

生物資訊學
分子生物學介紹
From DNA to protein

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學習目標

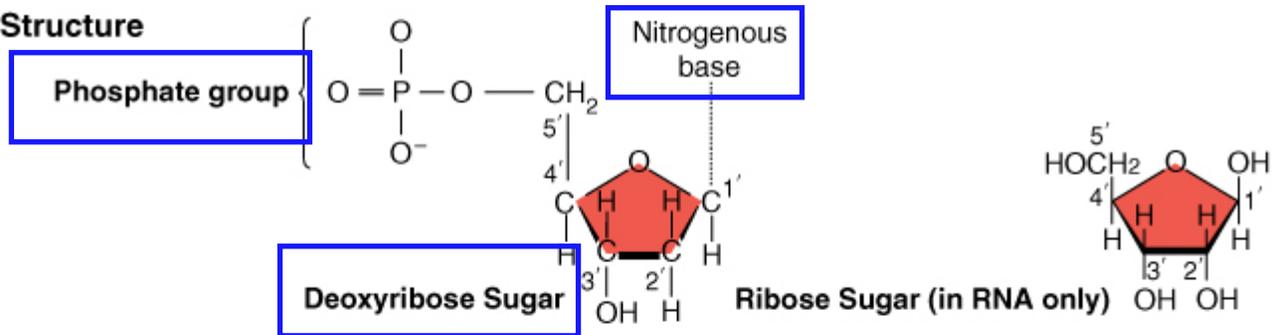
- 原核與真核生物 structures of pro- and eu-karyotic cells.
- 核苷酸的構造 structure of a nucleotide.
- 遺傳密碼 DNA的複製 DNA replication.
- 基因體 what 'genomes' are.
- 蛋白質的構造 Protein structure
- 細胞如何調控基因的表現 Regulation of gene expression
- 生物技術介紹- Cloning

Cell

- Structural and functional unit of all life forms!
- Simple vs complex
 - Bacterium vs human
 - Single cell vs $\sim 1 \times 10^{14}$ cells
- Although structurally and functionally different in most cases, all cells share at least one component:
 - Deoxyribonucleic acid (DNA)

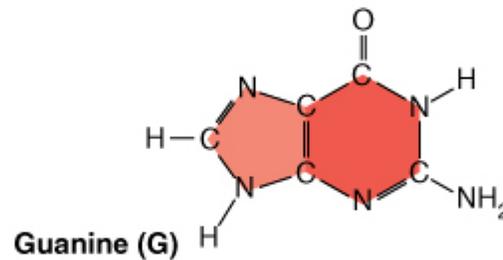
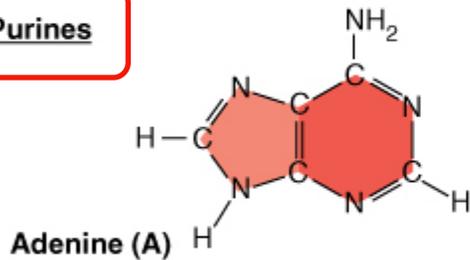
Structure of DNA/RNA

Nucleotide Structure

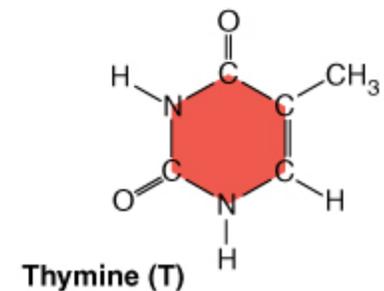
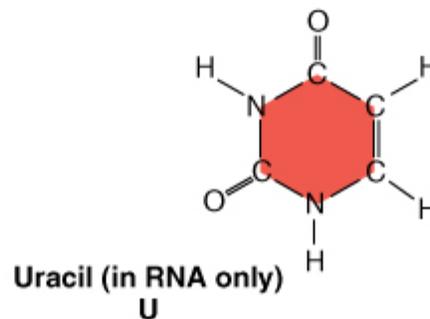
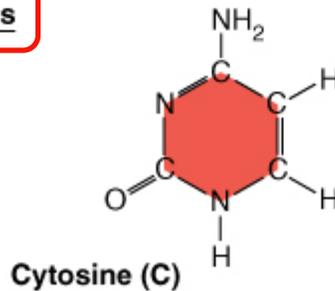


