Review II: Cell Biology

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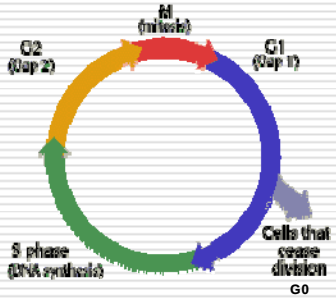
Outline

- Cell Cycle
- Signal Transduction

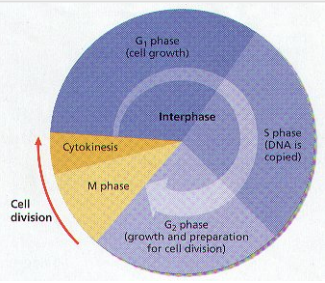
Cell Cycle

- 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)



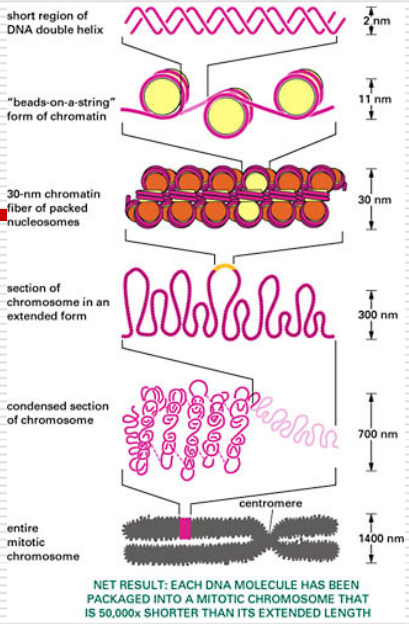
Cell Cycle Phases

- 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)



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

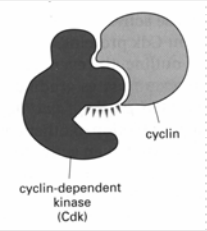


- Mitotic chromosomes = transcriptionally inactive (heterochromatin)
- Interphase chromatin = transcriptionally active (euchromatin)

- **Mitosis animations:**
- www.cellsalive.com/mitosis.htm
- www.biology.arizona.edu/cell_bio/tutorials/cell_cycle/cells3.html

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))

