Review III: Cellular Processes

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Outline

- Metabolism
- Cell cycle
- Transcription and RNA processing
- Translation: protein synthesis
- Signal transduction
- Immune response
- Disease states

Metabolism

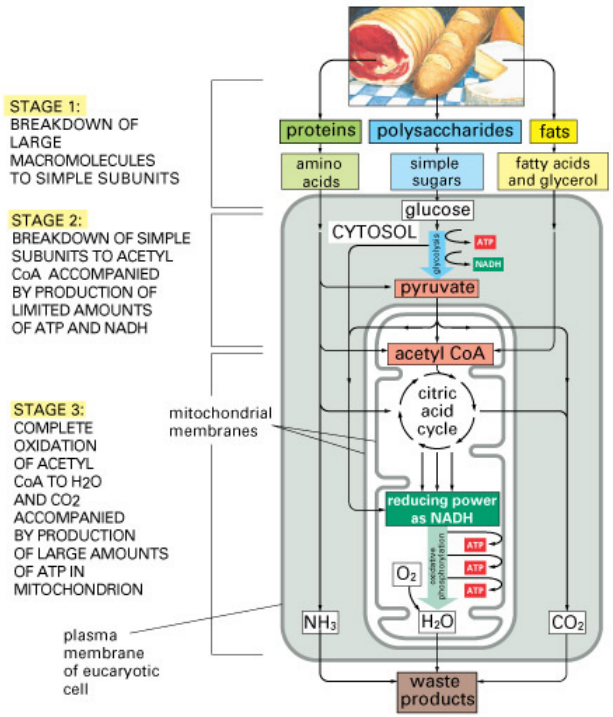
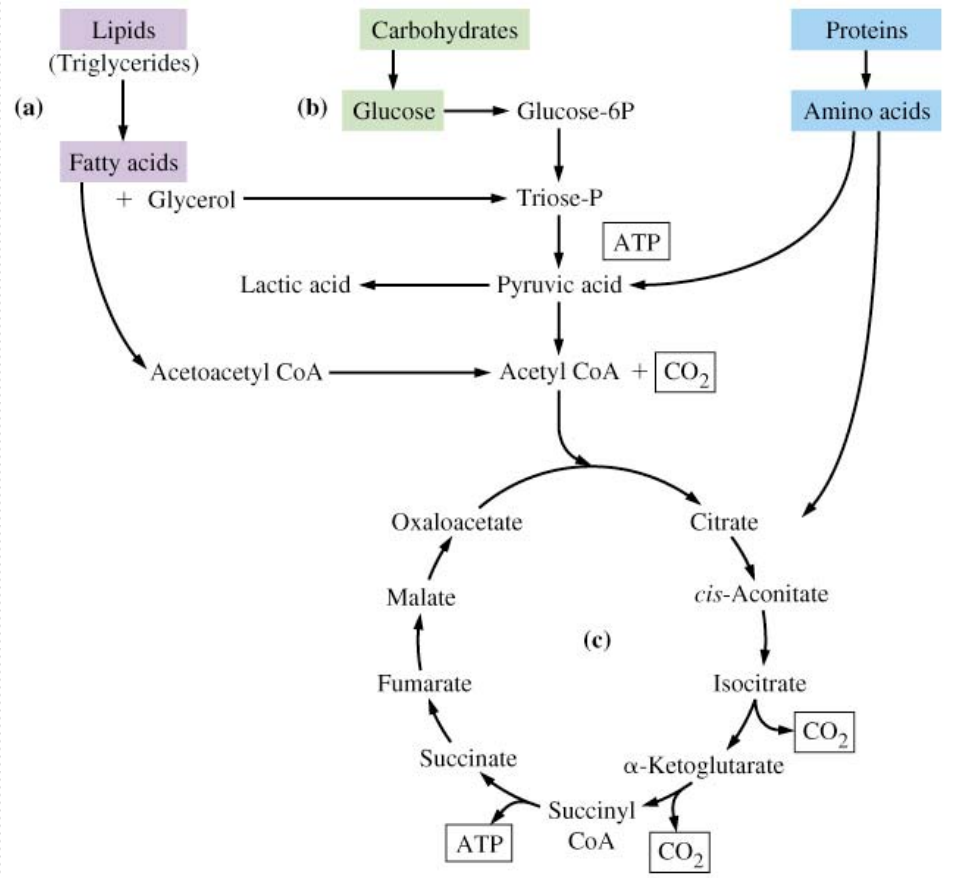


Figure 13-2 Essential Cell Biology, 2/e. (© 2004 Garland Science)

Metabolism (continued)