Nitrogenous Bases

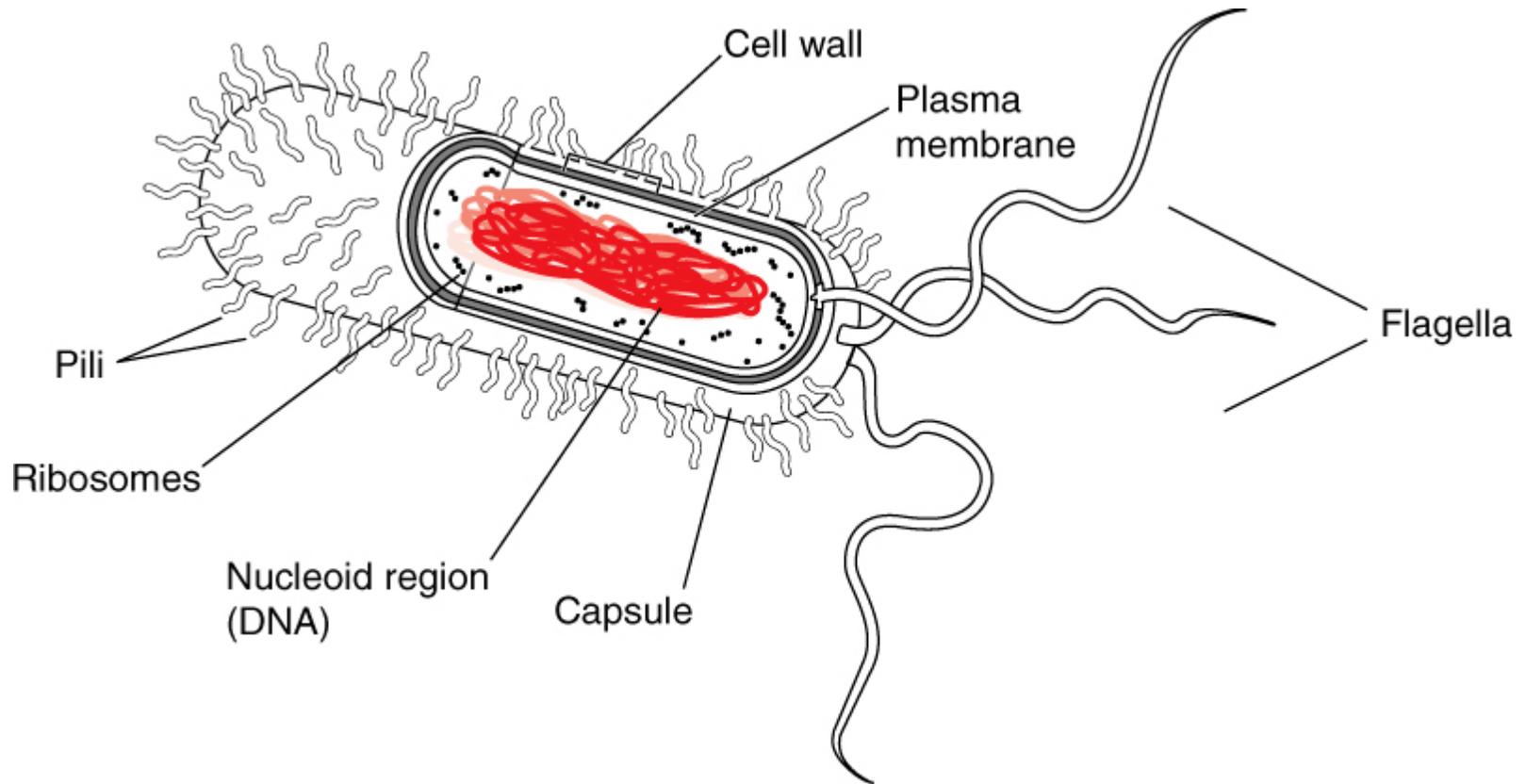
Purines



Pyrimidines



Prokaryotic cell



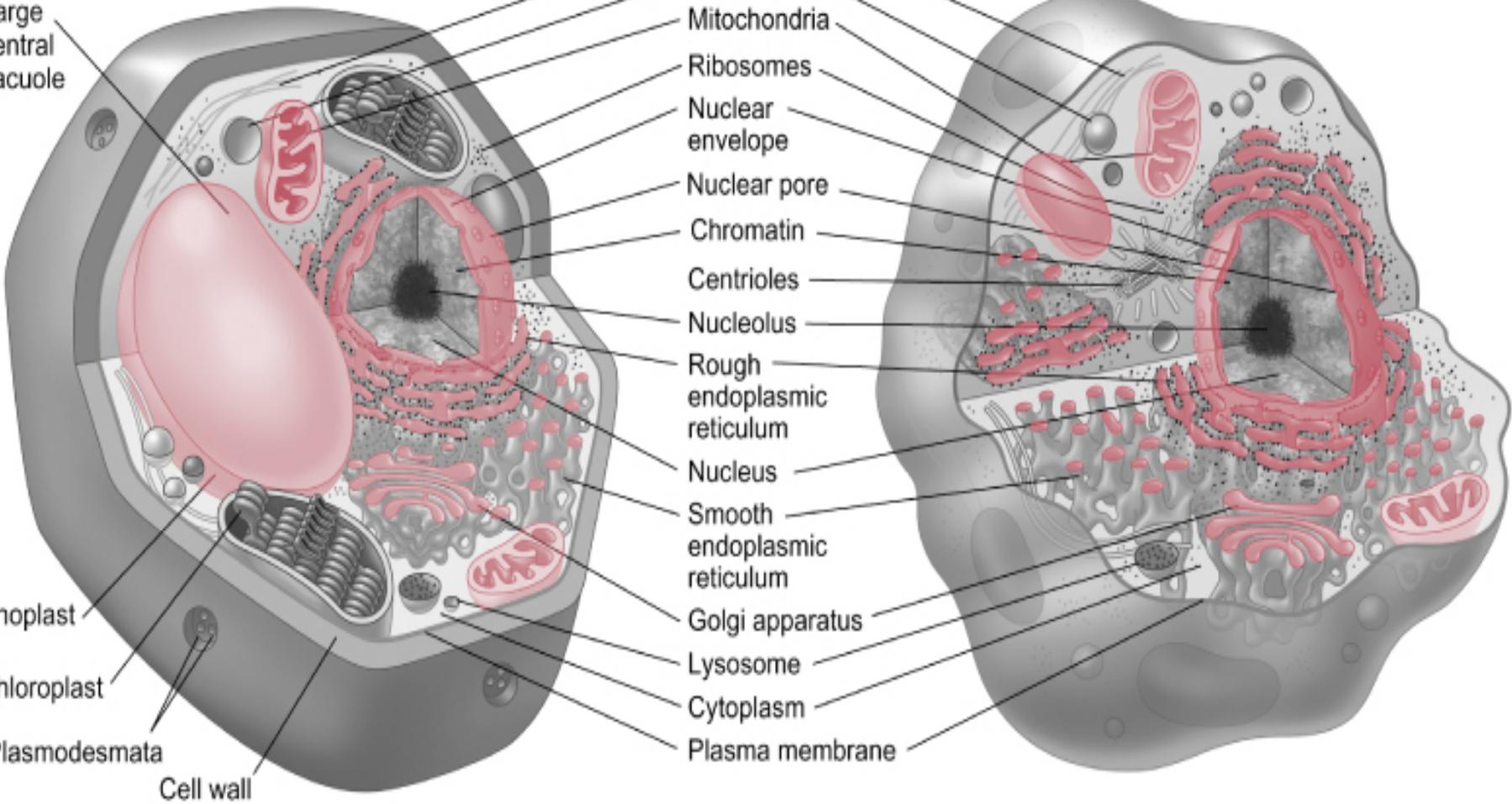
Eukaryotic cell

(a) Plant cell

(b) Animal cell

- Large central vacuole
- Tonoplast
- Chloroplast
- Plasmodesmata
- Cell wall

- Cytoskeleton
- Peroxisome
- Mitochondria
- Ribosomes
- Nuclear envelope
- Nuclear pore
- Chromatin
- Centrioles
- Nucleolus
- Rough endoplasmic reticulum
- Nucleus
- Smooth endoplasmic reticulum
- Golgi apparatus
- Lysosome
- Cytoplasm
- Plasma membrane

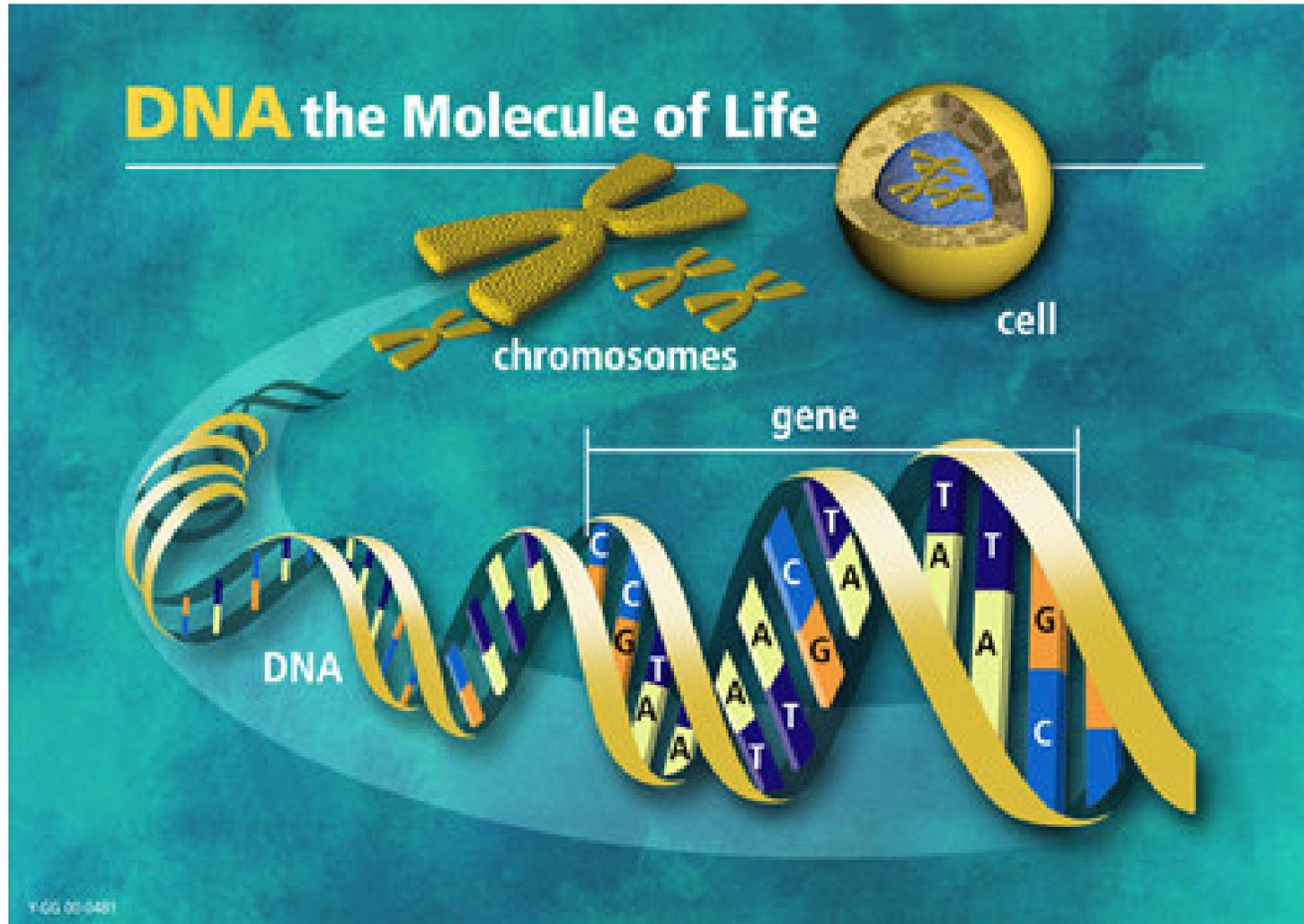


Prokaryotes vs. Eukaryotes

	Prokaryotes	Eukaryotes
Membrane Bound Nucleus	NO	YES
Membrane Bound Organelles	NO	YES

