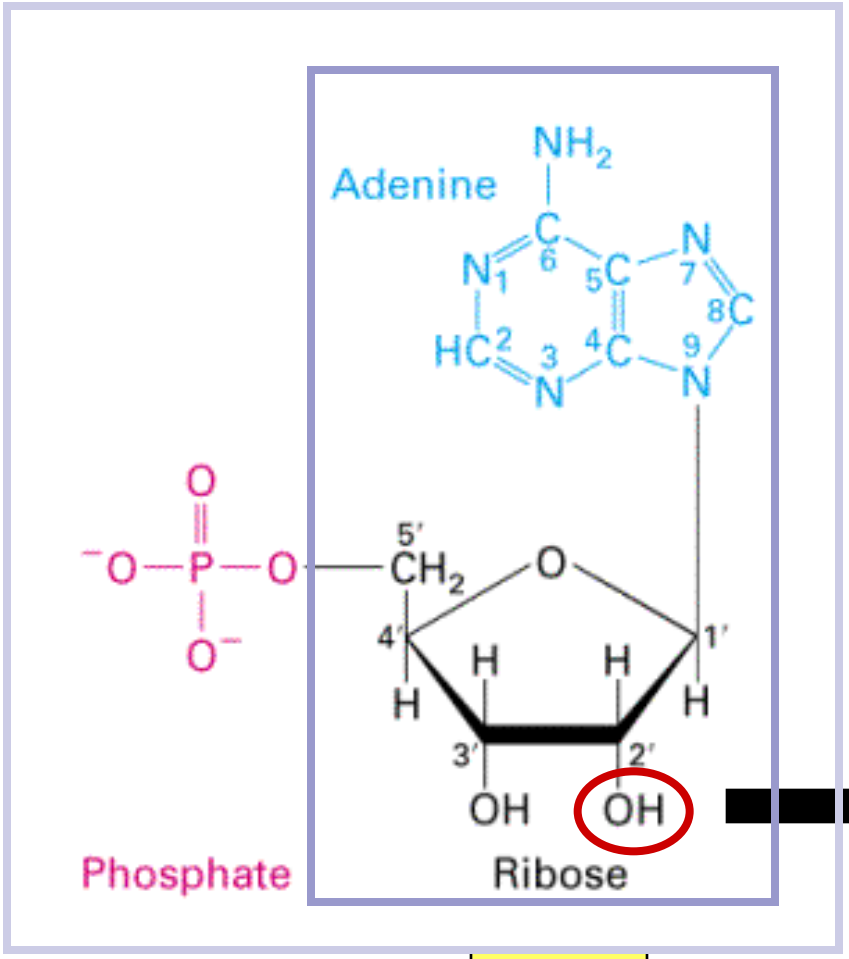


Overview of Basic Molecular Genetic Process



1. DNA Structure

Primary Structure : Nucleotides



Base	Nucleoside	Nucleotide
Adenine	Adenosine	Adenylate
Guanine	Guanosine	Guanylate
Cytosine	Cytidine	Cytidylate
Thymine (D)	Thymidine	Thymidylate
Uracil (R)	Uridine	Uridylate

