YTOLOGY

Premed 2018 - JU

◉ Sheet ○ Slides

Number

25

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This sheet was written according to videos 25 + record 25 from 33:40 .ಠ_ಠ

Cell differentiation

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*the body of the human first form zygote that undergo fast mitosis to produce a lot of cells that were distributed to cells specialized in specific function such as liver cells, bowel cells, epithelial cells, neural cells and etc……..

Why zygote needs to be divide?

*Because a single cell can't perform more than one function at the same time so it undergoes differentiation into specialized cells for a given function.

*The zygote has been divided into cells that are 100% identical , So all of these cells will have the same DNA, so we wonder how do each specialize in a different function?

*This is due to gene activity and different gene expression in a particular cell ,to produce a protein for specific function.

For clarification: we have two cells, let's assume A&B…….

The DNA of cell A has on one site active gene and on the other site it has inactive gene

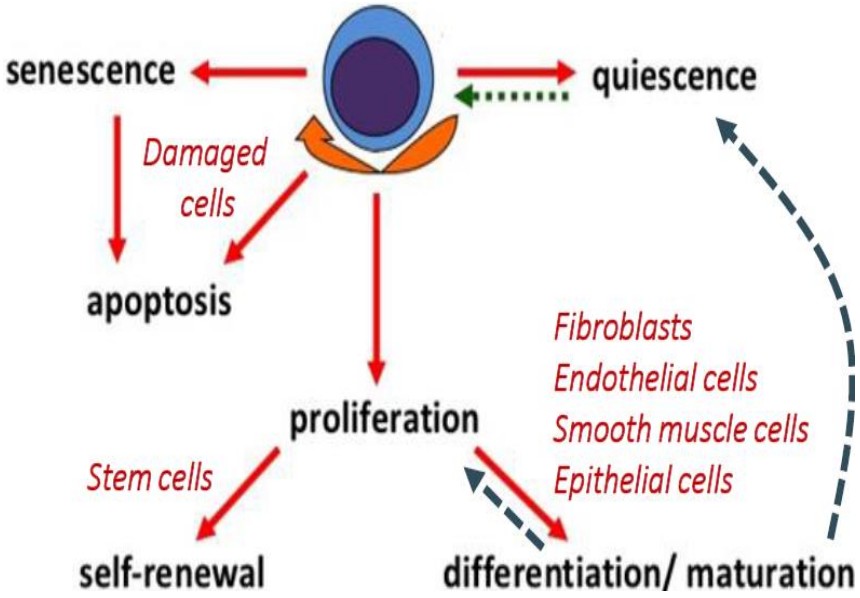
In the DNA of cell B we might find this gene -that was active in cell A- inactive gene and vice versa.

Cell fate

Cell Fate: Determines which path that the cell follow it to reach its final functional form.

That's mean it will pass through certain stages and in the end it has several options, for example ending as RBCs or WBCs.

1 –One of these paths: Any cells can undergo mitosis for a certain purposes. One of these purposes, for example renewal, such as the renewal of bowel cells.



2 – other paths:

-Once the cell has grown and differentiated , the cell enters a dormancy stage and does not divide into another cells This stage is called **quiescence ,e.x : neural cells.**

-After the cell grows older it enter the stage called **senescence** and Then it ends up to **apoptosis.**

-The **apoptosis** may occur immediately before the cell reaches the **senescence**. When certain changes occur, it is has to be eliminated because its absence is better than its presence, so that its presence may cause problems.

What are stem cells?

Are cells that retain the ability (this ability is differ among types of stem cells) to renew themselves through cell division and can be differentiated into a wide range of specialized cell types.

All stem cells are unspecialized (undifferentiated) cells ,that's mean these cells don't perform specific function like the cells of liver.

Function:

In embryo: The formation of the fetus and its tissues and organs.(Less specialized than adult stem cells).