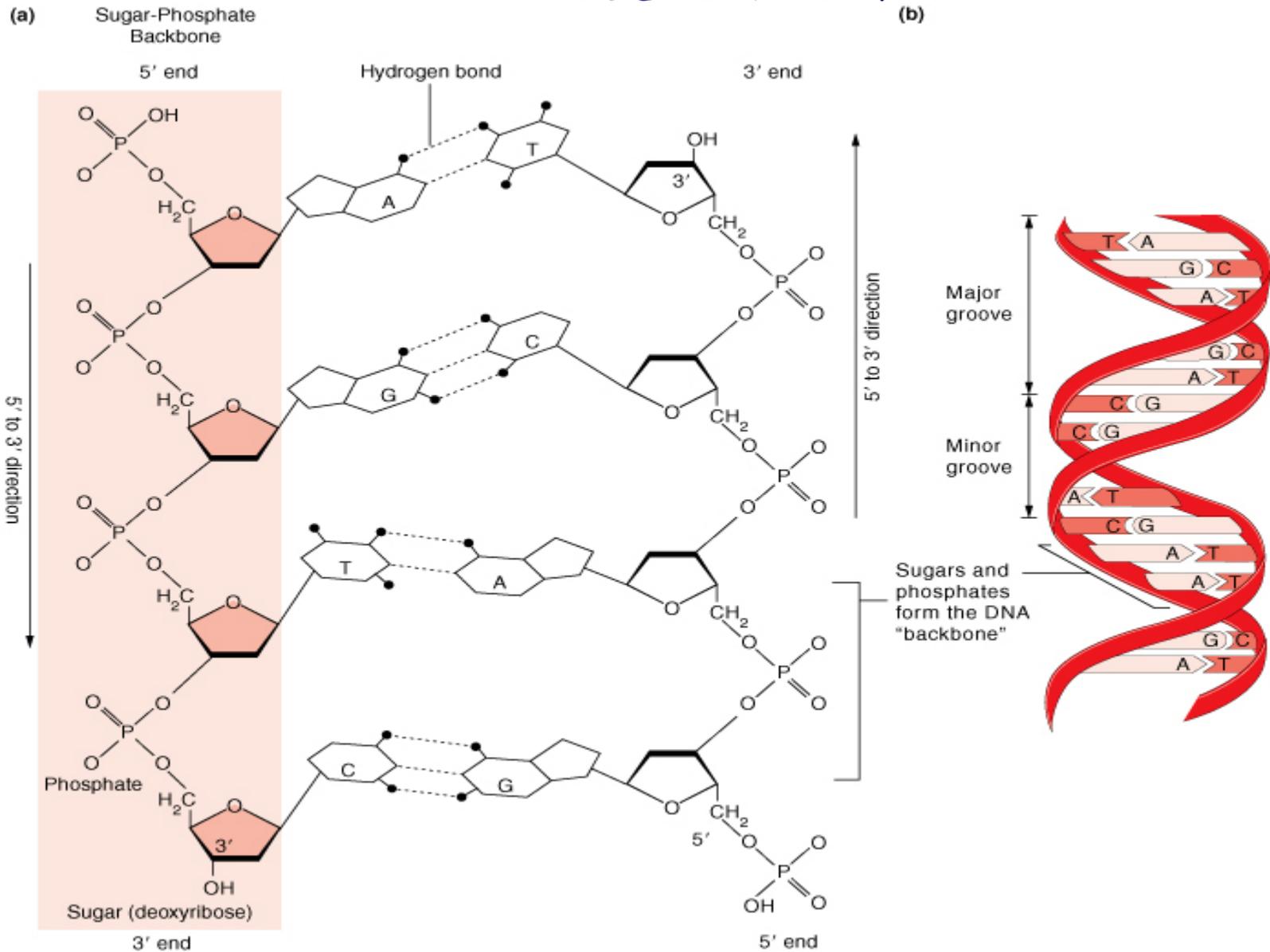
- Prokaryotes have circular DNA molecules, while eukaryotes have linear chromosomes condensed with many proteins.