Purine

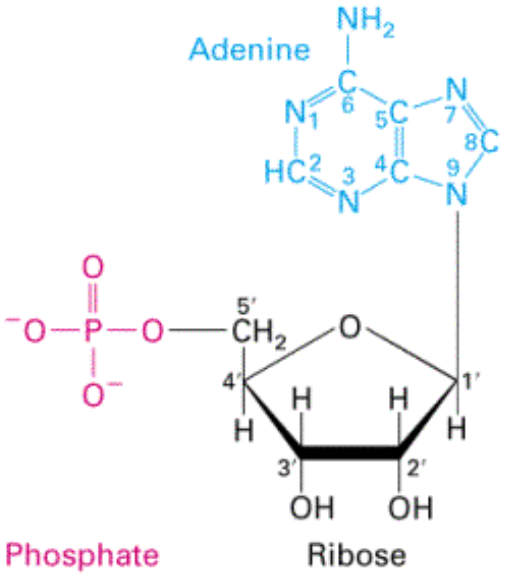
Pyrimidine

H

2’-Deoxyribose

RNA

DNA



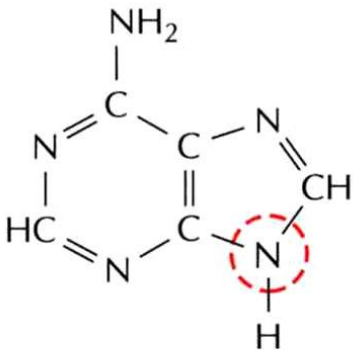
Nucleoside

AMP : Adenosine monophosphate

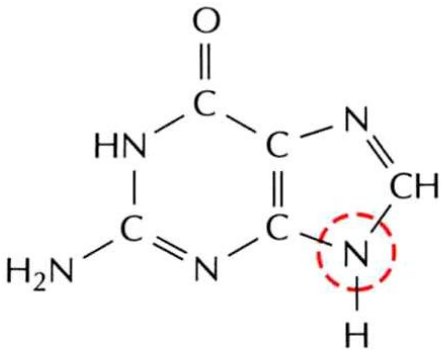
dCDP : Deoxycytidine diphosphate

dGTP : Deoxyguanosine triphosphate

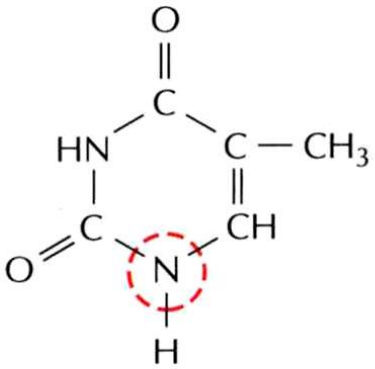
Bases



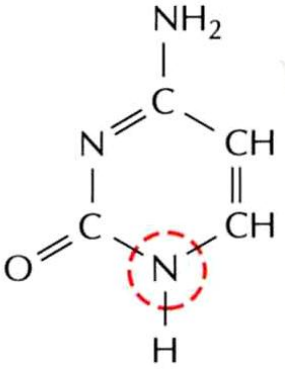
Adenine



Guanine

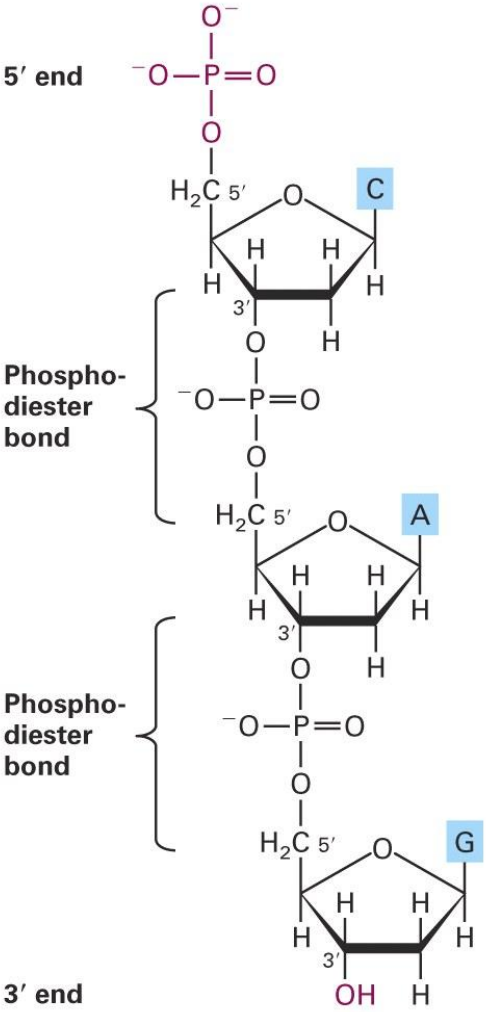


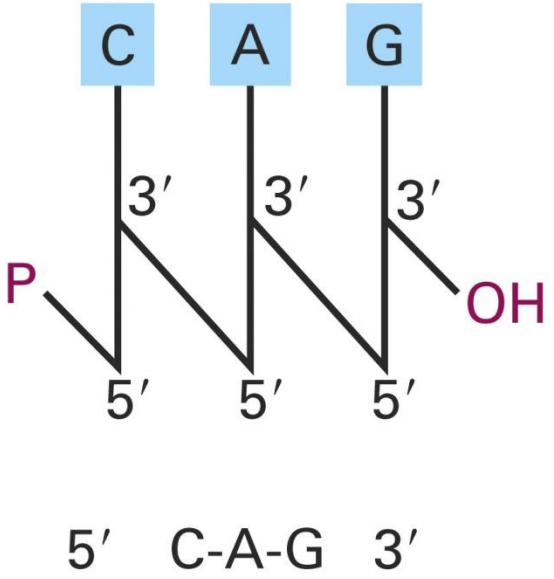
Thymine



Cytosine

Nucleic Acid Strand

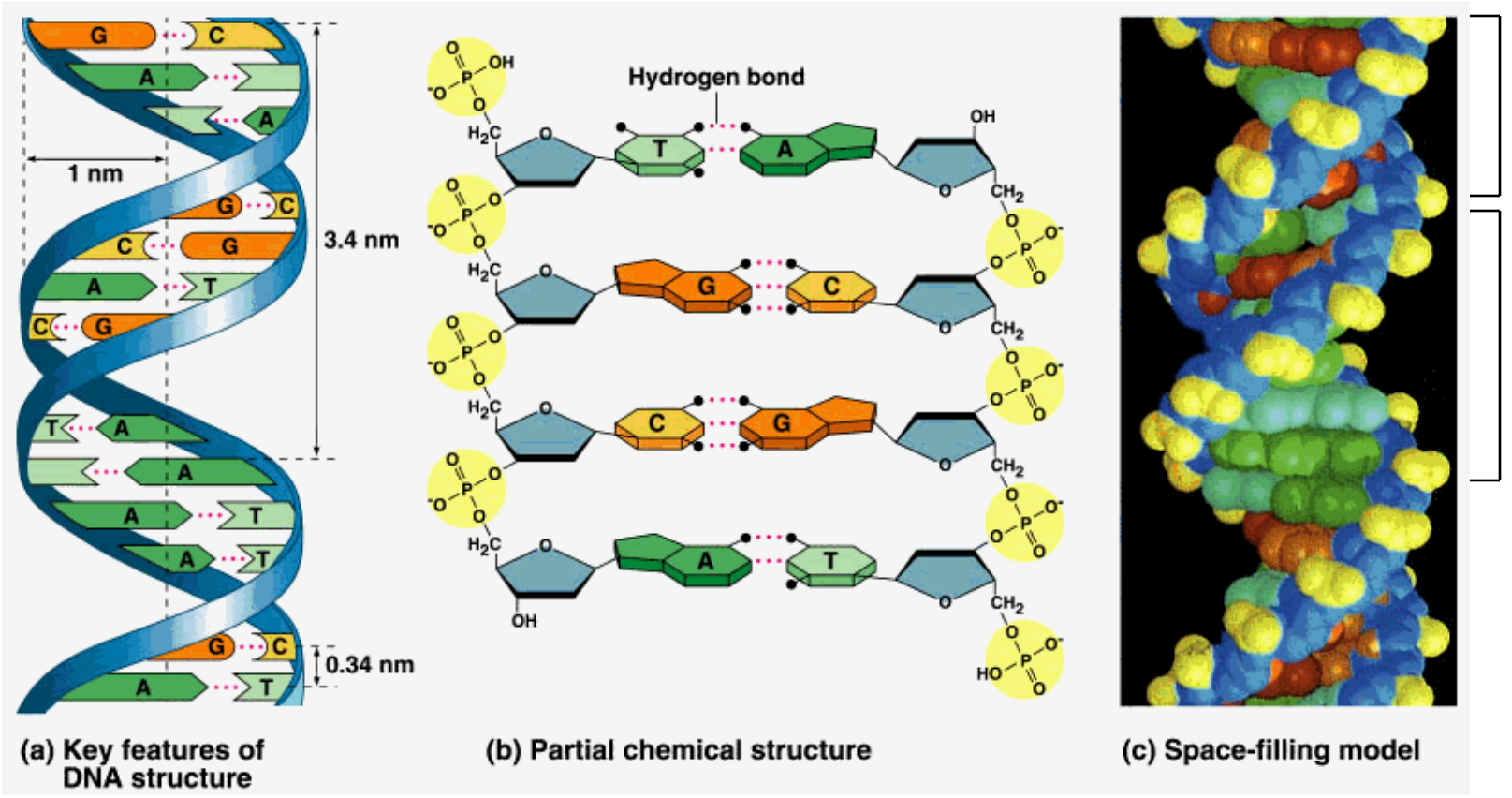




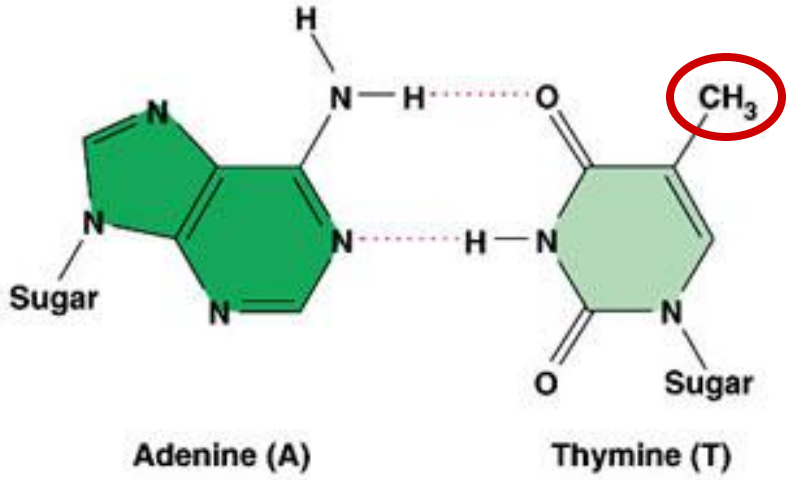
DNA Double Helix

- DNA double helix structure
  - Two antiparallel chains of ribose-phosphate backbone
  - Two chains are joined by complementary base pairing
    - A::T, G:::C
    - Hydrogen bonding
- DNA size
  - Indicated by the number of base pairs
  - Kb: 10^3 bp, Mb: 10^6 bp

DNA Structure



Base Paring



H

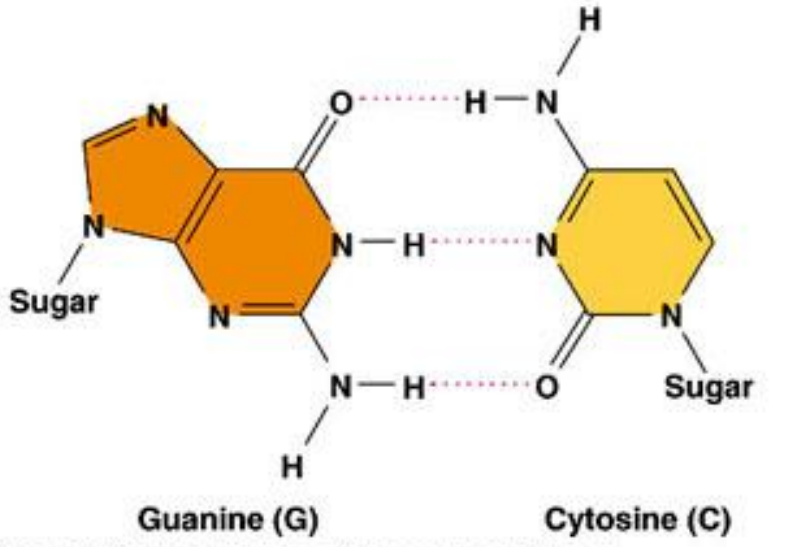
Uracil (U)

Purine

Adenine (A)

Thymine (T)