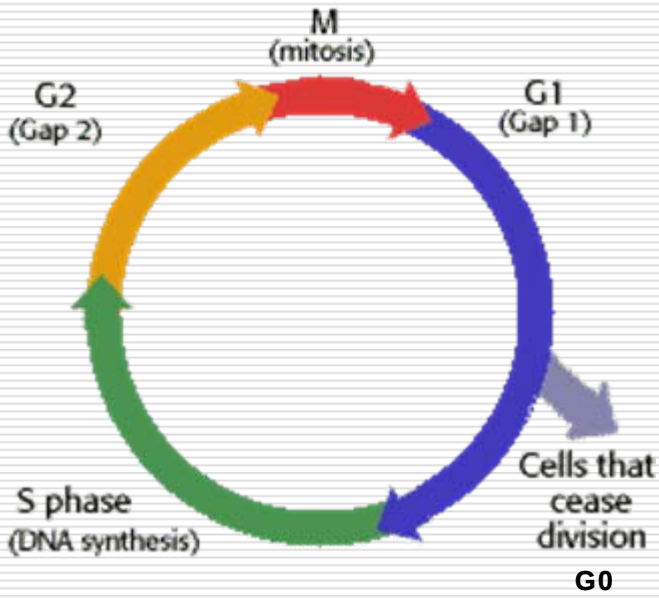
(ATP formation)

Regulation via Phosphorylation

- Phosphorylation and dephorphorylation regulate many key events
- Cell cycle control
- Signal transduction
- Transcription

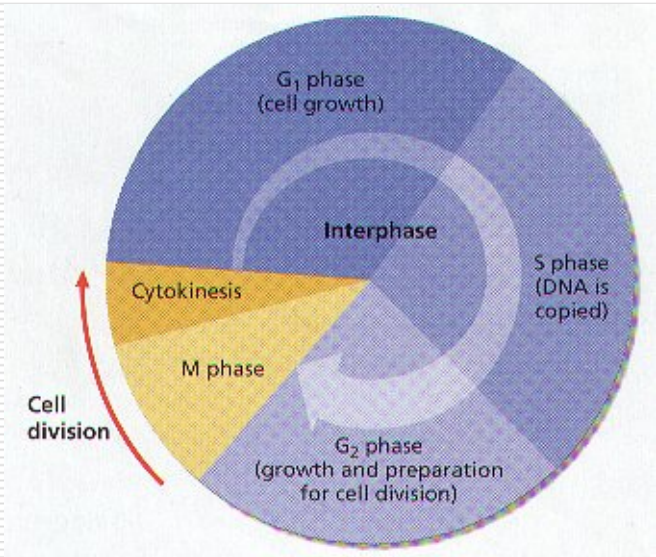
Cell Cycle

- Four phases of the cell cycle:
- Mitosis (M phase)
- Gap 1 (G1 phase)
- DNA Synthesis (S phase)
- Gap 2 (G2 phase)
- A fifth "phase": G0 (quiescence)



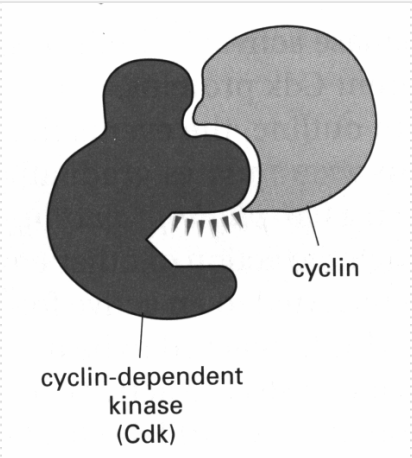
Cell Cycle Phases

- M: cell division; each cell gets 1 copy of the genome
- G1: cell growth; preparation for DNA replication
- S: DNA synthesis (replication)
- G2 : preparation for M phase
- M phase animations: (1) (2)



Cell Cycle Control

- Web animation (link)
- Checkpoints controlled by proteins
- Important group of checkpoint proteins are the cyclins
- Cyclin levels "cycle" during different phases
- Cyclins, by themselves, are inactive
- Associate with cyclin-dependent kinases (cdk)
- Cdk levels invariant throughout the cell cycle
- G1 cyclin — cyclin D (cdk4)
- S-phase cyclins — cyclins A and E (cdk2)
- G2 cyclins — cyclin B (cdc2 (cdk1))