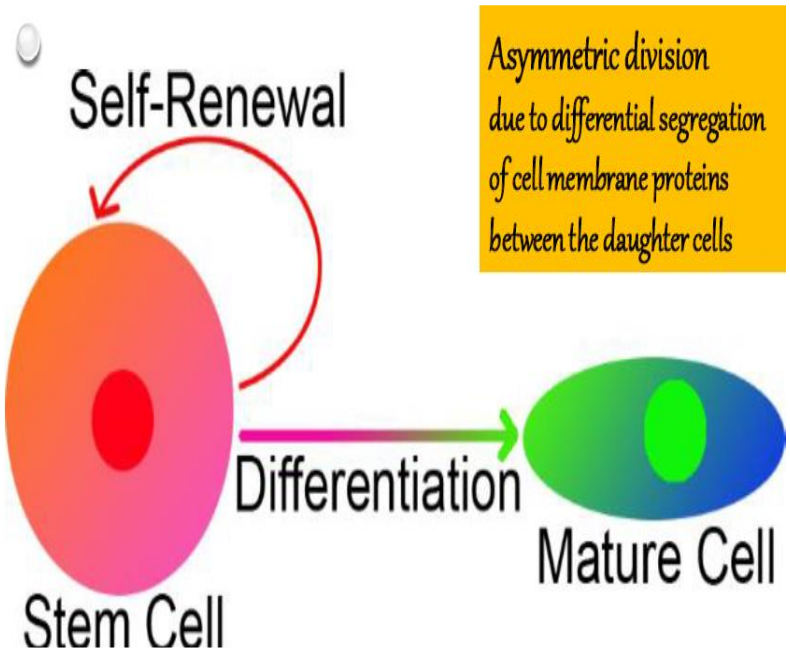
In adult: regeneration and renewal.

Differentiation vs.self-renewal

** we all know that the mitosis of cell produces two identical cells, but in the case of stem cells, it's little different…..

- the asymmetrically dividing of the stem cells to give rise to two distinct daughter cells: one copy of the original stem cell for self-renewal as well as a second daughter programmed to differentiate into a non-stem cell fate.

(**Asymmetric cell division**).



**How these cells separated from each other?

This is like the idea of cell polarity, so as we know previously, the apical and basolateral surfaces separated from each other-in addition to the tight junction- via proteins, So that the specialized proteins to work in apical surface go to the basolateral surface and the specialized proteins to work in basolateral surface go to the basolateral surface.

(For clarification)

www.allthingsstemcell.com

The same thing happen in stem cells ……

The stem cells divide into two groups of cells one of these groups undergo **differentiation** and the another groups have to be stem cells for renewal so we need a proteins for keep the Stem properties for renewal stem cells and **proteins that assists in differentiation**.

So the *proteins in the stem cells* divide into three parts:

1-*still in stem cells*.

2-go to renewal stem cells.

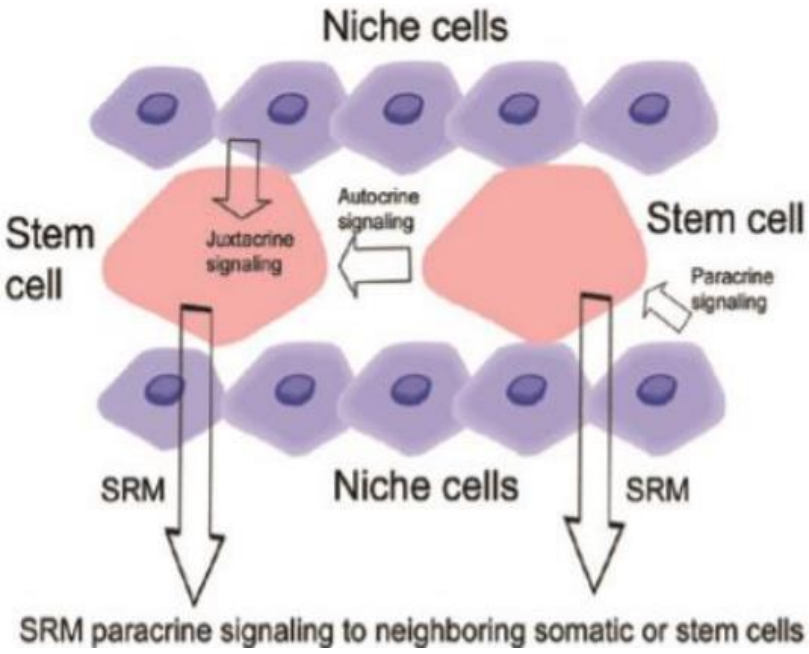
3-**go to cells that going to differentiate**.