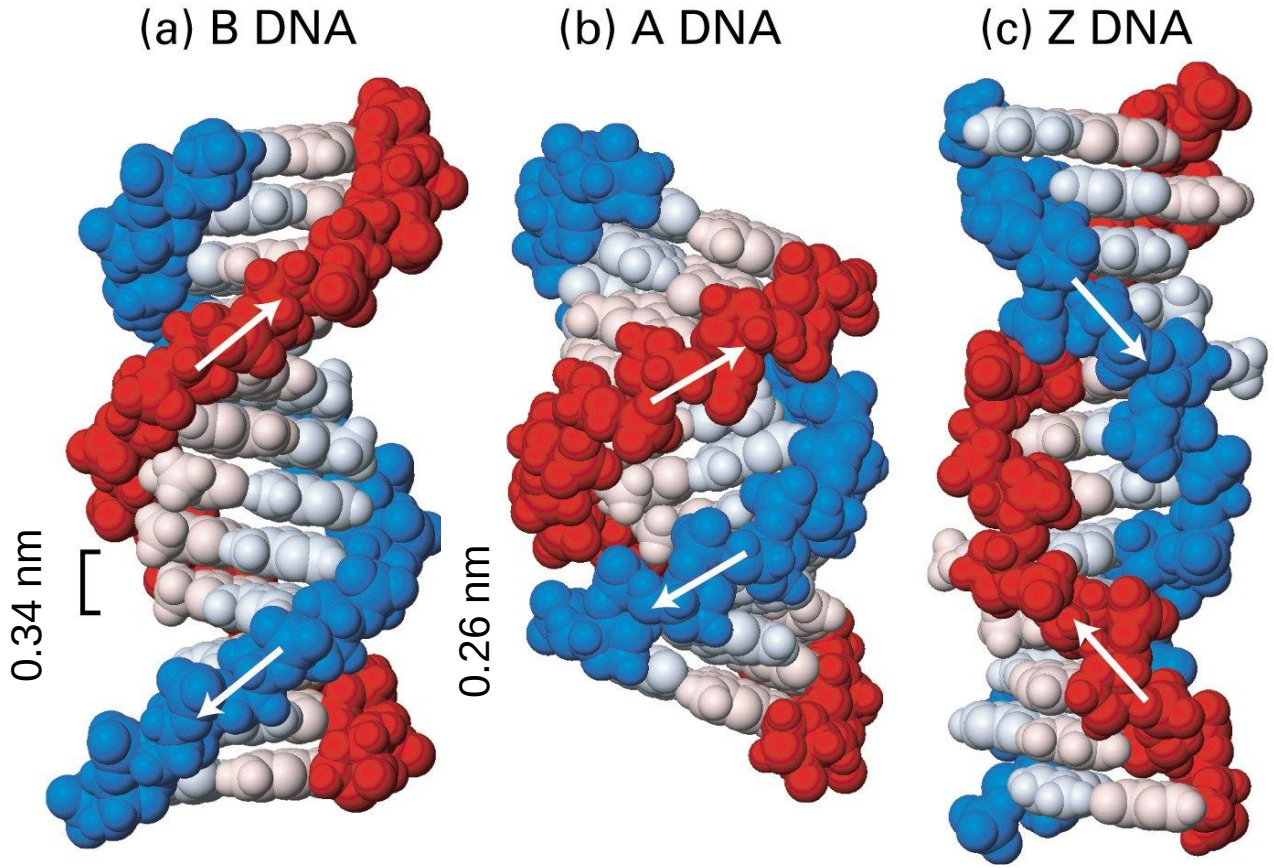
Pyrimidine



Guanine (G)

Cytosine (C)

Models of Various Known DNA Structures



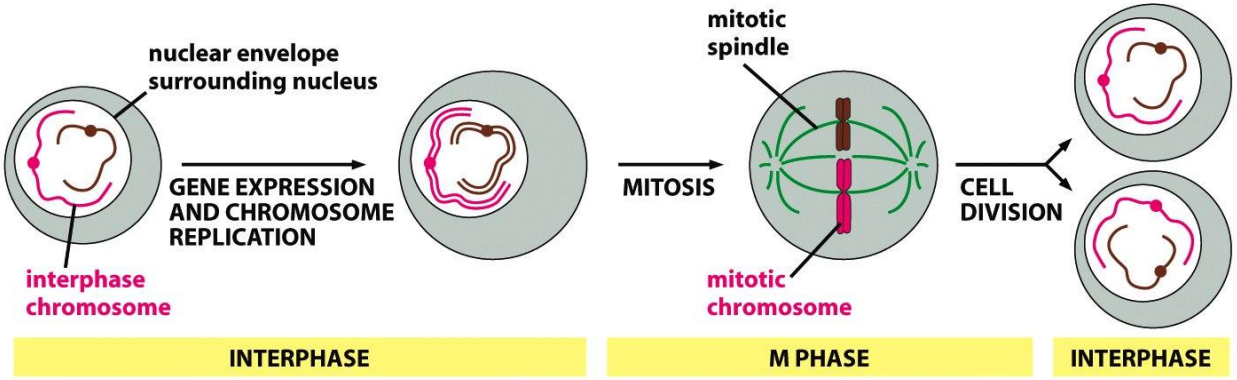
In very low humidity

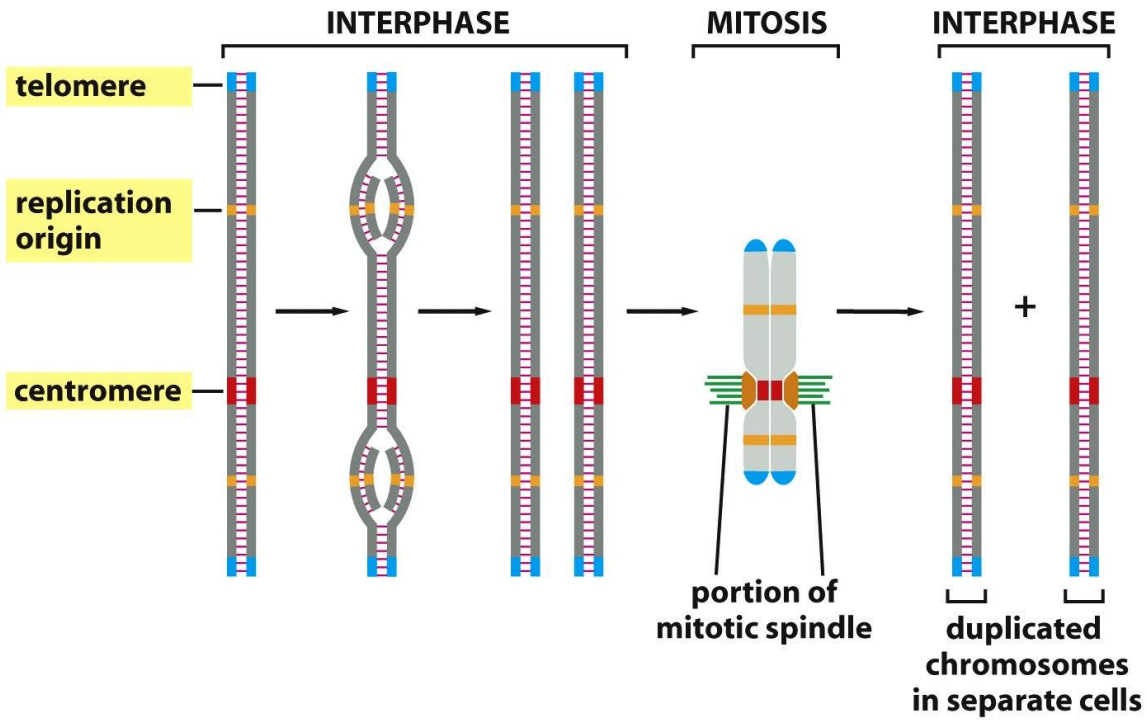
RNA-DNA, RNA-RNA helix

Short DNA with alternating purine and pyrimidine (Gs and Cs)