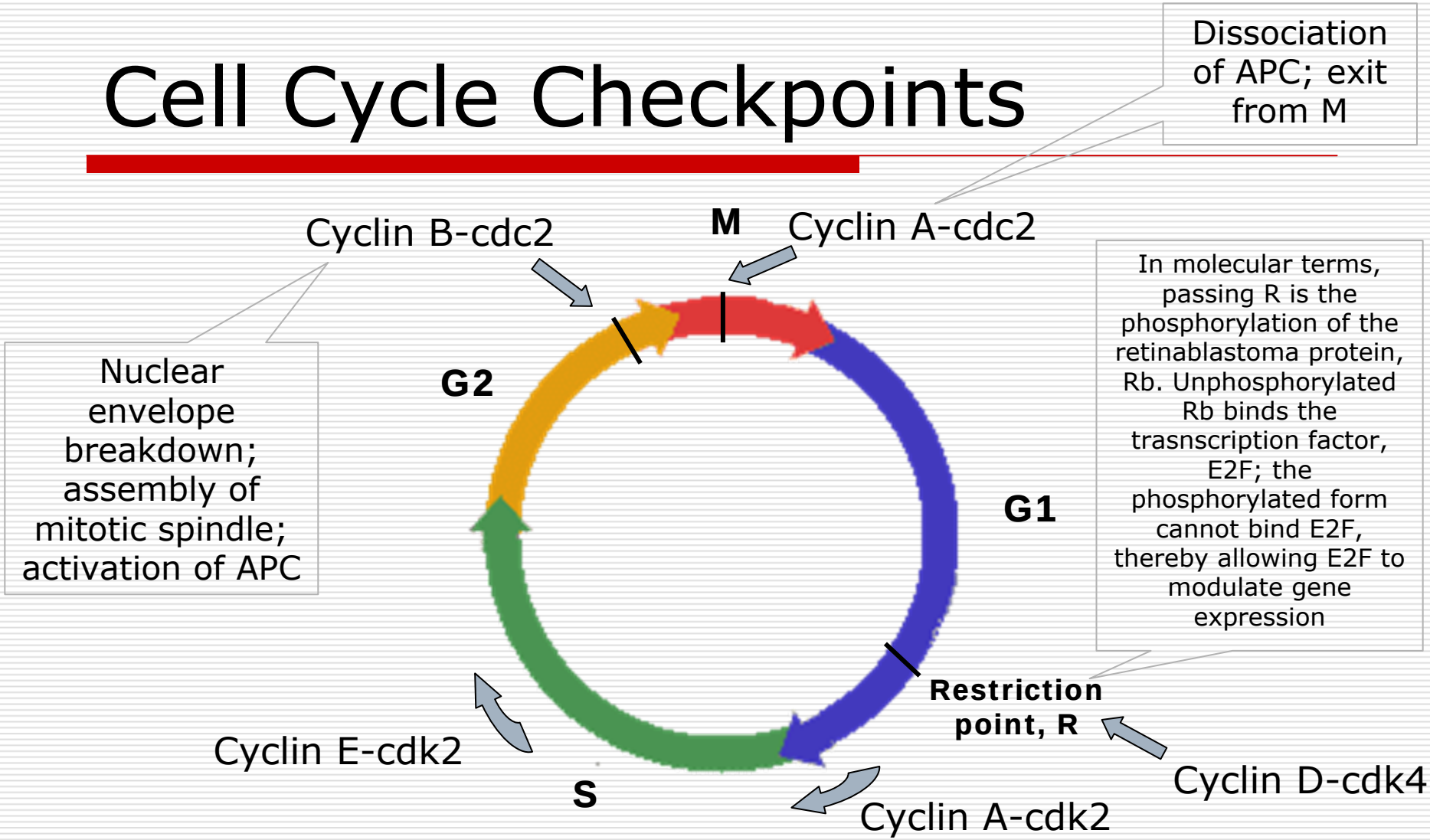


Cyclins and cdks

- **Cyclins**
- G1 cyclin (cyclin D)
- S-phase cyclins (cyclins E and A)
- Mitotic cyclins (cyclins B and A)

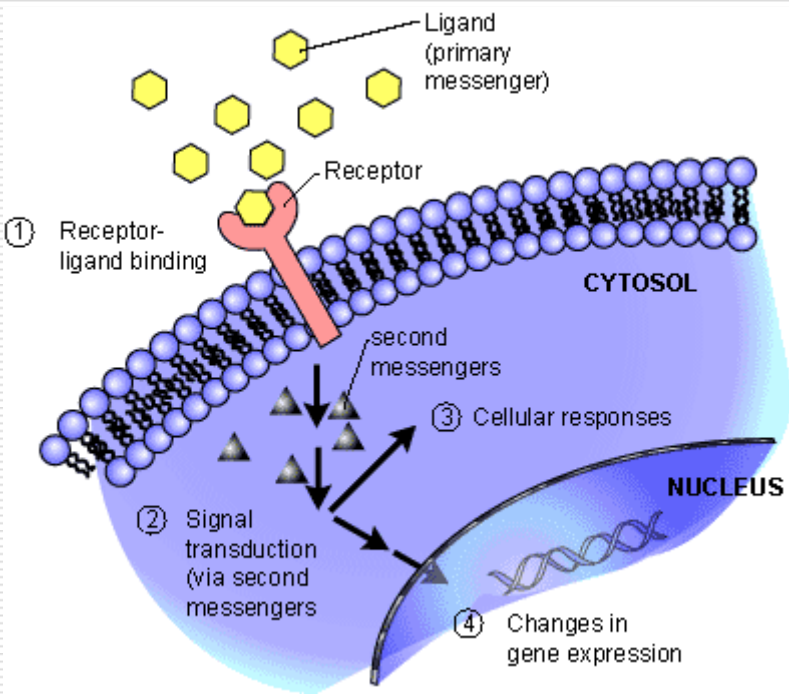
- **Cdks**
- G1 Cdk (cdk4)
- S-phase cdk (cdk2)
- M-phase cdk (cdc2 (Cdk1))