Self-renewal: The ability to go through numerous cycles of cell division while maintaining the undifferentiated state.

Stem-cell niche

A specialized cellular environment that provides stem cells with the support needed for self-renewal.

Stem-cell niche refers to a micro-environment, within the specific anatomic location where stem cells are found, which interacts with stem cells to regulate cell fate.



Stem cell niche might be cells or cells with ECM or soluble factor like Wnt and growth factors .

various niche factors act on **embryonic stem cells** to alter gene expression, and induce their proliferation or differentiation for the development of the fetus.

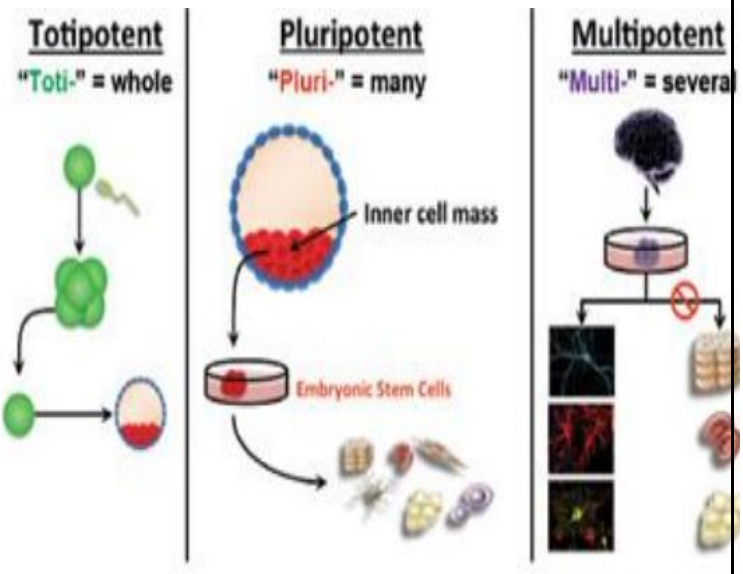
Within the human body, stem-cell niches maintain **adult stem cells** in a quiescent state, but after tissue injury, the surrounding micro-environment actively signals to stem cells to promote either self-renewal or differentiation to form new tissues.

Potency of stem cells

Cell potency is a cell's ability to differentiate into other cell types.

The ability for stem cells to differentiation is different, that's mean not any stem cell can differentiate into any cell in the body.

Type of potency :



1-Totipotent: (***has the largest ability***) is the ability of a single cell to divide and produce all of the differentiated cells in an organism in addition to extra embryonic tissues like *Placenta.*

Totipotent cells is anembryonic cells.

2-Pleuripotent: a stem cell that has the potential to differentiate into any of the three germ layers: endoderm ,mesoderm, or ectoderm .

In another word this cells can able to differentiate into all body cells with all types.

pluripotent cells is an embryonic cells.

3-Multipotent: :a stem cell that has the potential to differentiate into several type of cells might 3 or 4 or 5 But not more.

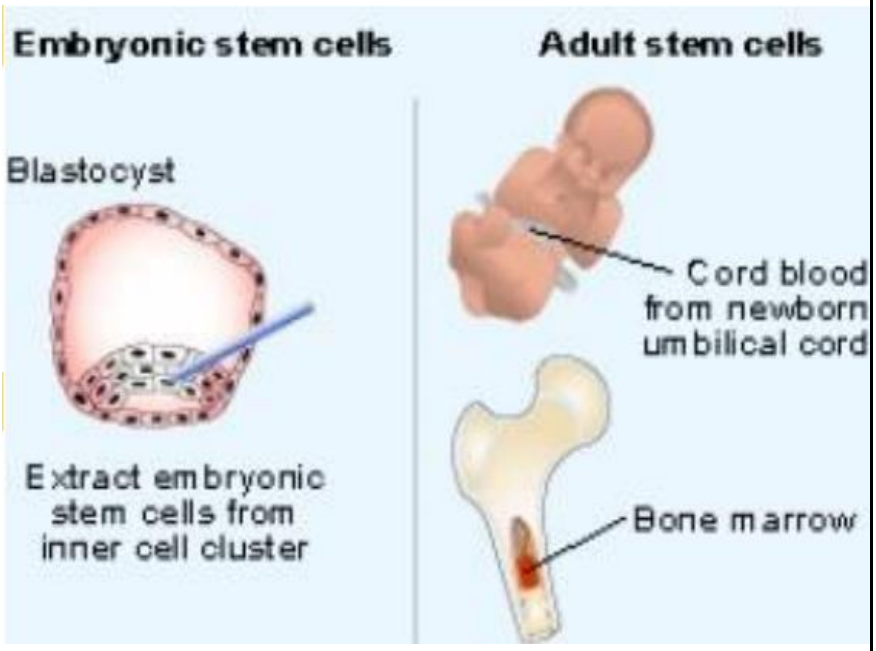
Multipotent cells is an adult cells.