2. Chromosome in Eukaryotes

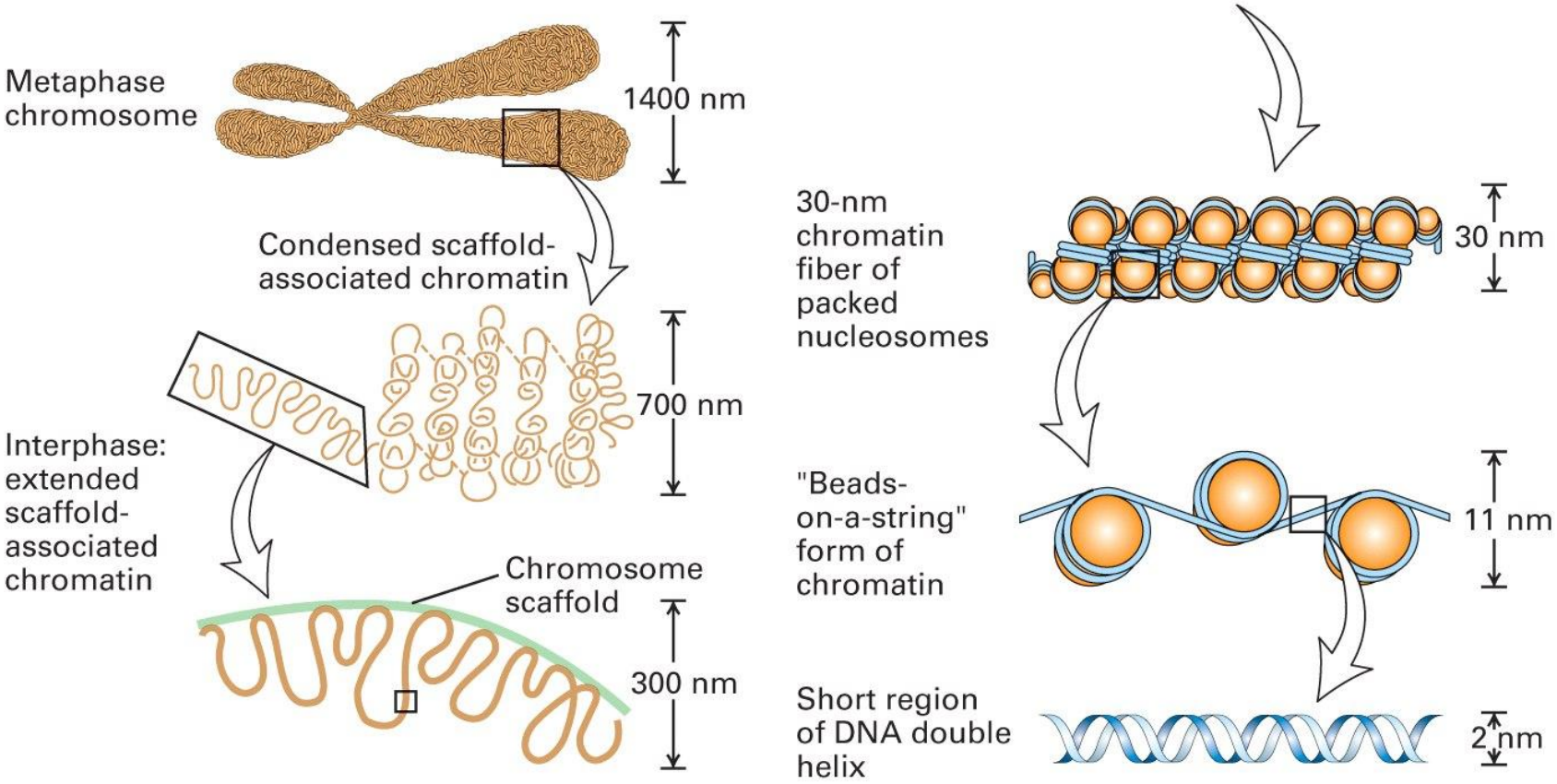
Cell Cycle and the Chromosome Structure



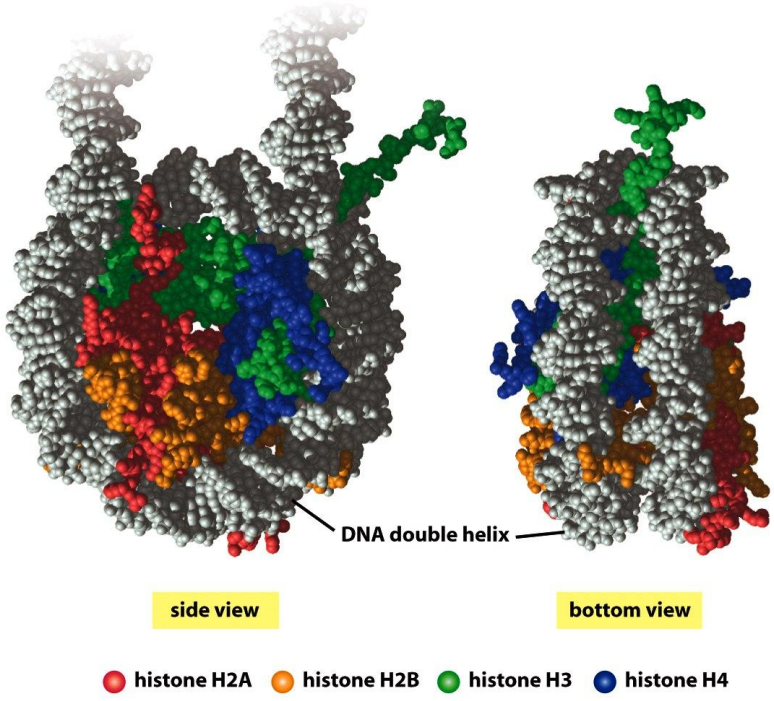


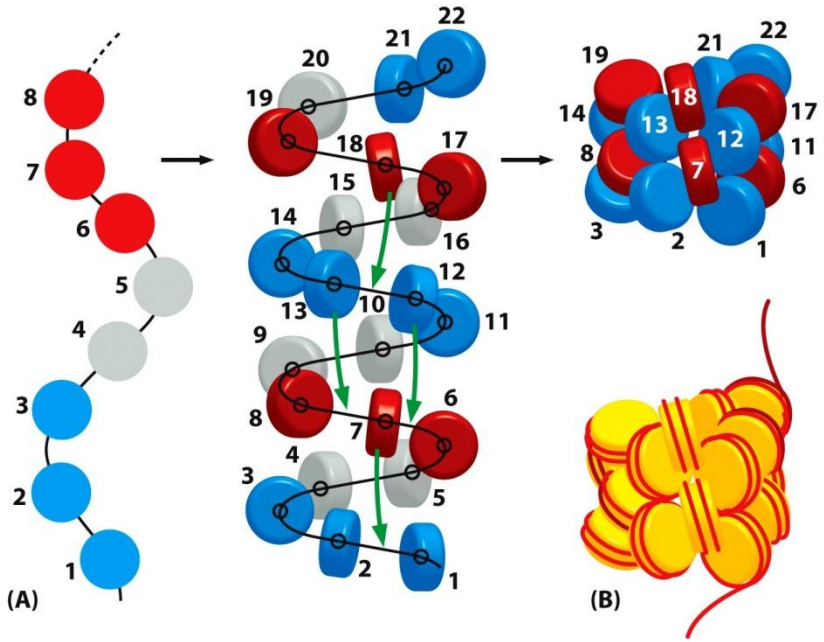
Chromosome

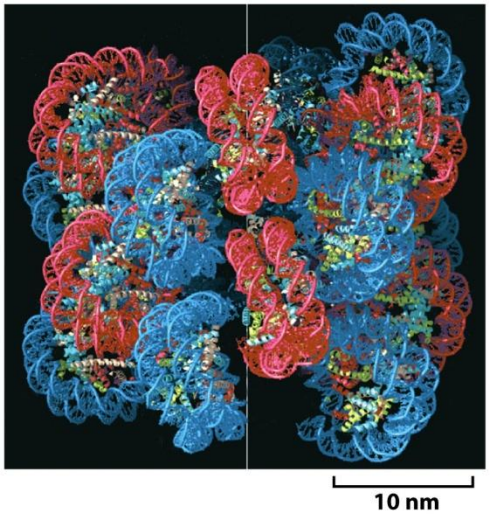
- Tightly packed complex of DNA and histone proteins