Cell Cycle Checkpoints



Signal Transduction

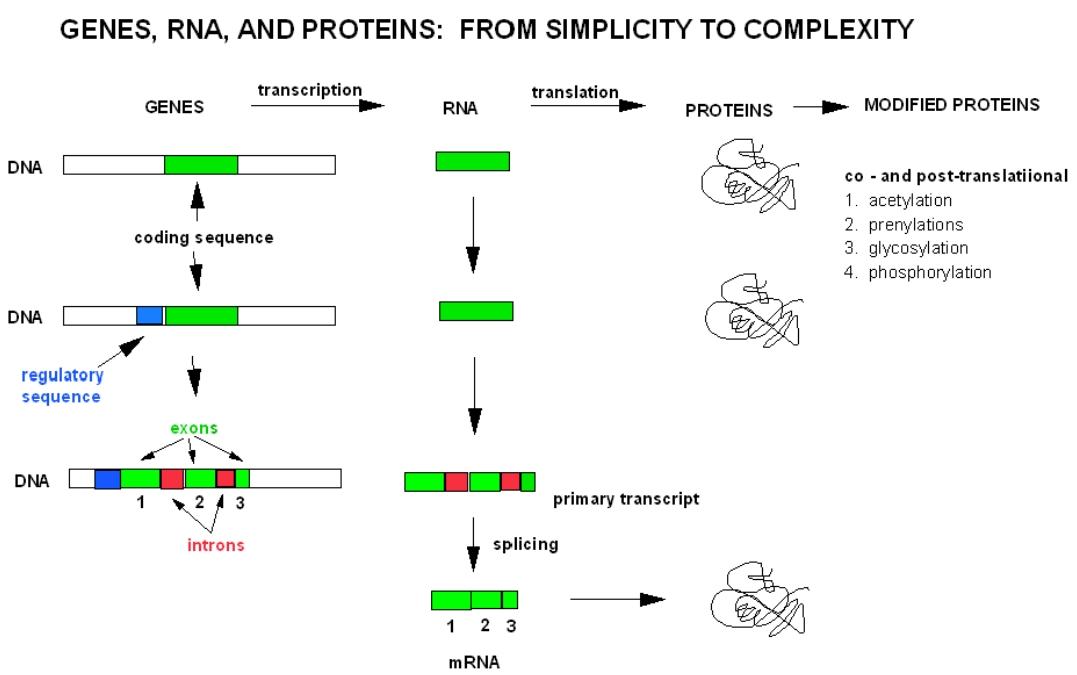
- Ensures that a signal is converted from one form to another
- From the exterior of the cell to the interior
- *Retain* original signal content