4-Unipotent: (**has limited ability**) that gives one type of cells, for example chondroblasts, which differentiate into chondrocytes.

unipotent cells is an adult cells.

Types of stem cells

There are mainly two types of stem cells: embryonic stem cells, which are derived from embryo, and adult stem cells.



Embryonic stem cells (Totipotent and Pleuripotent)

- Are able to differentiate into all the specialized embryonic tissue

Adult stem cells (Multipotent and unipotent)

- Act as a repair system for the body replacing specialized damaged cells.

The cell cycle

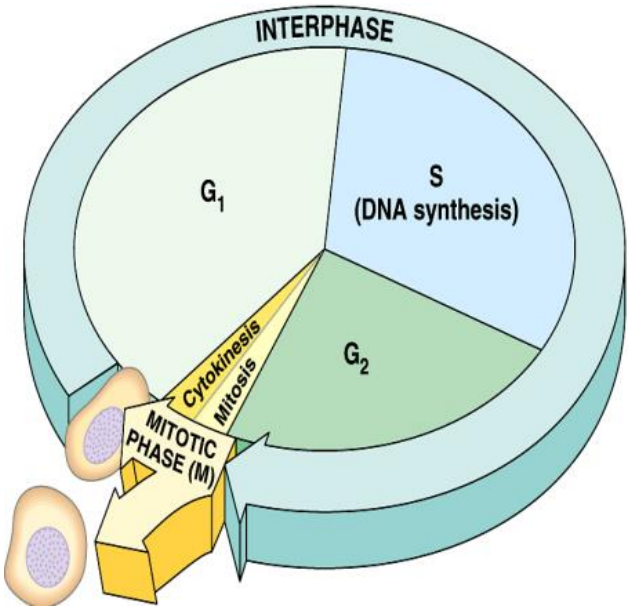
The cell cycle divide into two phases:

Starts with interphase (G_1,S and then G_2): cell growth and DNA replication occur in an orderly manner in preparation for cell division.

End up with mitotic phase-M phase- (Mitosis and cytokinesis)1 hour.

A typical eukaryotic cell cycle- divides every 24 hours.

Zygote: no G_1 or G_2, but rapid S-and M phases.

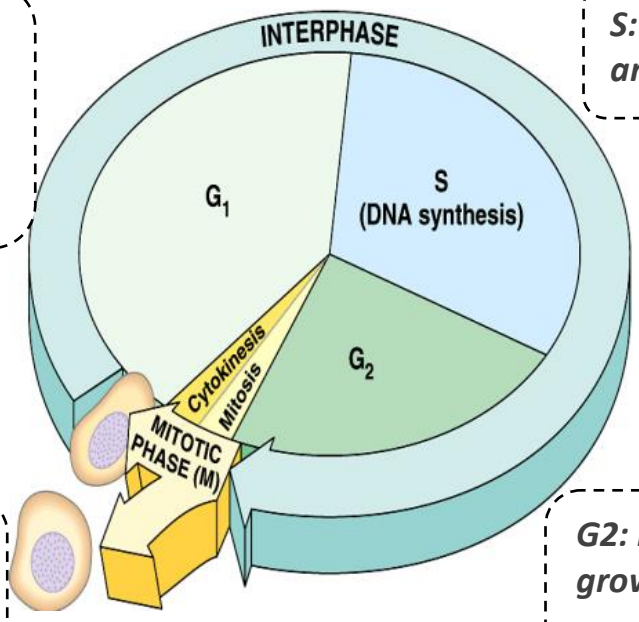


The cell that does not need division will remain in G_0 phase until it is stimulated by certain stimuli, then it enter G_1 phase and complete the whole cycle until it divides. (These cells enter this phase temporarily).