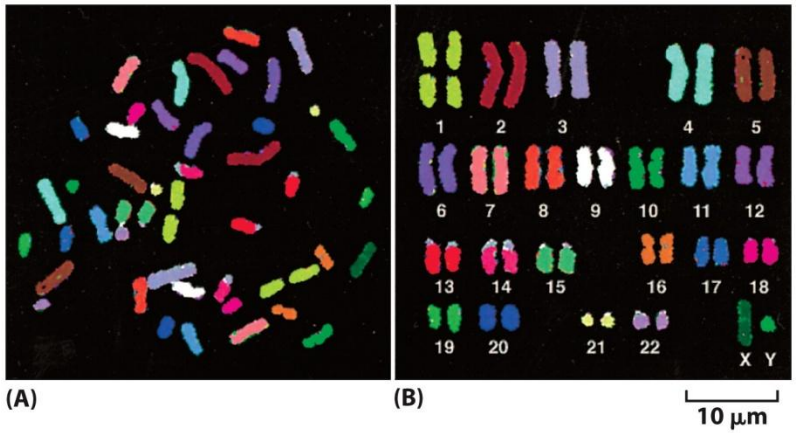
Generation of 30 nm Fiber



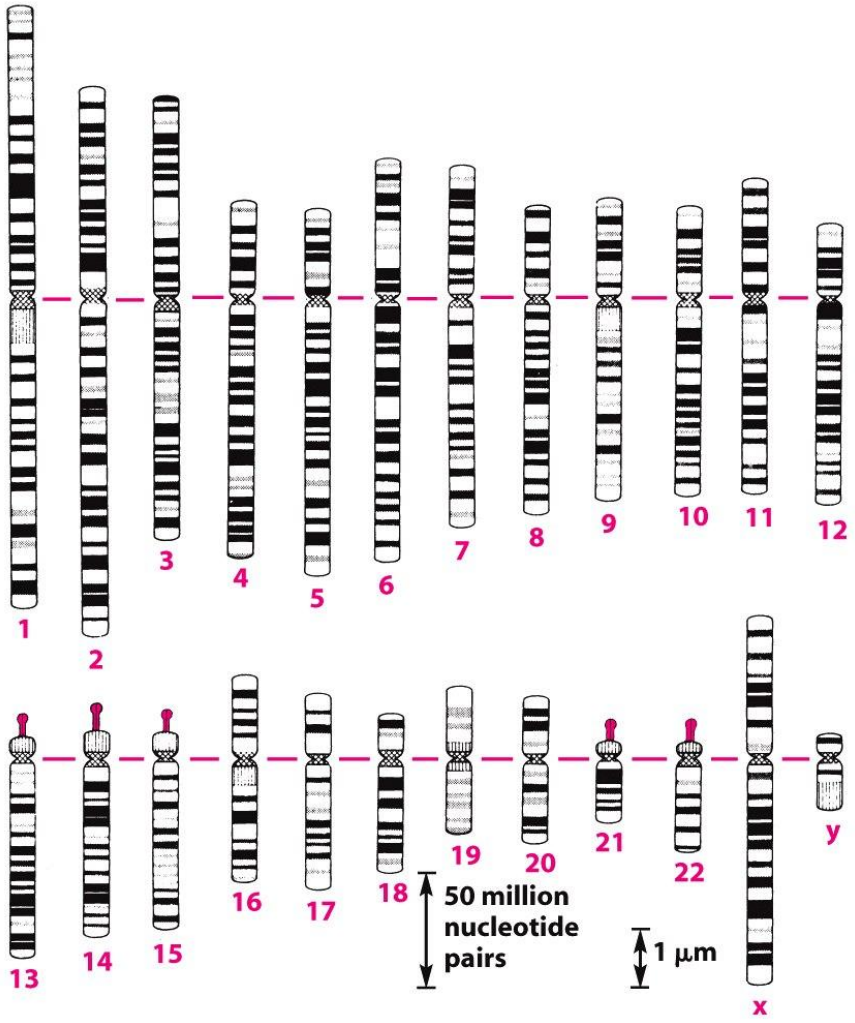




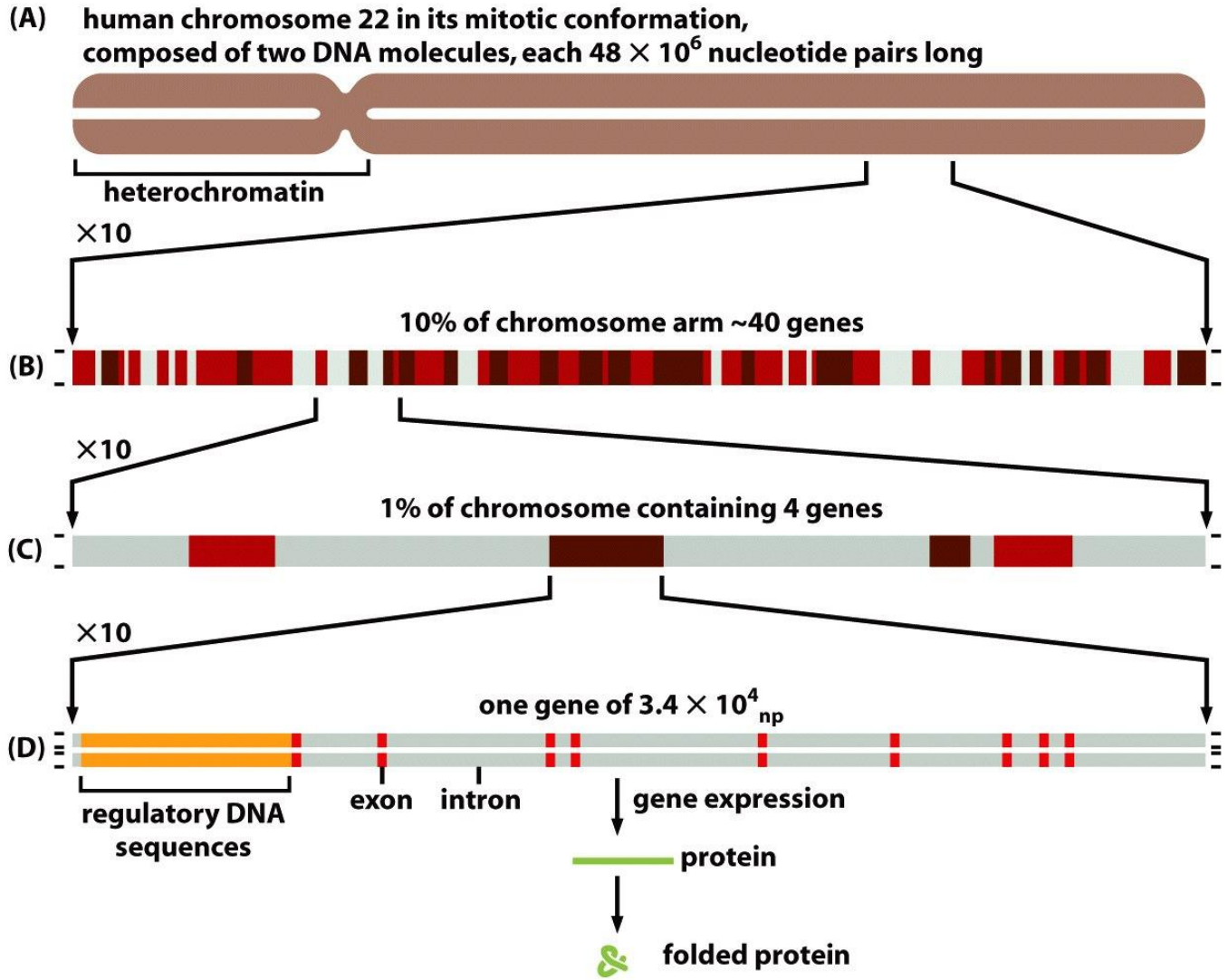
Human Chromosome



- 3.2 x 10^9 bp
- ~25,000 genes
- 46 chromosomes
  - (22 x2) somatic chromosomes
  - 2 sex chromosomes