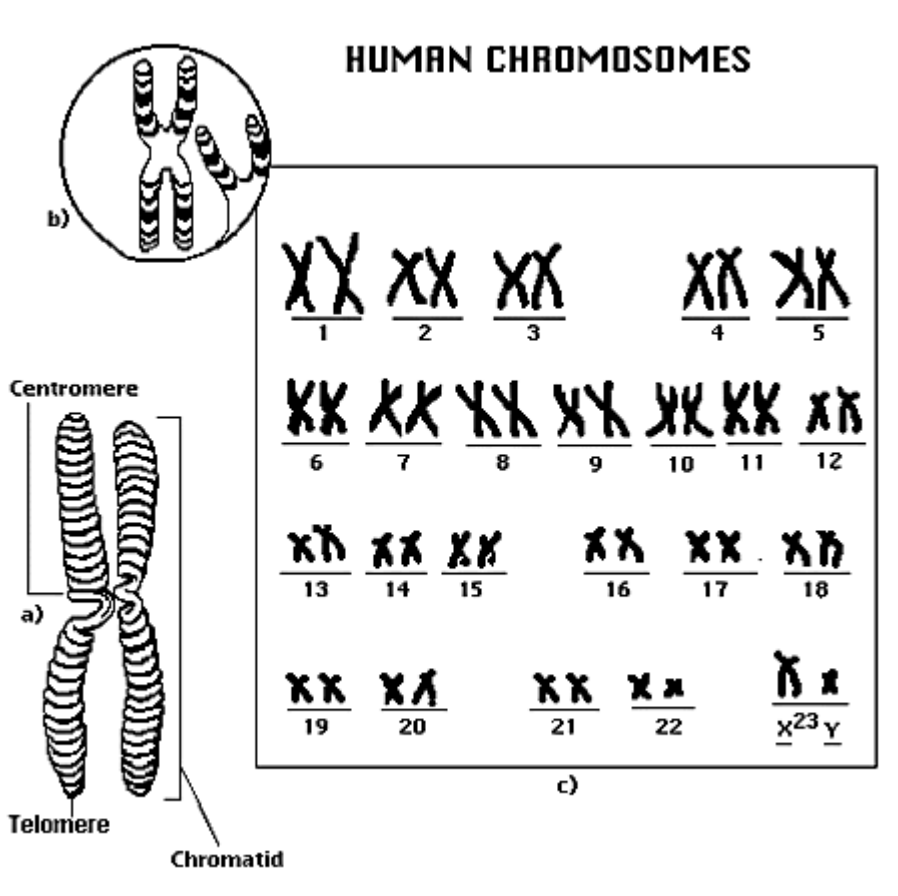
Steps in Signal Transduction

- Signal is sent. e.g. hormone, non-steriod ligand (epinephrine)
- Recognition of the signal by the cell via a *receptor.*
- Receptors can be present on the cell membrane or in the cytosol
- *Internal signaling molecules* transduce and amplify the signal
- Carried out via a *signaling cascade*, with multiple regulatory steps
- E.g. Glycogen breakdown in response to epinephrine

Genes, RNA, and Proteins



Chromosomes

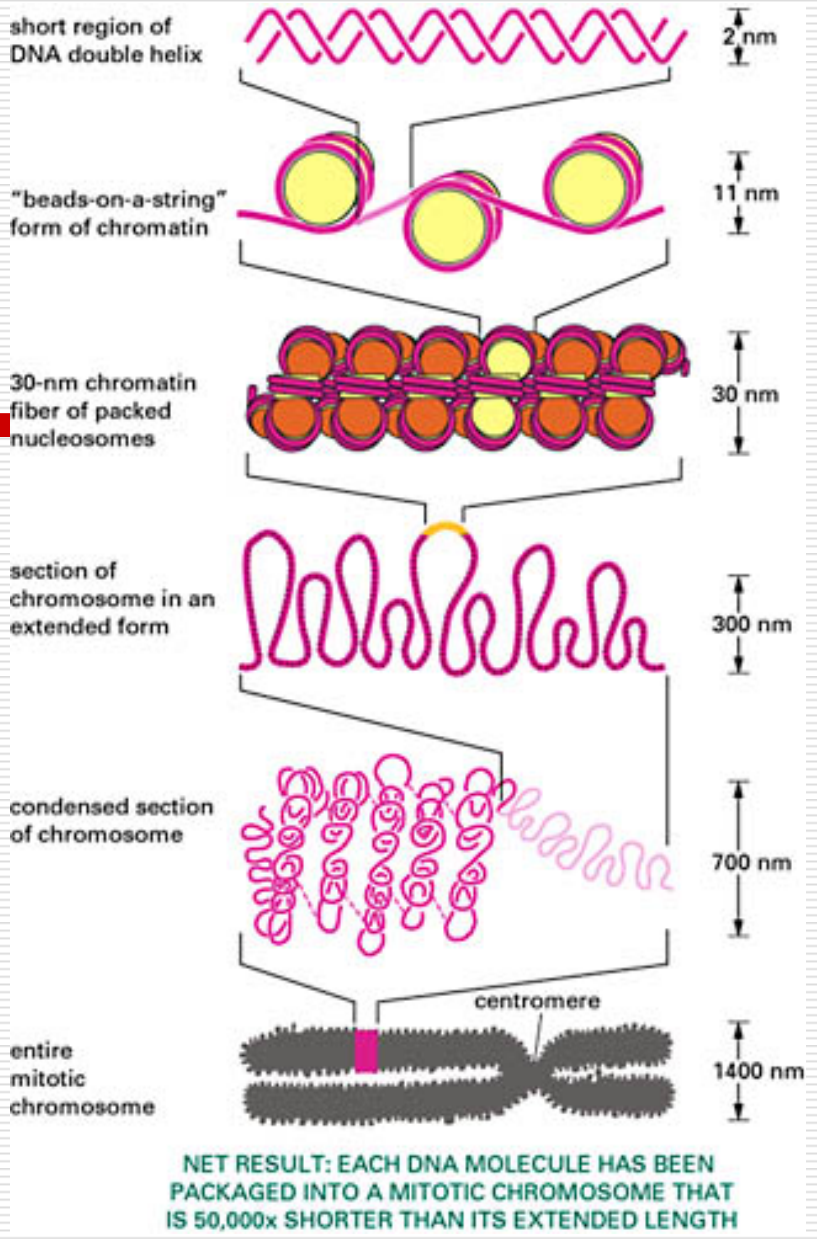


Mitosis

(Mitosis with music)