Some cells (nerve cells) enter a quiescent stage (G_0 phase). (These cells enter this phase permanently).

Phases of cell cycle

G_1: increased metabolism and cell growth; cells are dipoloid (2n).



S: DNA replication; cells are 2-4n.

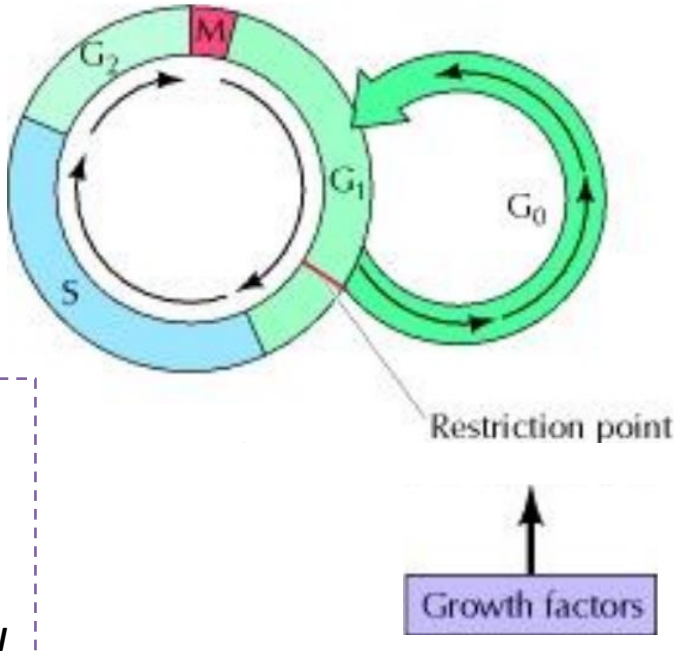
M: chromosomal segregation, nuclear and cell division (4n.)

G2: metabolism and cell growth; cells are 4n.

Regulation of cell cycle

Restriction point: a decision point in late G_1 regulated by the extracellular growth factors rather than the availability of nutrients.

If not there, cells enter G_0 phase where they are metabolically active without growth.



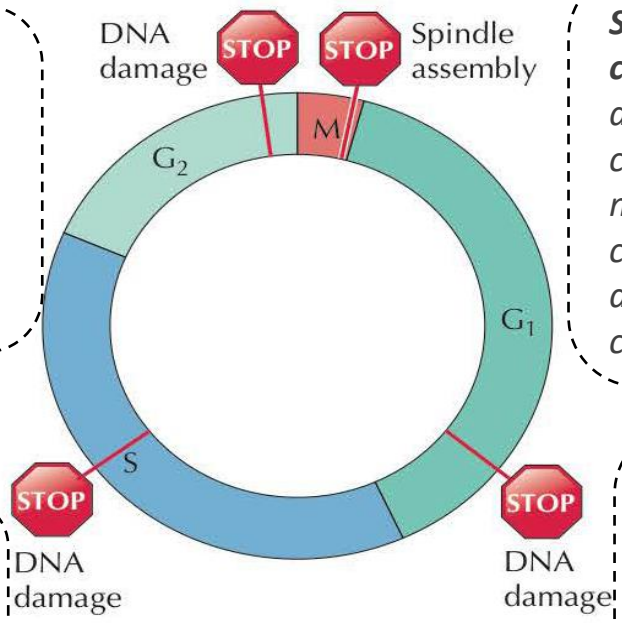
In another words, the restriction point checks the availability of the necessary nutrition to complete the division.

if available, allowing the cell to complete the phases of division

If the necessary nutrition is not available, the cell returns to the G_0 phase.

