12.3 Notes: The eukaryotic cell cycle is regulated by a molecular control system


*cool game that goes through the various parts of the cell cycle!

- The cell cycle is controlled by signal molecules present in the cytoplasm. (If 2 cells that are different stages in the cell cycle are fused together, the cells continue to function at the later stage of mitosis because of molecules present in the cytoplasm)

Checkpoints:

- Checkpoints exist to control the progress of the cell cycle
- There are built in “stops” in the cell cycle, that have to be over-ridden by signal molecules to continue.
  - This is to make sure that crucial cell processes that should’ve been completed, HAVE BEEN completed (and correctly).
    - i.e. Cell size, chromosome duplication, environmental conditions, correct chromosome alignment
- 3 checkpoints
  - **G1**: if it gets a go-ahead signal at G1, the cell will typically complete the rest of the cell cycle. If not, it will switch to G0 (a non-dividing state)
    - Ex: mature nerve cells & muscle cells are in G0. Liver cells are in G0, but can be called back to G1 due to growth factors (signal molecules) released during an injury.
    - Several different Cdk proteins & cyclins operate at this checkpoint
  - **G2**: “go-ahead” to M caused by Mitosis Promoting Factor (MPF) (a Cdk-cyclin complex).
  - **M**: regulated by all kinetochores being attached to spindle, which activates the protein complex to start anaphase (guarantees 1 copy of each chromosome for each daughter cell)

Cell Cycle Control System:

- Pace determined by regulatory proteins (either protein kinases or cyclins)
  - Protein kinases (act as go-ahead signals at G1 & G2 checkpoints)- enzymes that activate or inactivate other proteins by phosphorylating them. Many kinases are inactive until attached to a cyclin protein (their concentration fluctuates cyclically).
Cyclin-dependent kinases (Cdks) - their activity level changes depending on the presence of cyclin.
  - Ex: Maturation Promoting Factor (MPF; a type of Cdk) activity peaks when cyclin concentration is high (during S & G2 phase in a frog). Promotes M phase (by acting as a kinase, phosphorylating a variety of proteins that initiate mitosis).
    - MPF causes nucleus to break down, & is indirectly involved in chromosome condensation & spindle formation.

Both Internal & External Signals regulate the checkpoints

- Internal control
  - Ex: separation of sister chromatids will not happen until ALL kinetochores are connected to spindle fibers (this activates a protein complex to initiate the start of anaphase).

- External control
  - Growth factors - released by 1 cell, stimulating ANOTHER cell to divide
  - Density dependent inhibition - crowded cells stop dividing
  - Anchorage dependence - most be anchored to another surface in order to divide.

Cancer - loss of cell cycle controls

- Cancer cells don’t show density-dependent inhibition, nor anchorage dependence 😊
- Transformation - normal cell gets converted into a cancer cell (and isn’t destroyed)
- Metastasis - movement of cancer cells to new locations
- Benign - tumor-abnormal cells stay where they are because they don’t have ENOUGH changes to survive at another site.
- Malignant - tumor - abnormal cells (usually unusual chromosome #s) spread to new tissue & impair organ function

Cancer Treatment

- radiation - focuses on cells in 1 area. Damages DNA in cells. Cells typically check for DNA damage & repair it before dividing, but DNA in cancer cells is often already mutated in these regions, so they have trouble repairing the new damage from radiation, so they die

- chemotherapy - drugs introduced into the blood stream that are toxic to cells (especially rapidly dividing ones) since they interfere with specific steps in the cell cycle. This is WHY more research needs to be done about different types of cancer & better understanding the cell cycle in each type of cell. (Different types of chemotherapy work for different types of cancers.)
  - side effects: - intestinal cells impaired= nausea
    - hair follicle cells impaired= hair loss
    - immune system cells impaired= higher rate of infection from other illnesses
  *These are areas with common side effects because they are rapidly dividing cells