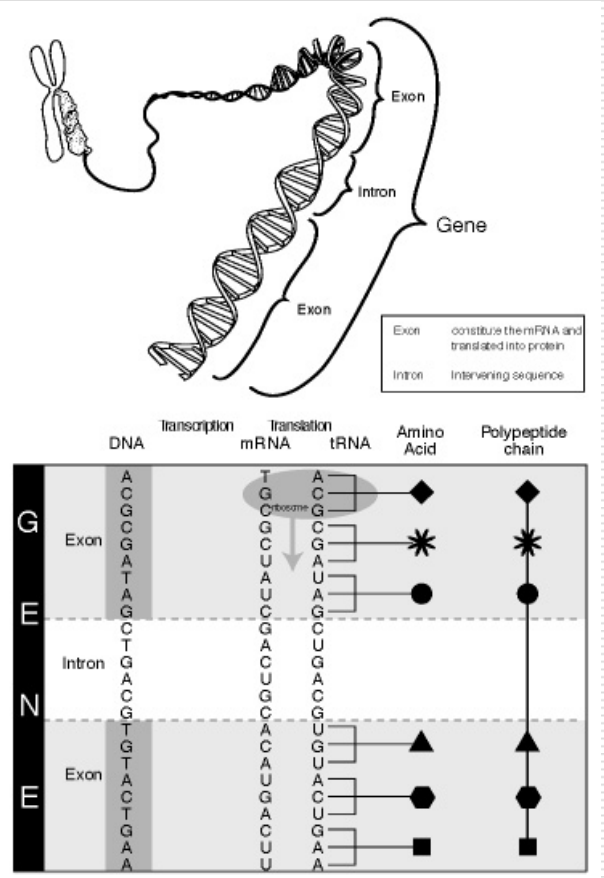
Chromatin Packaging

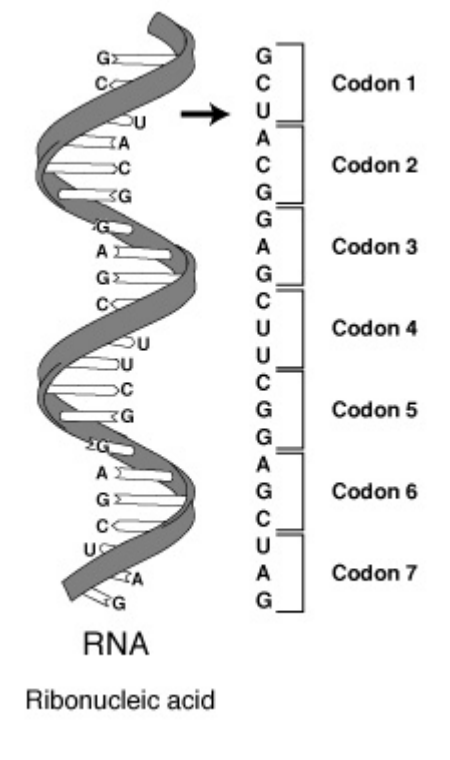
- Why does DNA in interphase "look" different from DNA in mitosis?
- Higher order of packaging
- Mitotic phase: DNA packaged into chromosomes
- Interphase: DNA present as chromatin
- "beads-on-a-string"
- beads = nucleosomes
- nucleosomes = DNA wrapped around histones