DNA molecule is the inherited genetic material

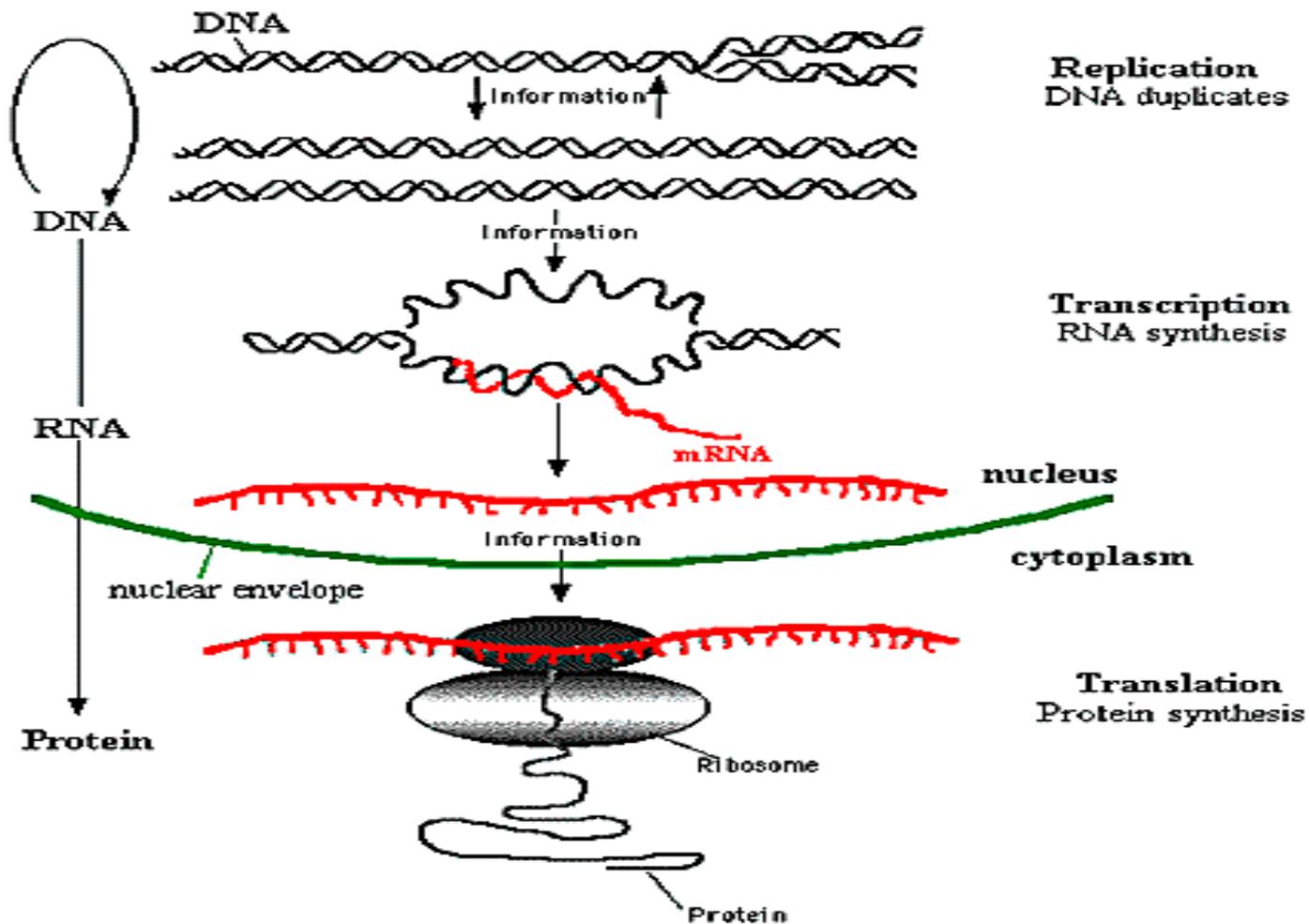


DNA is double-stranded helix

DNA的雙股螺旋構造



Central dogma 遺傳的中心法則

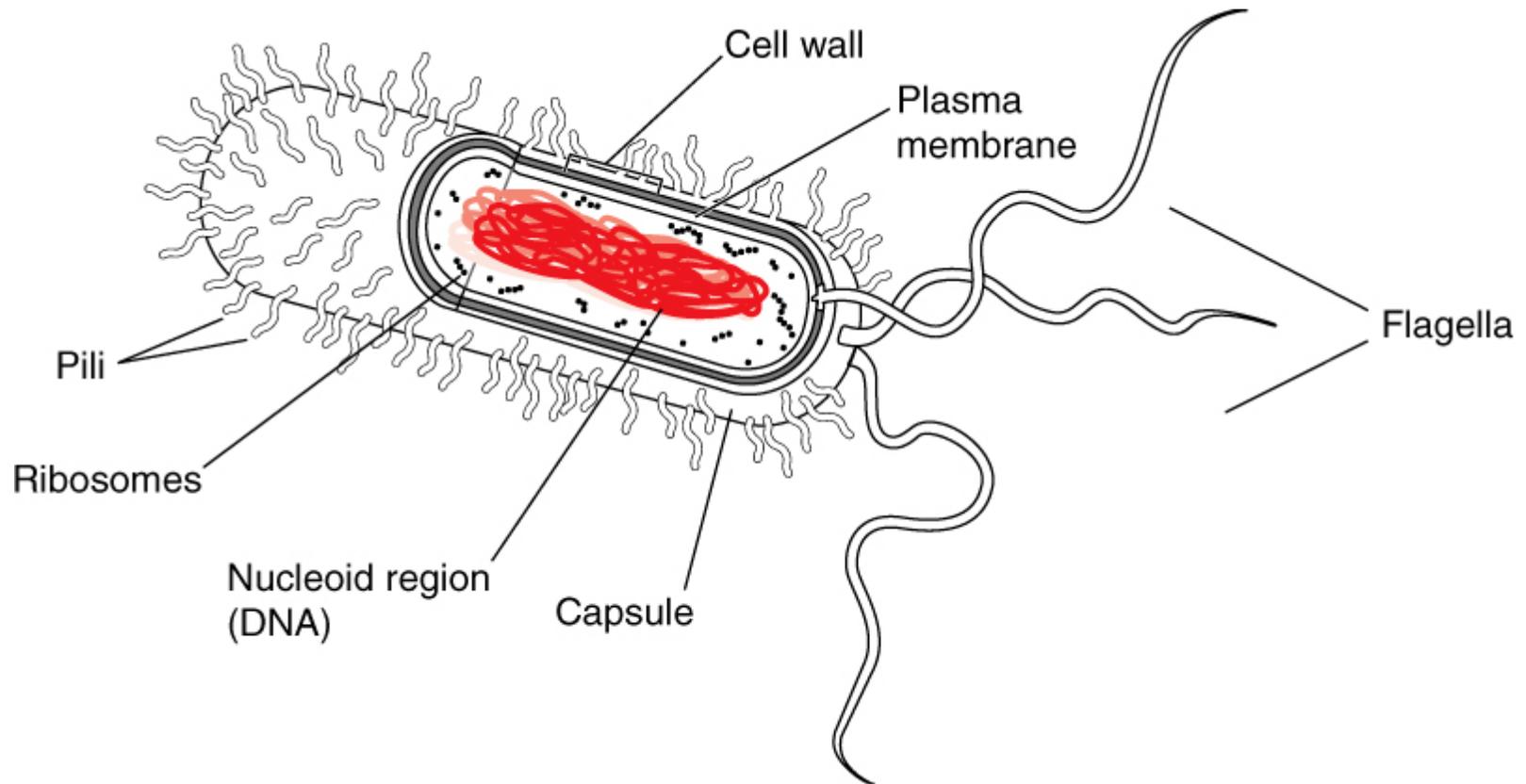


The Central Dogma of Molecular Biology

What is a gene?

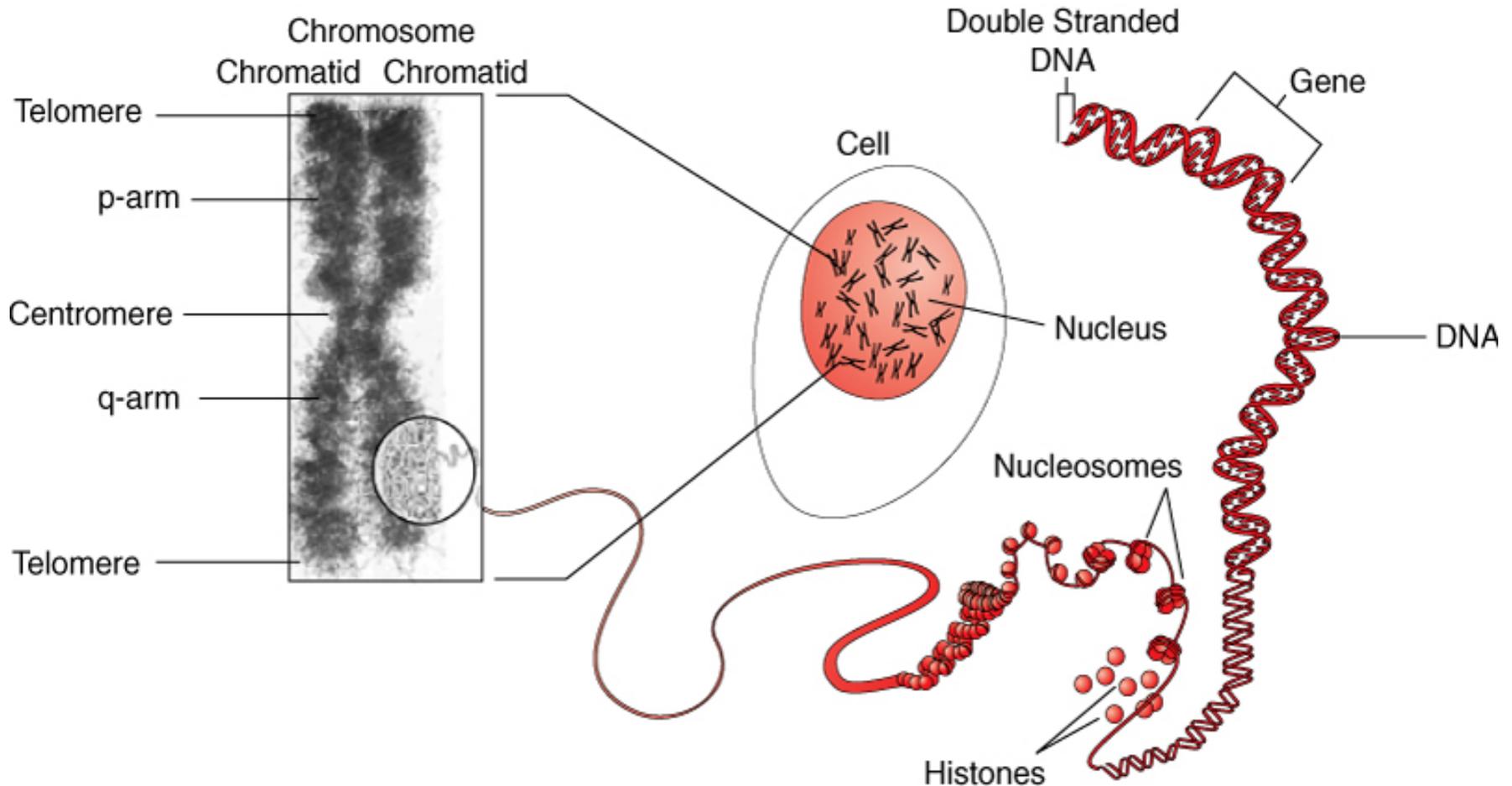
- A *sequence* of DNA that provides cells with the instructions for the synthesis of
 - a specific protein; or
 - a particular type of RNA

Prokaryotic chromosome

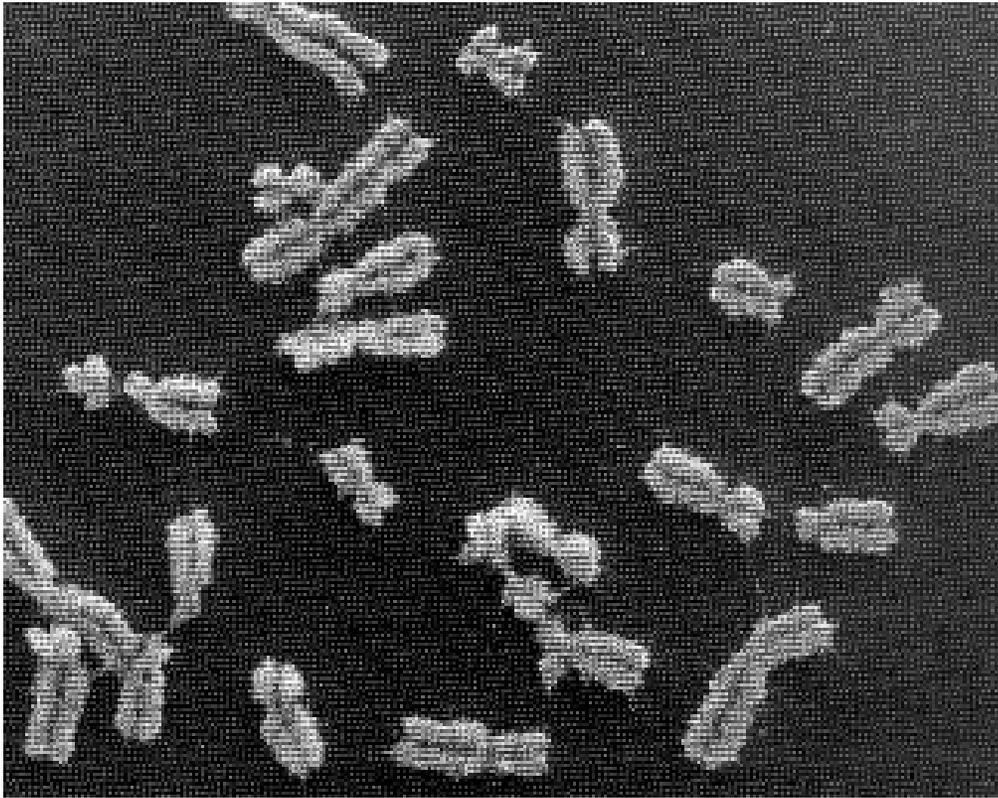


- Contains only a single circular chromosome (nucleoid)