Other Checkpoints:

G_2DNA damage checkpoints *ensure that incomplete or damaged DNA is not replicated and passed on to daughter cells.*



Spindle assembly checkpoints *monitor the alignment of chromosomes on the mitotic spindle to ensure complete and accurate distribution of chromosomes.*

S-phase DNA damage checkpoint *restricting DNA replication to once per cell cycle by helicase Complexes.*

at the ***G_1DNA damage checkpoint*** *allows repair of any DNA damage to take place before the cell enters S phase, where the damaged DNA would be replicated.*

S-phase DNA damage checkpoint not only provides continual monitoring of the integrity of DNA to ensure that damaged DNA is repaired before it is replicated, but also provides a quality control monitor to promote the repair of any errors that occur during DNA replication, such as the incorporation of incorrect bases or incomplete replication of DNA segments.

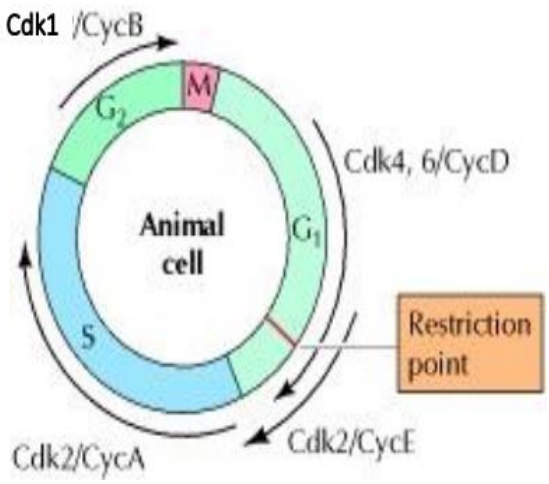
Regulators of cell cycle

Cyclins are proteins that accumulate throughout the interphase and are rapidly degraded toward the end of mitosis.

Cyclin-dependent kinases (Cdk's): bind to cyclins to activate them.

Cdk inhibitors: inhibit Cdk activity.

*****There are different kinases at different phases … for example: in G1 phase before restriction point there are Cdk4 and 6/CycD. BUT in the G1 phase after restriction point there are Cdk2 and CycE***



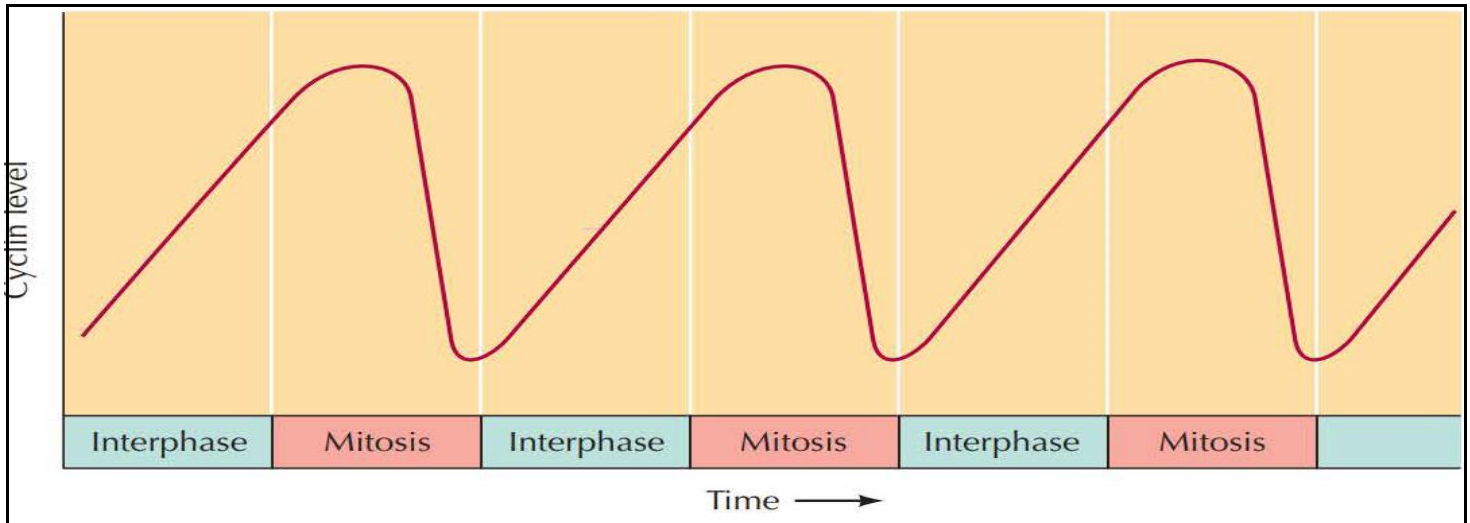


Figure 17.10 Accumulation and degradation of cyclins in sea urchin embryos The cyclins were identified as proteins that accumulate throughout interphase and are rapidly degraded toward the end of mitosis.