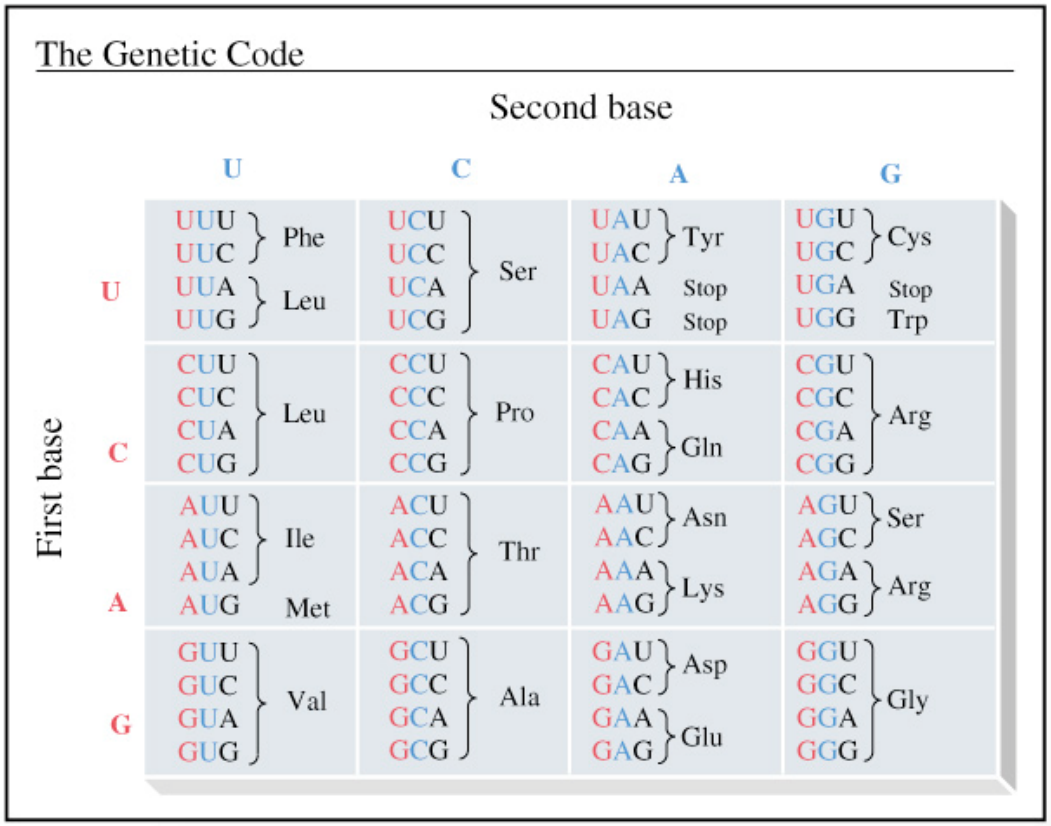
- Mitotic chromosomes = transcriptionally inactive (heterochromatin)
- Interphase chromatin = transcriptionally active (euchromatin)

Exons, Introns, Codons





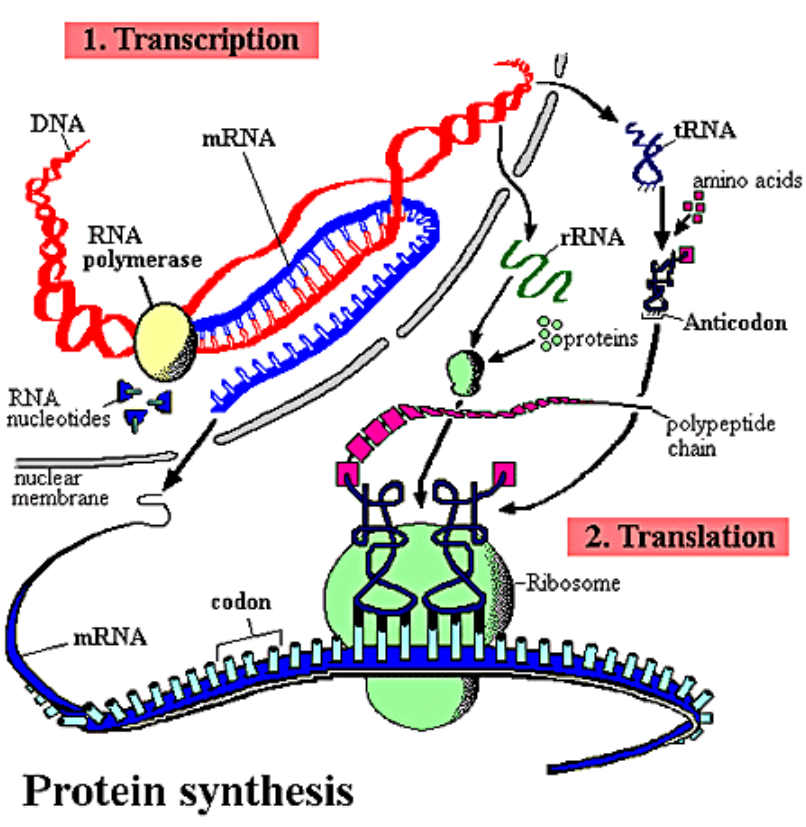
The Genetic Code



The Genetic Code

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

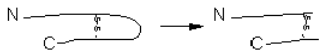
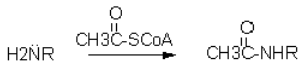
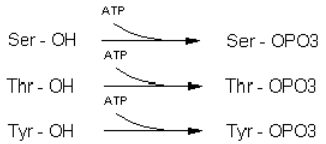
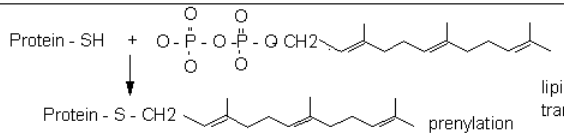
Transcription and Translation



(Translation)