Structure of a human chromosome

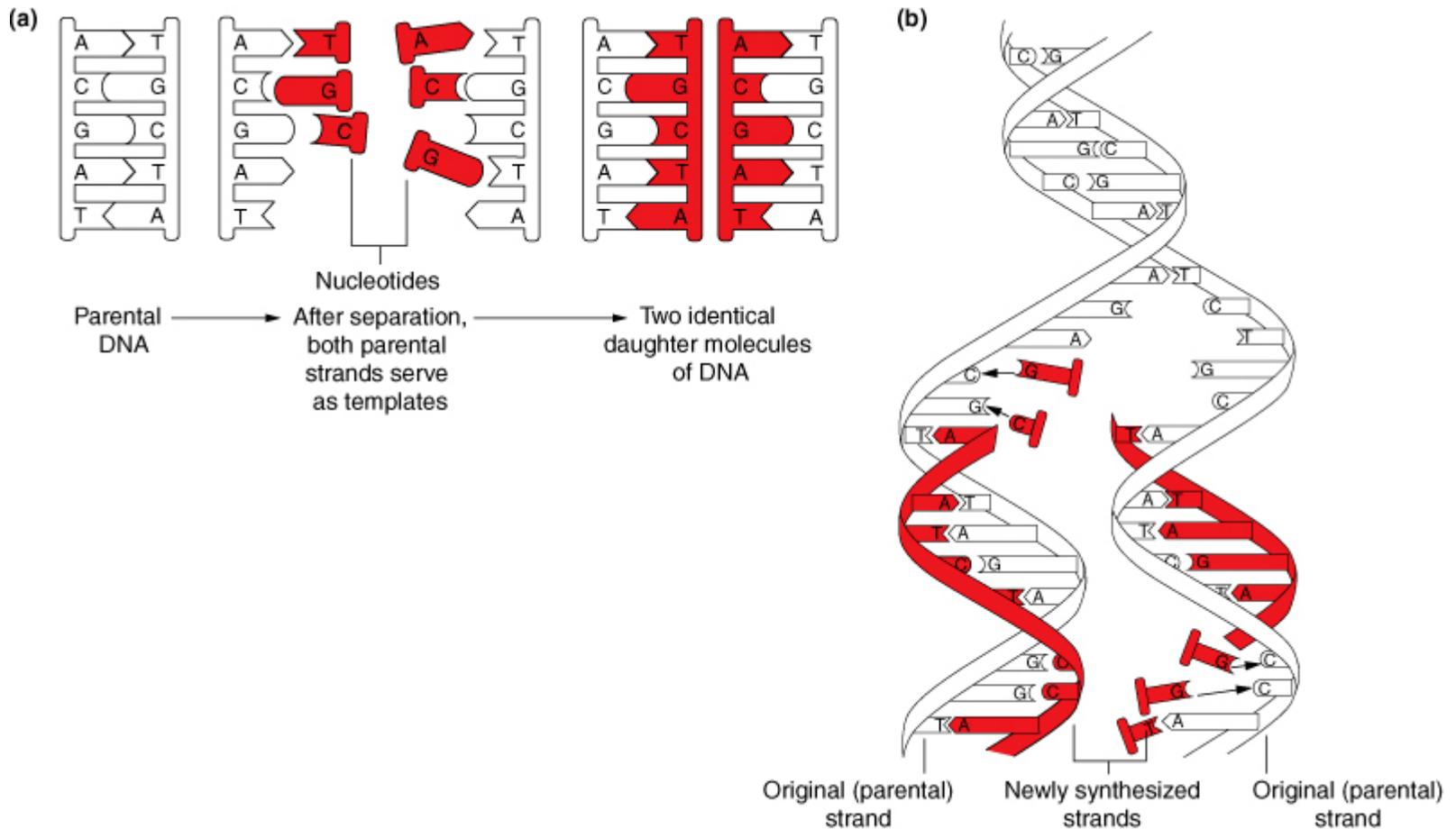


Human chromosomes

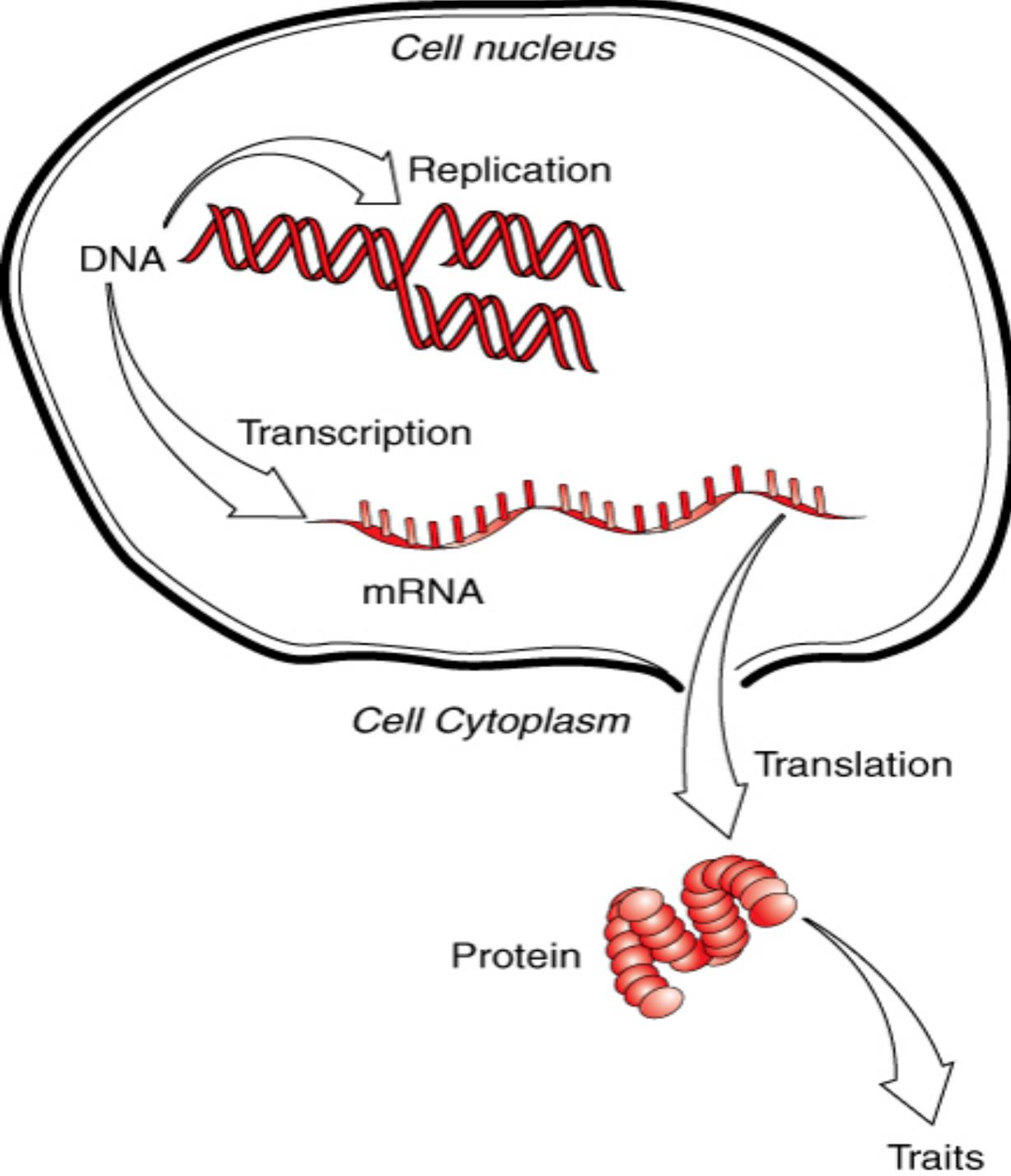


- Autosome vs sex chromosome
- 22 pairs vs 1 pair
- Each pair contains 2 homologous chromosomes (from each parent)

Overview of DNA replication (semi-conservative)



Flow of genetic information



What is transcription (轉錄)?
Where does it occur?