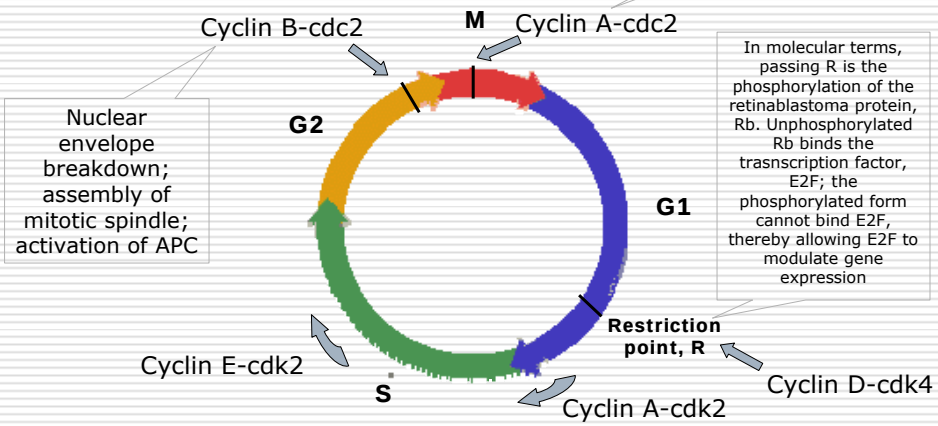


Cyclins and cdks

- **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

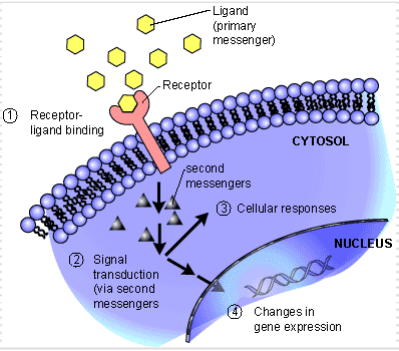


Regulation via Phosphorylation

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

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

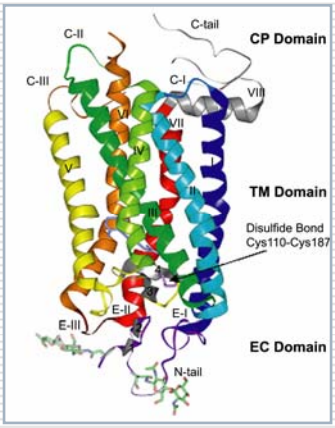
Cell Receptors

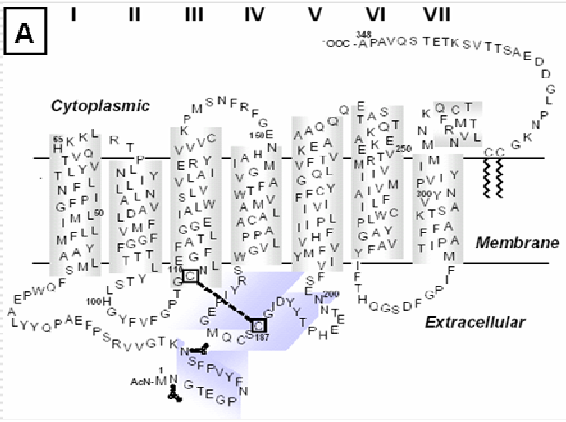
- **Ion-channel linked**: involved in rapid synaptic signaling between excitable cells; mediated by neurotransmitters
- **Enzyme-linked receptors**: when activated, either function directly as enzymes or are associated with enzymes.
- **G-protein coupled receptors (GPCR)**

GPCRs

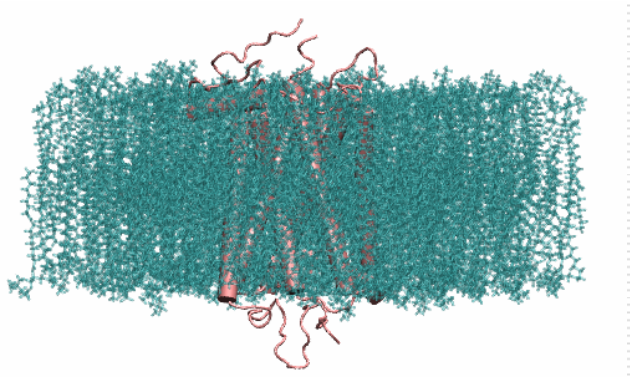
- Largest family of cell-surface receptors
- Biological functions include smell, taste, vision, blood pressure neurotransmission, embryogenesis, cell growth, development
- Rhodopsin is the only GPCR with a known 3D structure
- Contains 7 membrane traversing α helices (7TM)
- N terminal – outside cell, C terminal – inside cell
- Ligand binding outside cell induces conformational change detected inside cell
- Mediating molecule is a G protein (hence the name GPCR)
- Heterotrimeric GTP-binding regulatory protein (α, β, γ)
- Activated G protein transmits signal by binding to other proteins (e.g. adenylate cyclase: converts ATP to cAMP)

GPCR Structure





GPCR Structure (contd.)

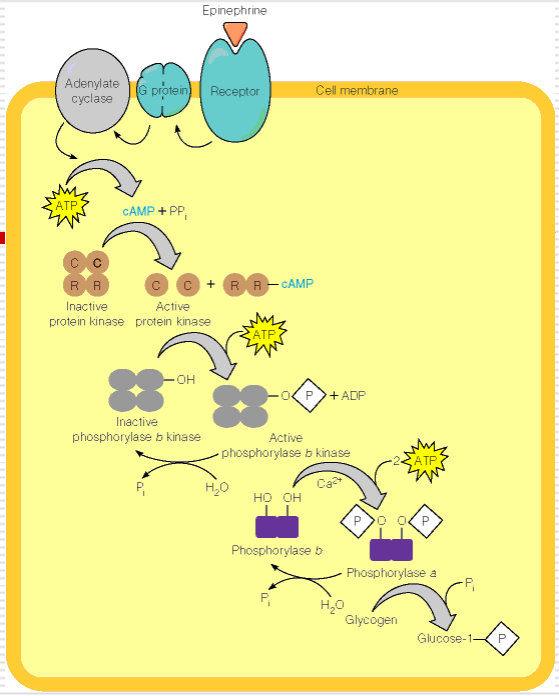


Signal reception

Signal mediation and amplification

Regulation by reversible phosphorylation and dephosphorylation

Signal effects



Additional Reading

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