Post-translational Modification

POST-TRANSLATIONAL MODIFICATION OF PROTEINS: EXAMPLES

MODIFICATION	REACTION EXAMPLES	ENZYME	PURPOSE
1. proteolysis		proteases	"activation of enzymes; targeting of proteins
2. acetylation; acylation		acetylase, acylase	chang charge; binding; protection
3. phosphorylation/ dephosphorylation		kinases phosphatases	change charge, binding; regulation
4. lipid attachement		lipid transferases	anchor proteins to membrane, regulation
	or + 14:0, 16:0, or PI attachment to amino acid		
5. glycosylation	Asn -NH2 Ser-OH, Thr-OH) → Asn -NH2-sugar (N-linked) Ser-OH-sugar (O-linked) Thr-OH)-sugar (O-linked)	glycosyl transferases	recognition increased t1/2 targeting

Eukaryotes vs. Prokaryotes

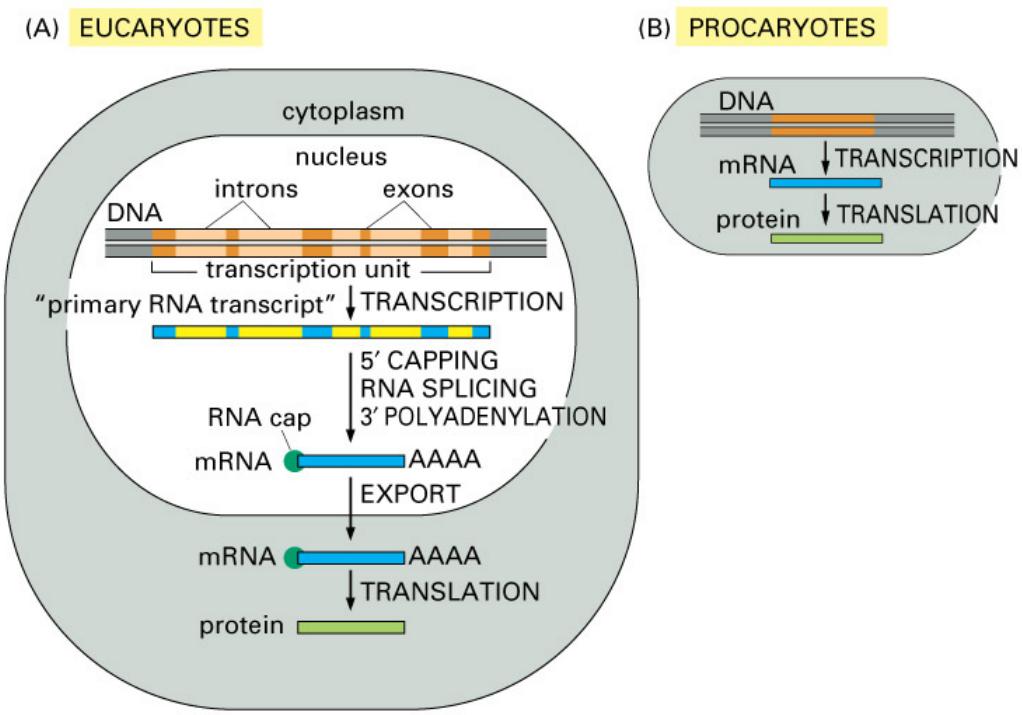


Figure 7-20 Essential Cell Biology, 2/e. (© 2004 Garland Science)

Immune Response

(Cells of the immune system)

(The cellular immune response)

Disease States

- Diabetes
- Cancer
- AIDS

Diabetes

(Insulin and glucose regulation)

(Type II Diabetes video)

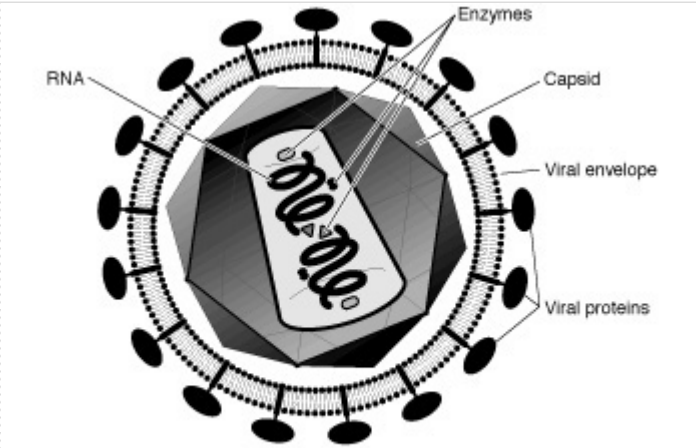
Cancer

(Oncogenes)

(p53's role)

(Nova - cancer programs)

AIDS



Structure of Human Immunodeficiency Virus (HIV)

(AIDS video – Kaiser)

(HIV lifecycle - Johns Hopkins)

Additional Reading

- Molecular Biology of the Cell, 3rd ed., Alberts *et al.*
- Biochemistry, 5th ed., Berg, Tymoczko, Stryer
- Biochemistry, 3rd ed., Voet & Voet