How does this process differ
in prokaryotes vs eukaryotes?



Different types of RNAs produced by transcription

■ mRNA

- Messenger RNA (contains 'genetic code')
- Contains information for translation (protein synthesis)

■ tRNA

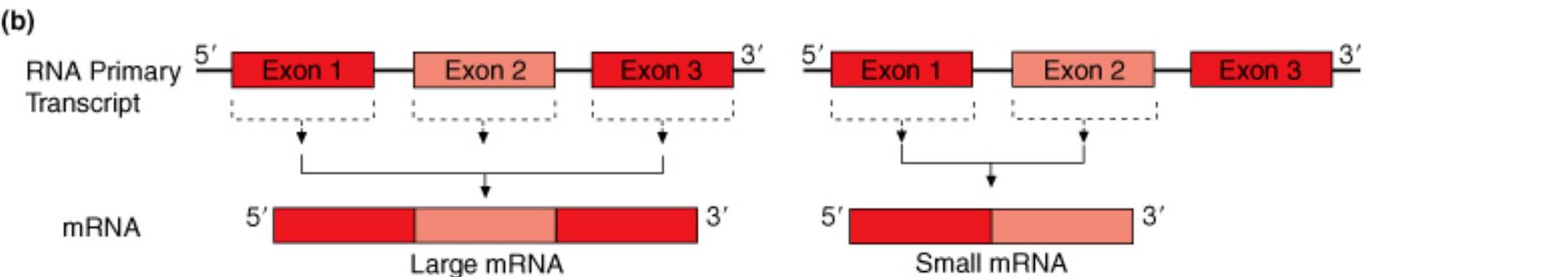
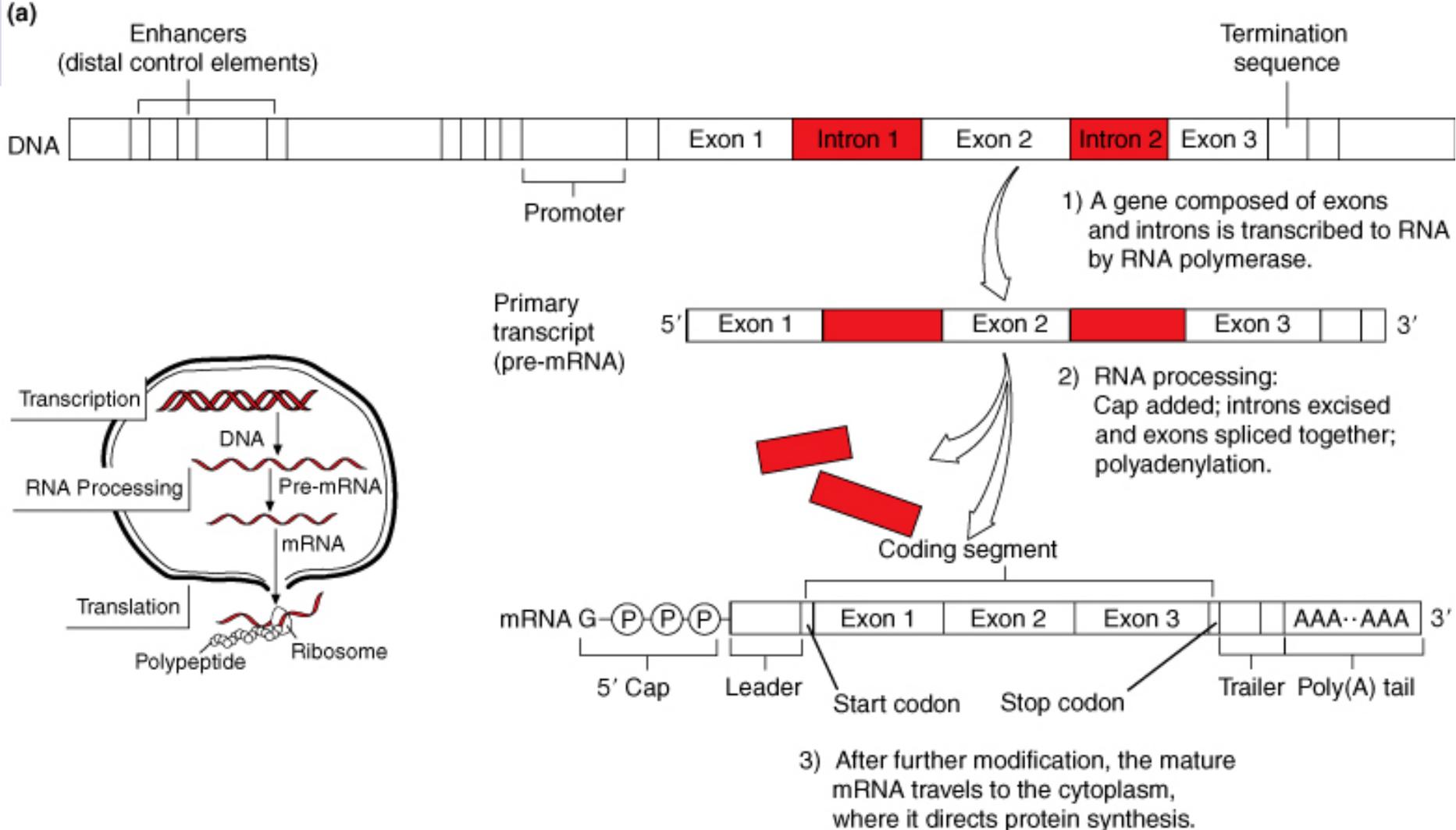
- Transfer RNA
- carries amino acid (a.a.)

■ rRNA

- Ribosomal RNA
- Constitutes physical location for translation

Processing of mRNA in eukaryotes

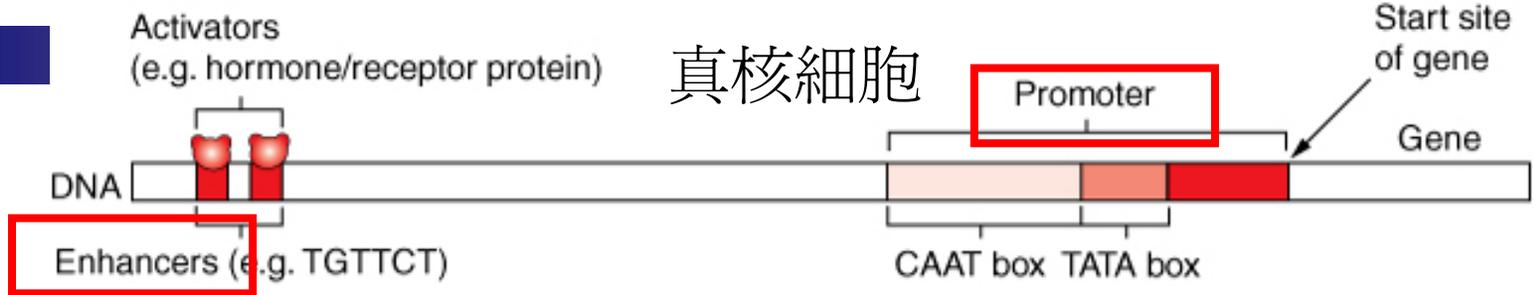
- Capping
 - Occurs at 5' end
- Poly adenylation
 - Poly(A) tailing
 - Occurs at 3' end
- RNA splicing
 - Removal of introns