Arrangement of Genes in Human Genome

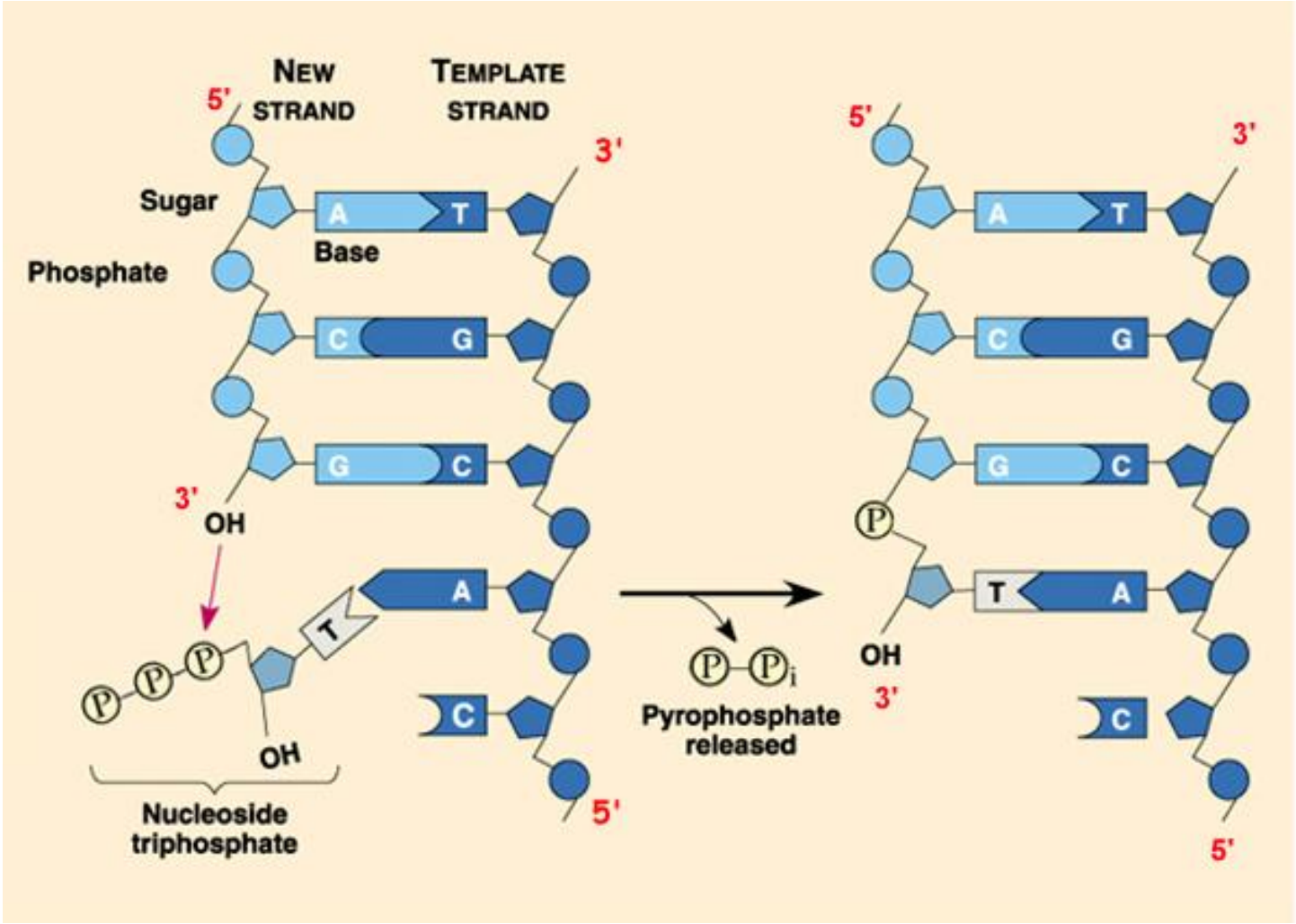


3. DNA Replication

DNA Replication

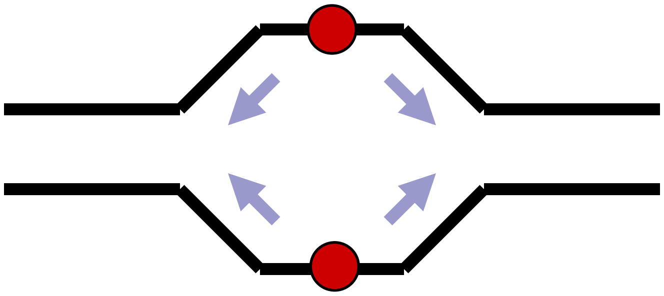
- Semiconservative DNA synthesis
- 5’ to 3’ polymerization by DNA polymerase
- Nucleotide thiphosphates (NTPs) as substrates

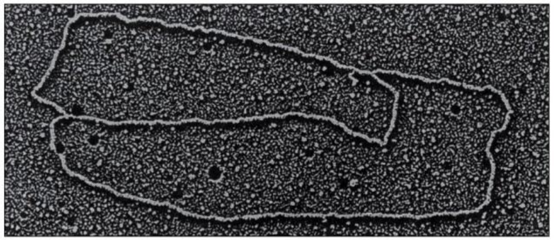
Formation of polynucleotide chains

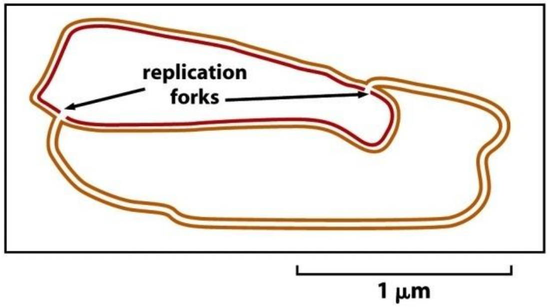


DNA Replication

- Replication Origin
  - 100 to 200 bp sequence region
  - Recognized by origin recognition proteins
  - Prokaryotes: one replication origin
  - Eukaryotes: multiple replication origins (thousands..)
- Bidirectional Replication
  - Two replication forks
  - Replication bubbles
- Speed of Replication
  - *E.coli*: 1000bp/sec, 5 Mbp
  - Human: 50 bp/sec, 3000 Mbp

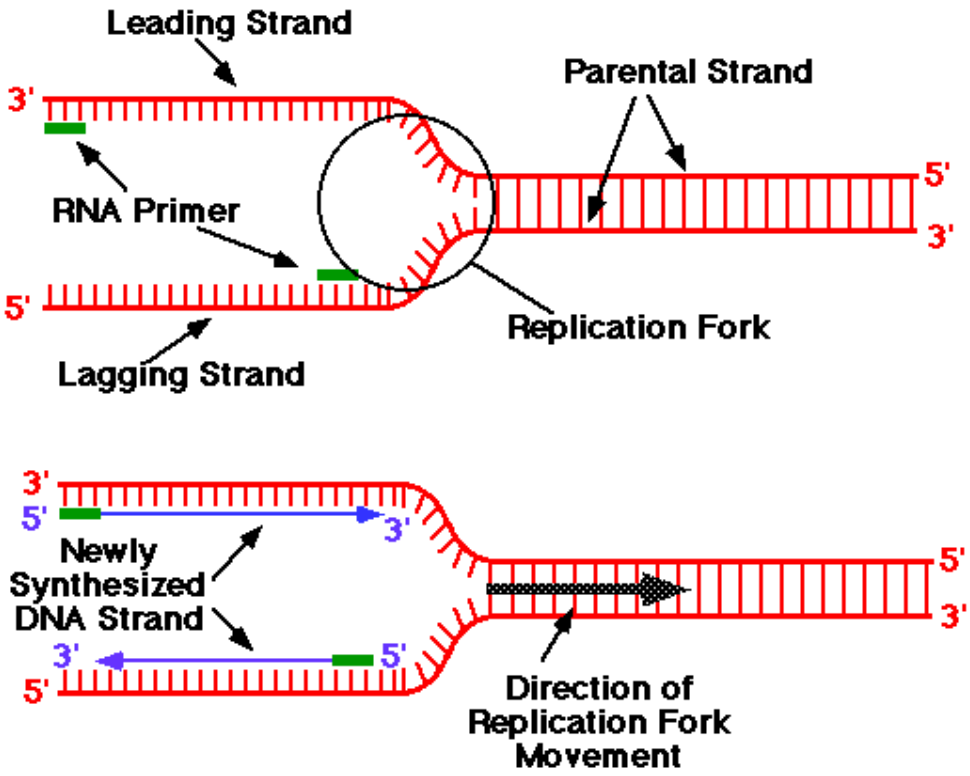




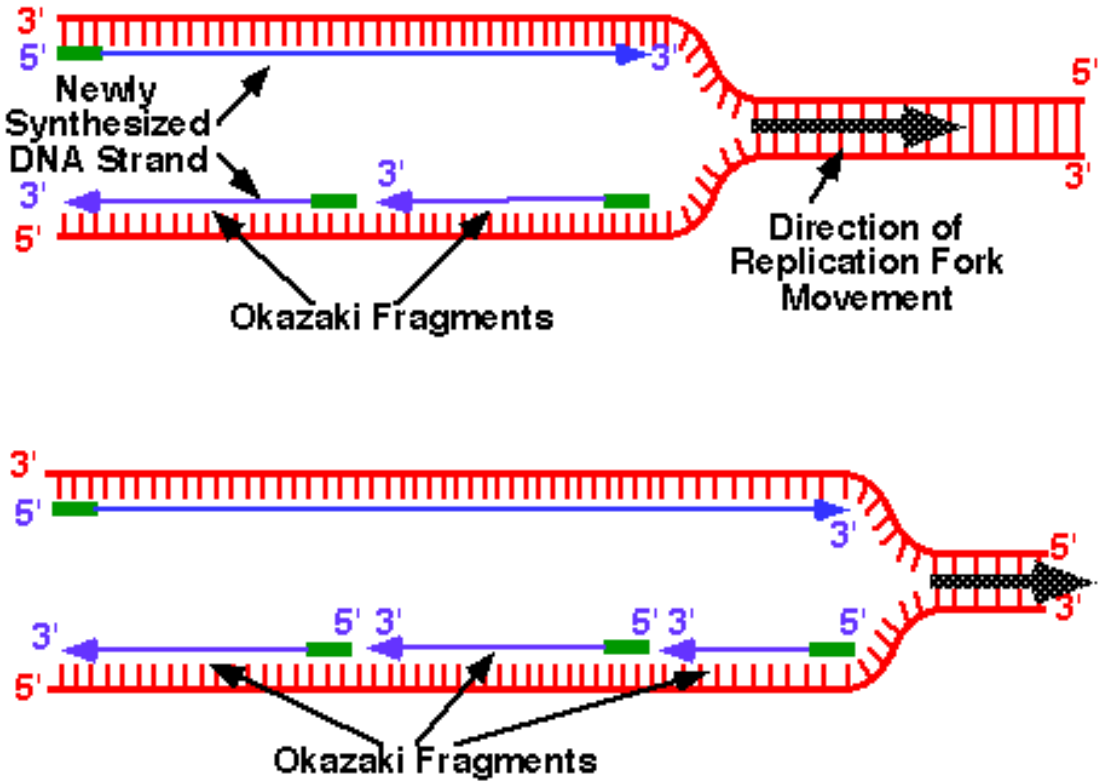


DNA replication (1)

- Helicase
  - Unwind DNA
- Single strand DNA binding protein
- Primase
  - Synthesis of RNA primer
- DNA polymerase
  - Synthesis of DNA
    - Leading and lagging strand
  - *E.coli* DNA Pol III



DNA replication (2)