Regulation of cell cycle progression

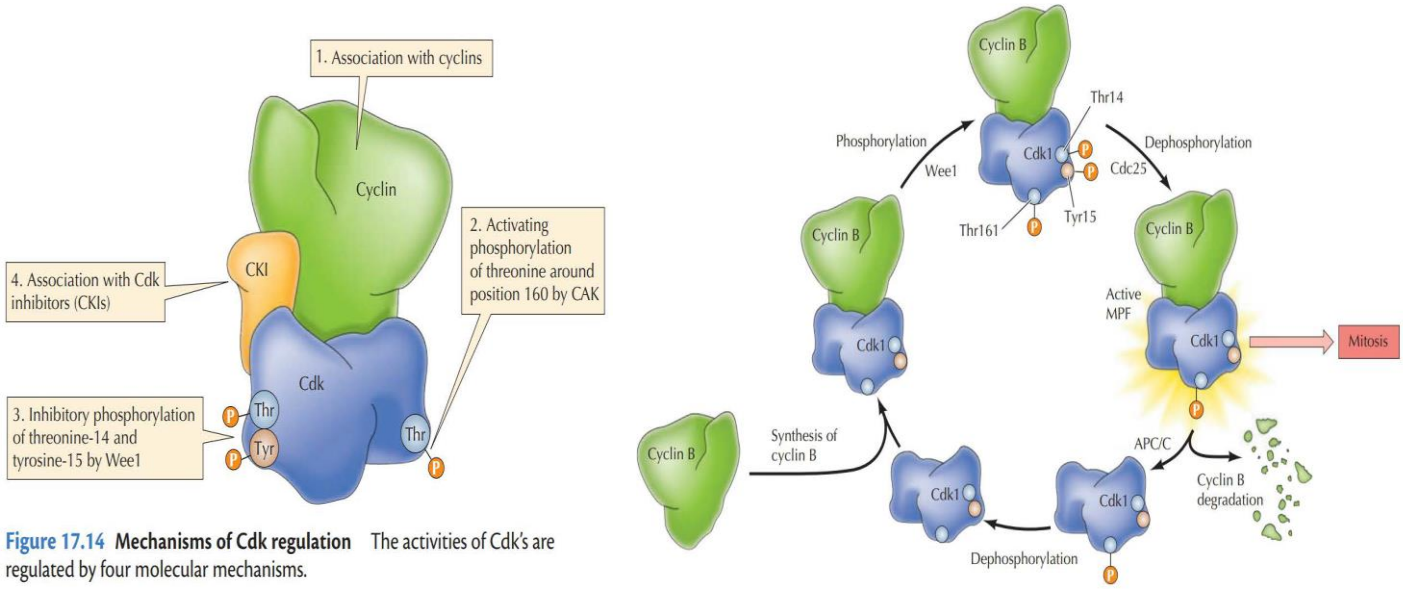


Figure 17.14 Mechanisms of Cdk regulation The activities of Cdk's are regulated by four molecular mechanisms.

MPF regulation Cdk1 forms complexes with cyclin B during G_2. Cdk1 is then phosphorylated on threonine~ 161 (Thr161), which is required for Cdk1 activity, as well as on tyrosine~ 15 (Tyr15)-and threonine~ 14 (Thr14) in vertebrate cells-which inhibits Cdk1 activity. Dephosphorylation of Tyr15 and Thr14 activates MPF at the G2 to M transition. MPF activity is then terminated to~ ward the end of mitosis by proteolytic degradation of cyclin B, which is followed by dephosphorylation of Cdk1.

GOOD LUCK ♂_♂