Regulation of gene expression

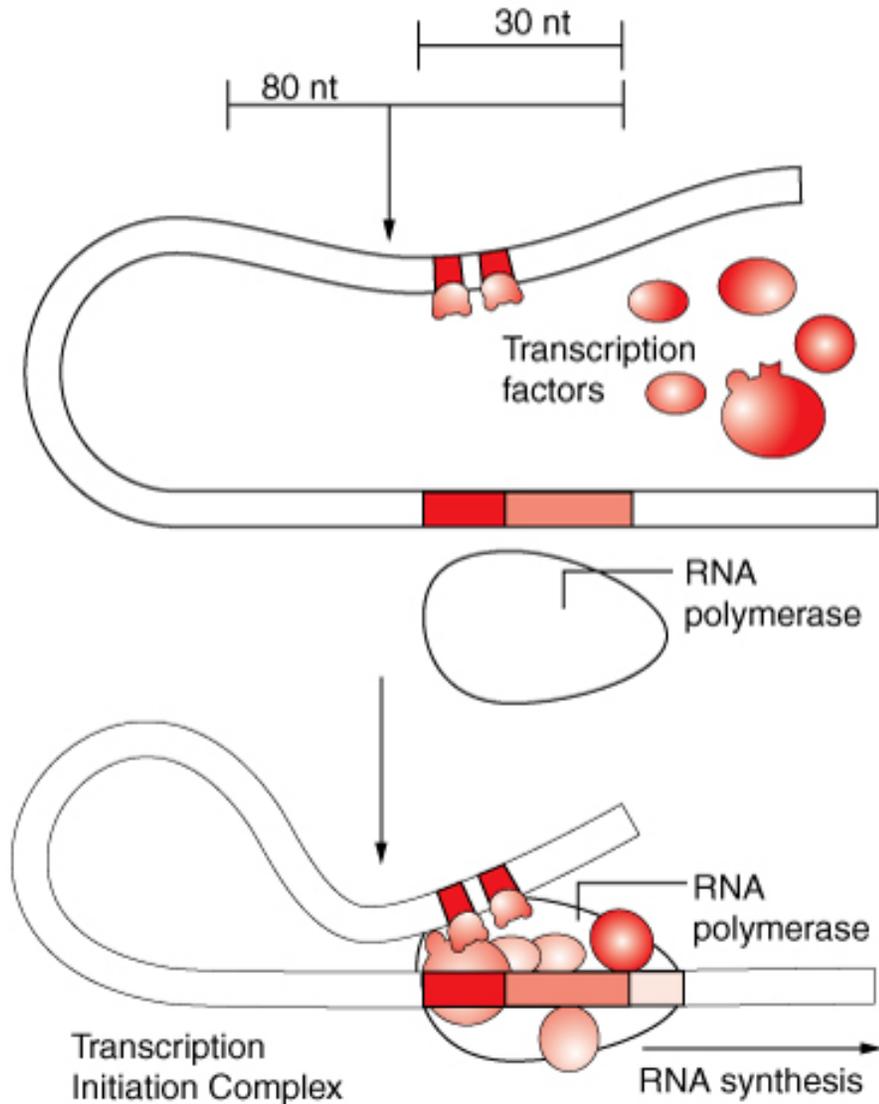
生物如何調控基因表現



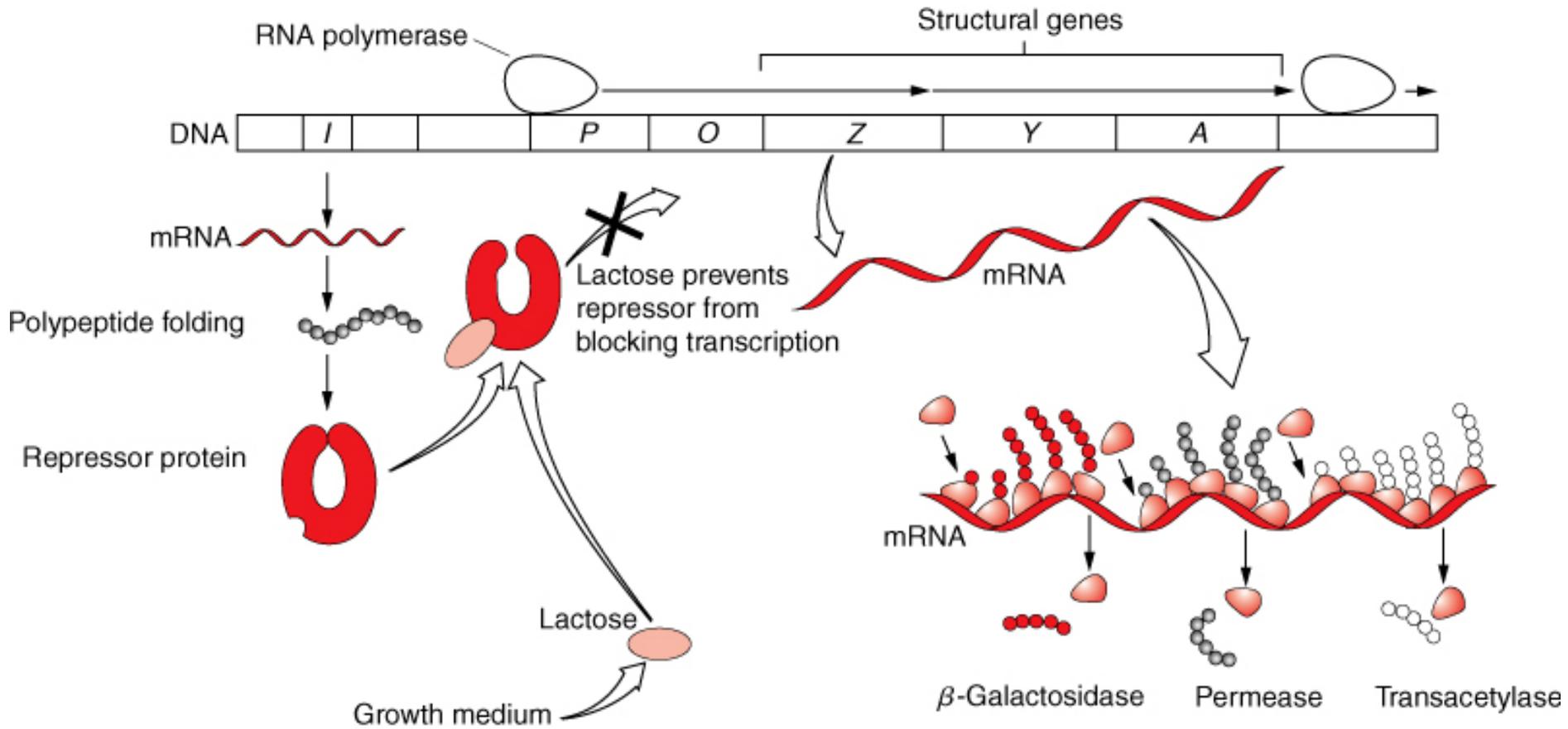
1) Activator proteins bind to enhancer sequences in the DNA.

2) DNA bending brings the bound activators closer to the promoter. Other transcription factors and RNA polymerase are nearby.

3) Protein-binding domains on the activators attach to certain transcription factors and help them form an active transcription initiation complex on the promoter that stimulates RNA synthesis by RNA polymerase.



原核細胞 (operon, 操作組)



How many types of RNAs does translation require?

- mRNA
- tRNA
- rRNA

- ALL three of these!!

Genetic code 通用遺傳密碼

- Information located on mRNA that directs proper tRNA molecules to carry corresponding amino acid residues to ribosome (composed of rRNA) during translation.
- 20 amino acids (a.a.)
- Codon = three-nucleotide units on mRNA
 - e.g. UUU, AUC, ACG,

First Letter	Second Letter								Third Letter
	U		C		A		G		
U	UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys	U
	UUC		UCC		UAC		UGC		C
	UUA	Leu	UCA	Ser	UAA	Stop	UGA	Stop	A
	UUG		UCG		UAG		UGG	Trp	G
C	CUU	Leu	CCU	Pro	CAU	His	CGU	Arg	U
	CUC		CCC		CAC		CGC		C
	CUA	Leu	CCA	Pro	CAA	Gln	CGA	Arg	A
	CUG		CCG		CAG		CGG		G
A	AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser	U
	AUC		ACC		AAC		AGC		C
	AUA	Ile	ACA	Thr	AAA	Lys	AGA	Arg	A
	AUG	Met	ACG		AAG		AGG		G
G	GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly	U
	GUC		GCC		GAC		GGC		C
	GUA	Val	GCA	Ala	GAA	Glu	GGA	Gly	A
	GUG		GCG		GAG		GGG		G

To what extent do DNA sequences vary
among different people?