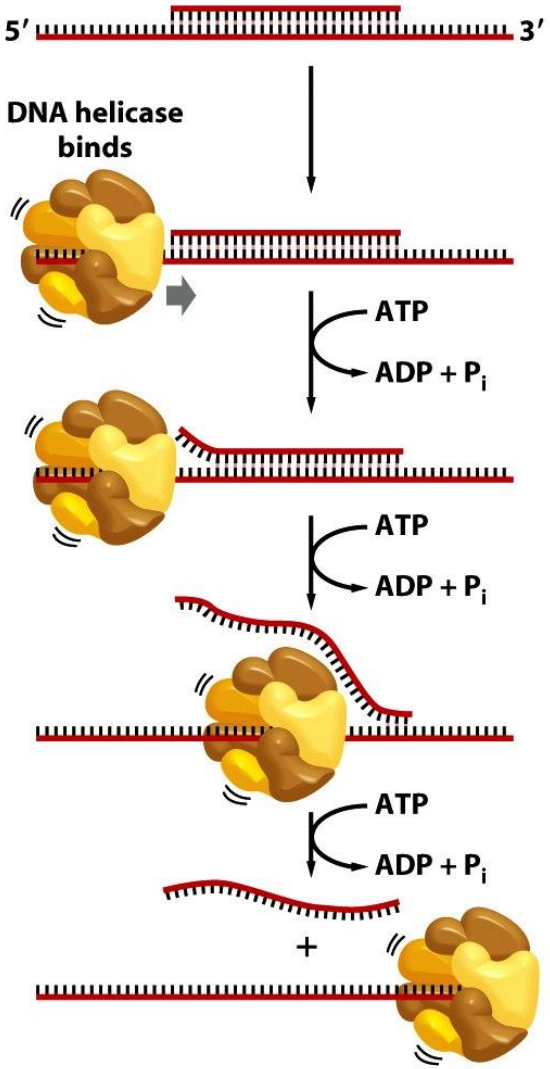
DNA Pol I: Remove RNA primer by 5' to 3' exonuclease activity

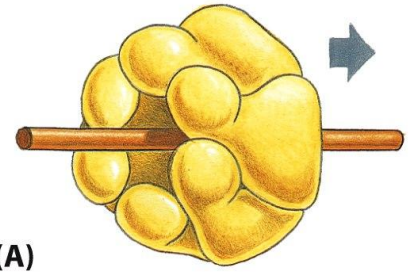
DNA Ligase: Join Okazaki Fragments

Topoisomerase: Solve topological problem

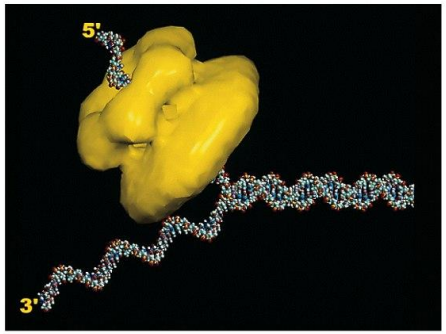
100r/sec

Helicase

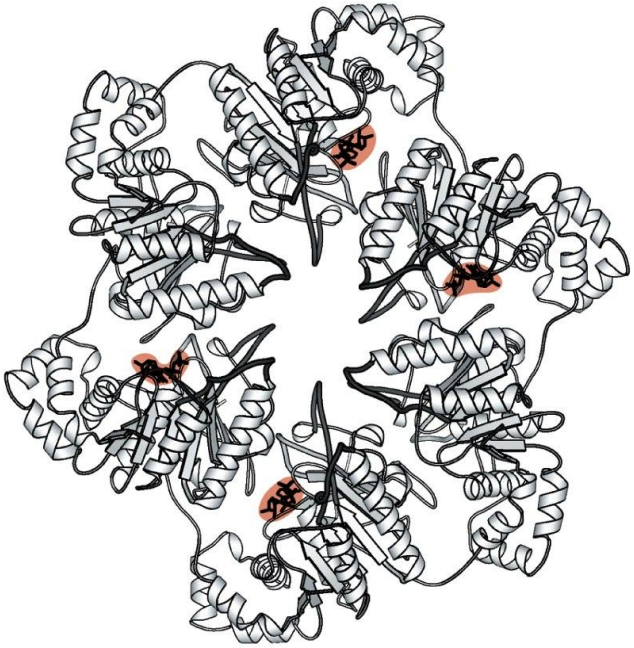




(A)

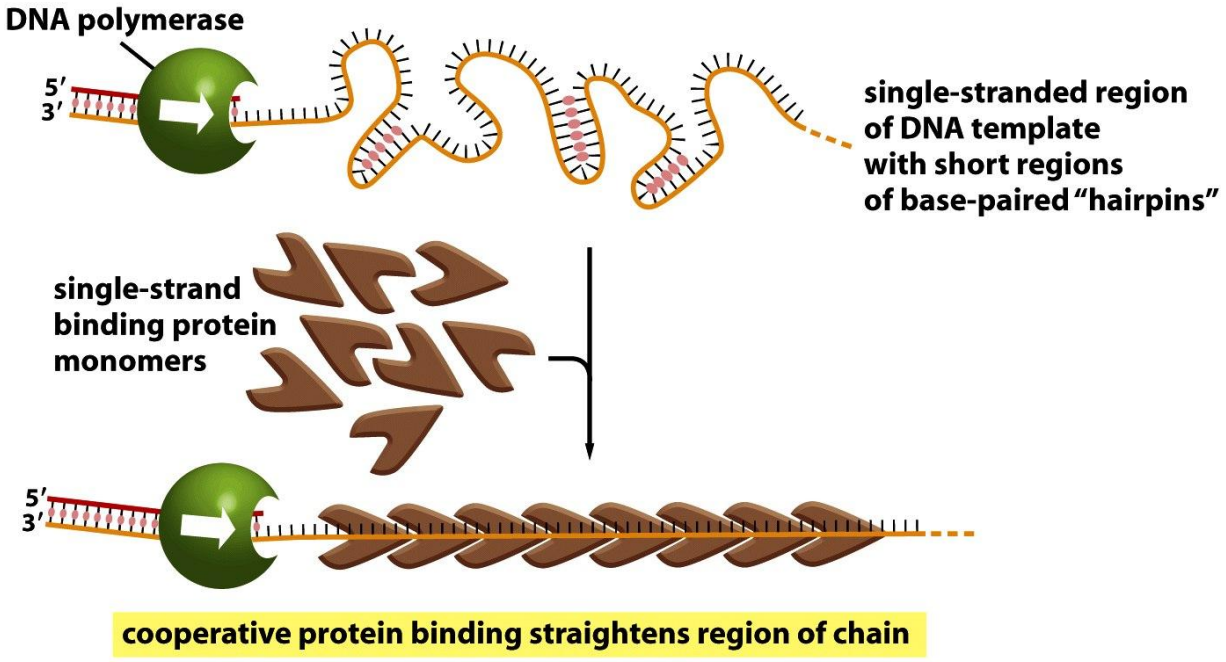


(B)

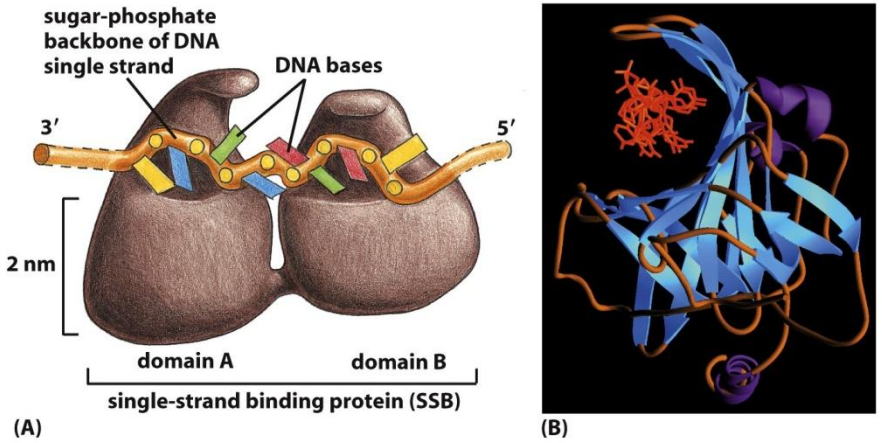


(C)