SNP

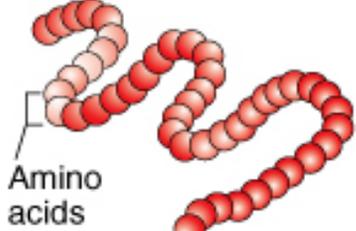
- Single nucleotide polymorphism
 - Substitutions of individual nucleotides
 - Most genetic variation between human genomes occur in this type
 - Mostly in the intron of the gene
 - Harmless in most cases



Structure of Proteins

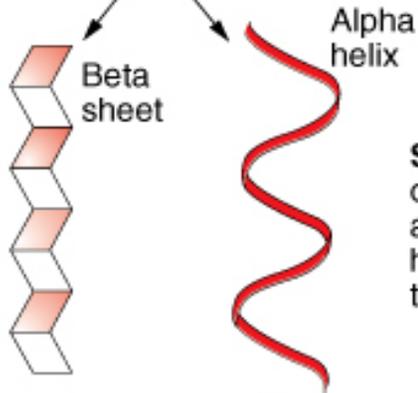
Protein structure

蛋白質的四級結構



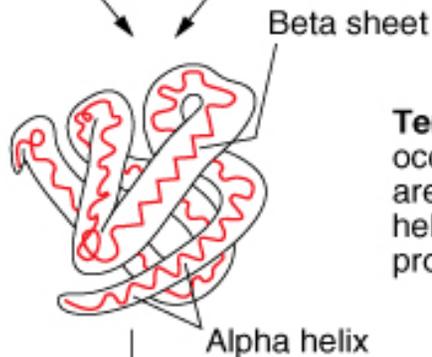
Primary protein structure is the sequence of a chain of amino acids

一級結構



Secondary protein structure occurs when the sequence of amino acids is linked by weak hydrogen bonds into one or two structural forms

二級結構
(氫鍵為主)



Tertiary protein structure occurs when certain attractions are present between alpha helices and beta sheets producing a unique 3D structure

三級結構
(氫鍵、離子鍵、共價鍵)

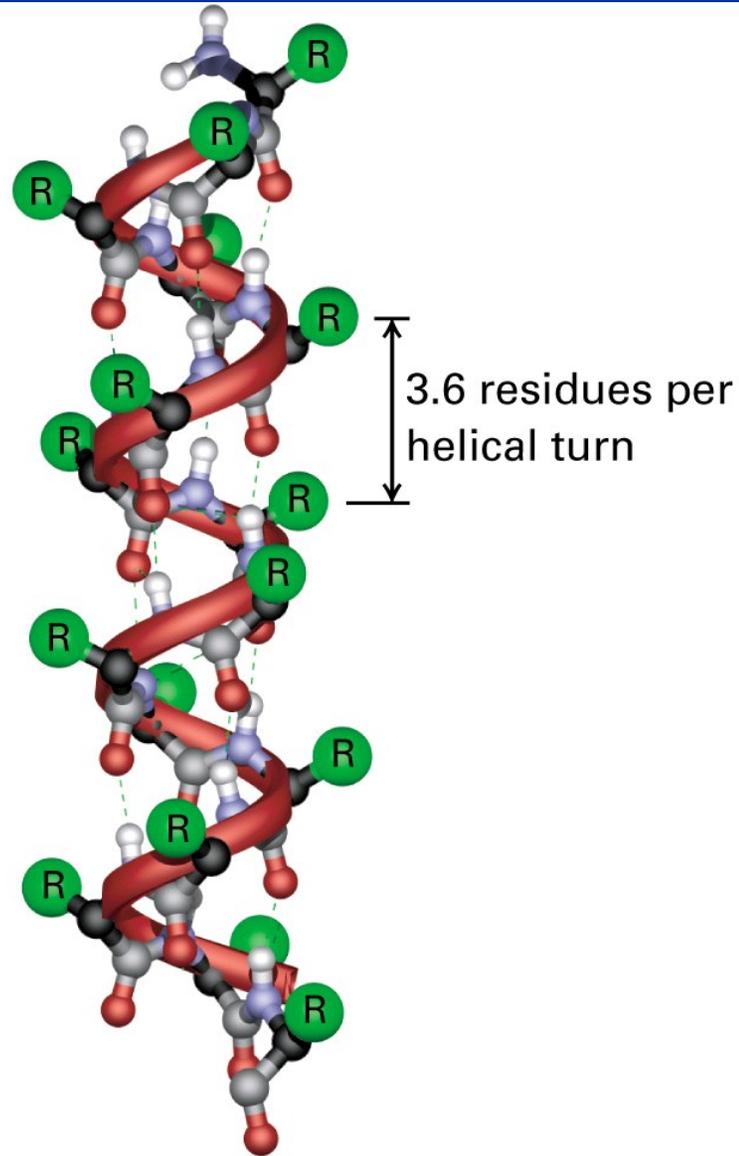


Quaternary protein structure is a protein consisting of more than one amino acid chain, each participating in the final 3D shape

四級結構 (兩個次單位以上)

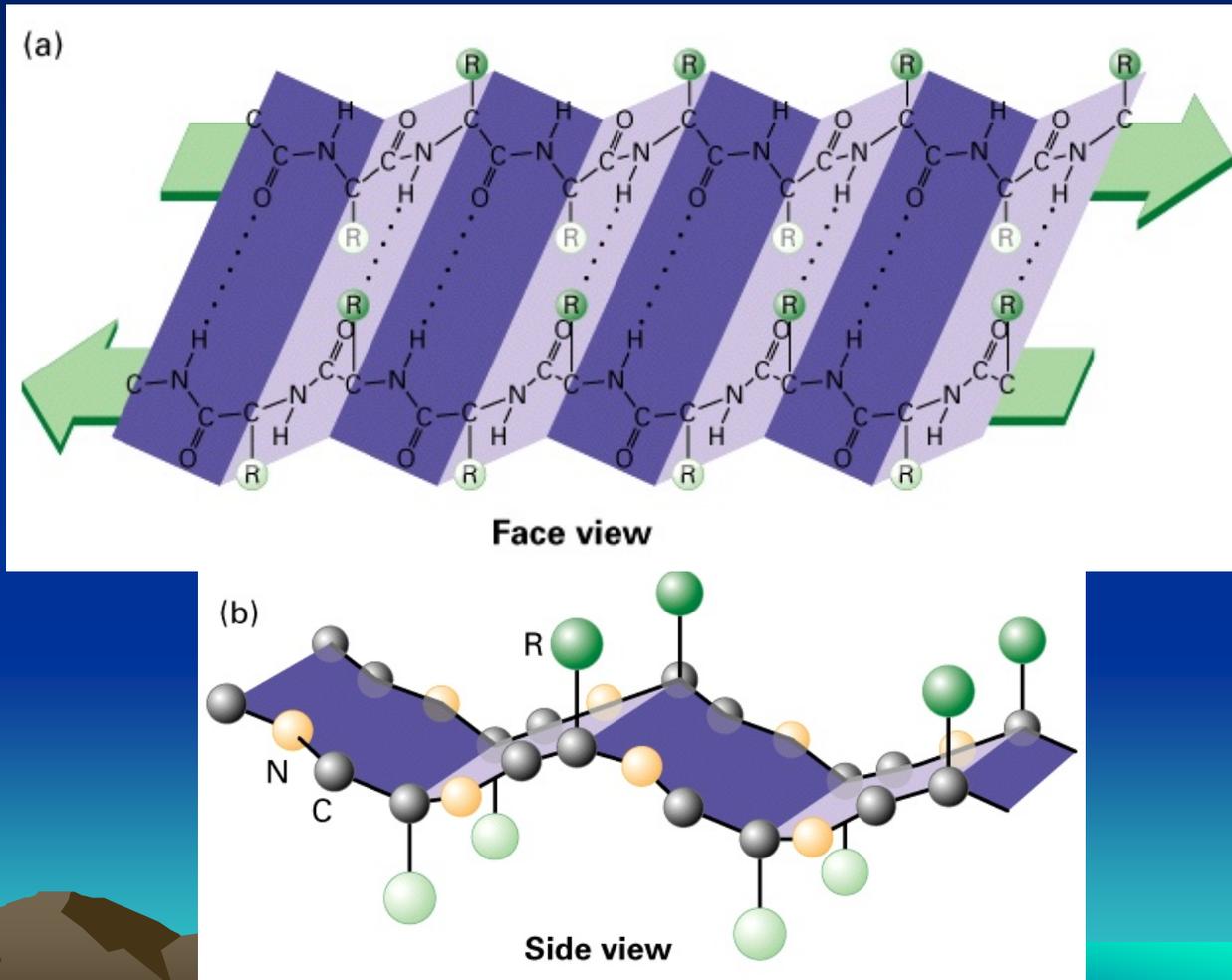
1. Primary structure
2. Secondary structure
3. Tertiary structure
4. Quaternary structure

蛋白質的二級結構- α 螺旋



Secondary structure: the β - sheet

二級結構- β 摺疊



Protein folding 蛋白質摺疊

- Correct folding depends on correct linkage between two main structures
 - structures:
 - α -helix, β -sheet



- 現代生物技術 –
recombinant DNA 重組DNA