Single Stand Binding Protein

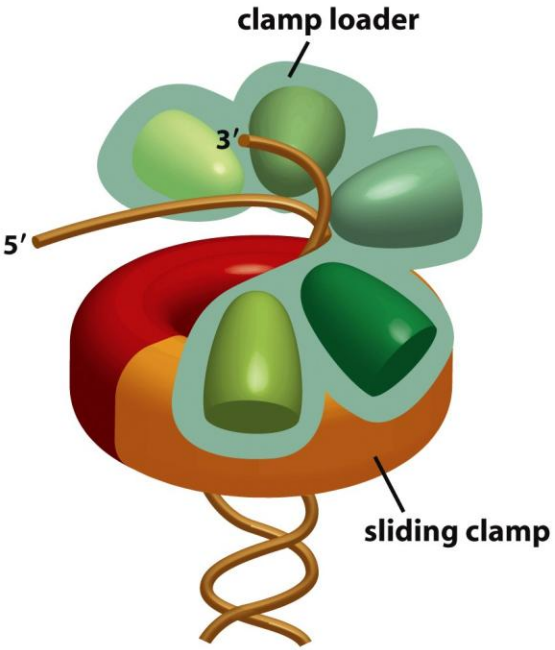


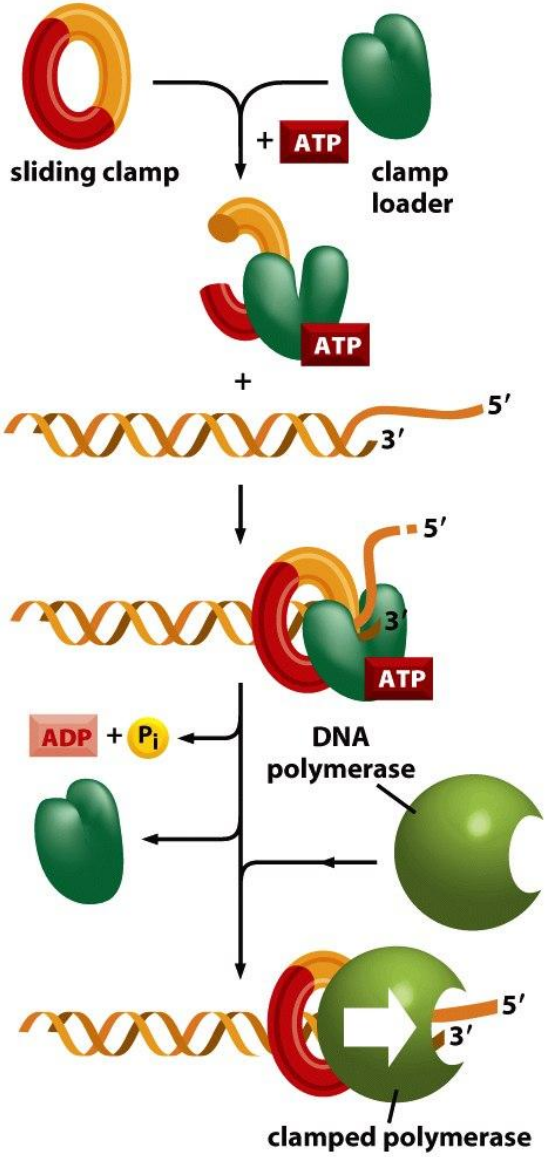
cooperative protein binding straightens region of chain



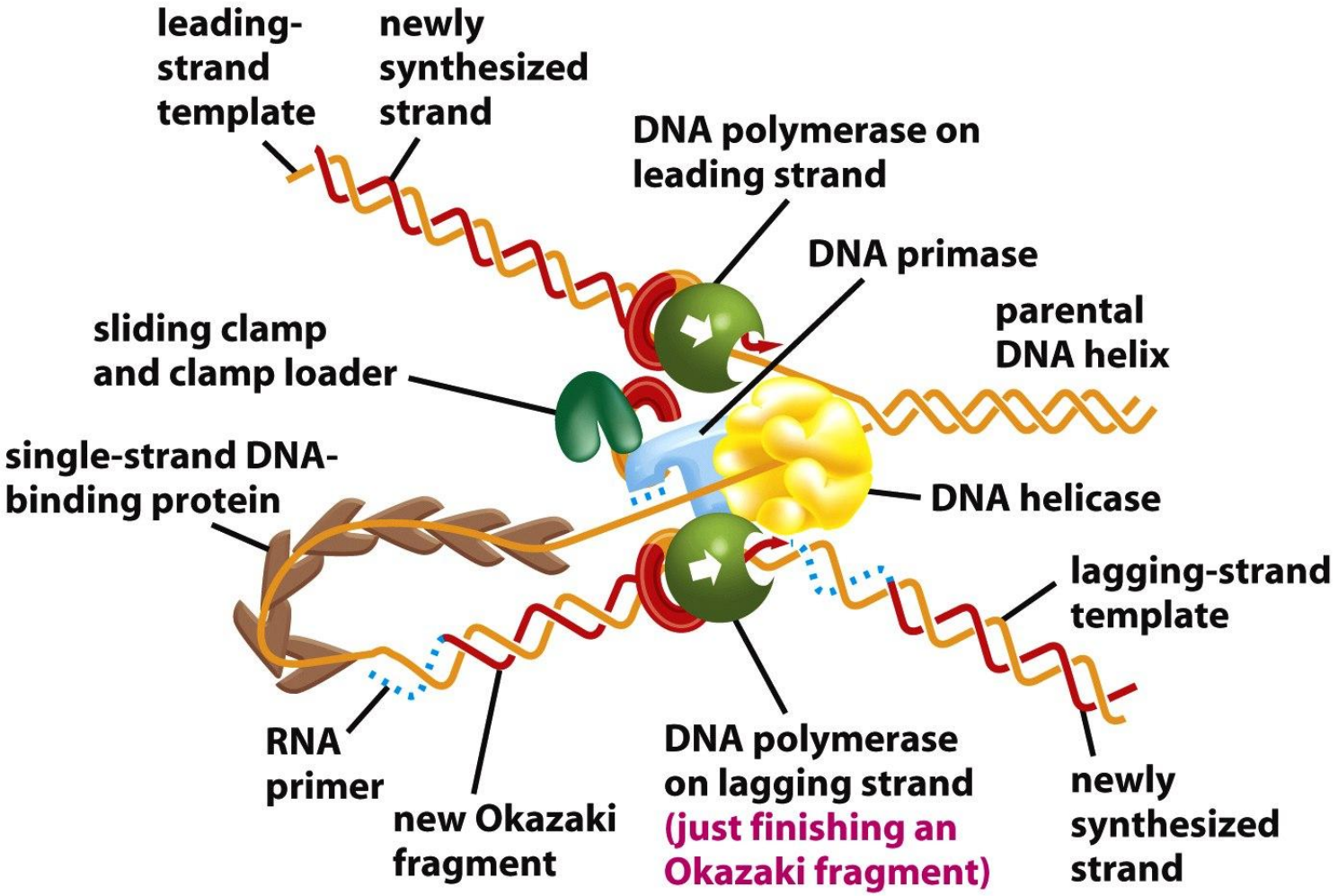
Sliding Clamp

- DNA polymerase dissociates quickly from DNA
- Sliding clamp keeps the polymerase on the DNA





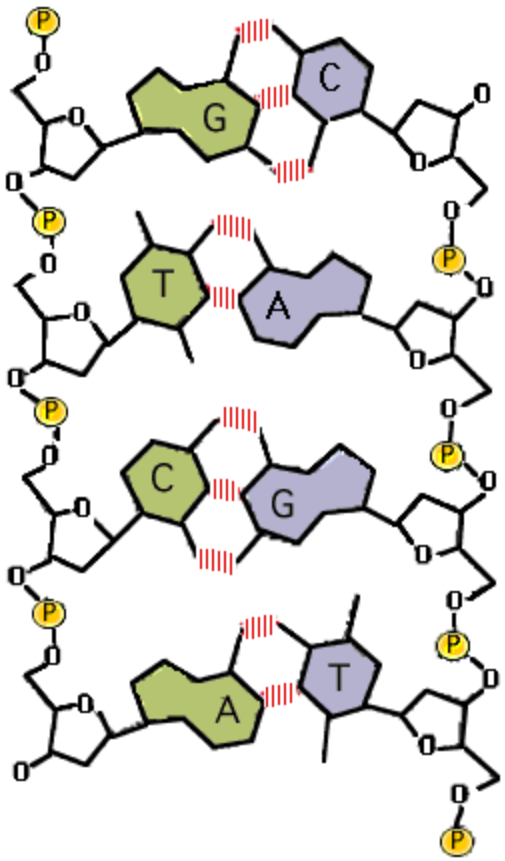
An Active Replication Fork



Prokaryotes vs. Eukaryotes : Replication

	Prokaryotes	Eukaryotes
Chromosomes	Circular	Linear
Replication Origin	One	Multiple
Telomeres	No	Yes
Replication Machinery		
DNA Polymerase	DNA pol III	DNA pol δ, DNA pol ε
Primase	dnaG	DNA pol α/Primase
Helicase	dnaB	MCM Proteins
ssDNA binding protein	SSB	RF-A
Origin Recognition	dnaA	ORC

Homework



Draw DNA structure of dGdTdCdA