The Cell Cycle

CHAPTER 12

READ CH 12.
VIEW SLIDES>
ALL SLIDES, INFO FROM VIDEOS AND QUESTION TOPICS WILL BE ON EXAM # 3
The Key Roles of Cell Division

- **cell division** = reproduction of cells
- **All** cells come from pre-existing cells

Thought question: What **pre-existing cells** did your cells come from?
• Unicellular organisms ➔ division of 1 cell reproduces organism

• Binary fission

ASSIGNMENT: View video on binary fission
http://www.youtube.com/watch?v=J6akNYlkehY

QUESTION 1:
a. How frequently do some bacteria divide?
b. How does this explain their ability to expand their numbers quickly?
Multicellular organisms

- Why cells reproduce
  - Development/Growth
    - Example: embryo → adult
  - Replacement
    - Example: stomach lining is continually replaced
  - Repair
    - Example: repair of burn
• Watch video
  
  https://www.youtube.com/watch?v=f7cXeWxxfD4

• Sea stars can reproduce cells in a way that humans cannot – view and understand.
Cellular Organization of Genetic Material

- **chromosome** = strand of DNA
  - 2 sets of 23 chromosomes in humans = 46
- **genome** = All DNA in a single cell
  - single chromosome (prokaryotes)
  - many chromosomes (eukaryotes)

**Assignment**: View the data on the website [http://morgan.rutgers.edu/morganwebframes/level1/page2/Chr
omNum.html](http://morgan.rutgers.edu/morganwebframes/level1/page2/Chr
omNum.html) Explore the number of chromosomes in each type of organism’s cells.

**Question 2:**

a. Is there a correlation between chromosome number and intelligence?
This is an electron micrograph of the 46 chromosomes in a human cell.
• chromatin complex of DNA and protein

Chromatin normally looks diffuse - hard to see individual chromosomes
Terms needed to continue

- **Haploid** – a cell with one set of chromosomes
- **Diploid** – a cell with two sets of chromosomes

**Assignment.**

**Question 3**

a. Look carefully at the list – are these diploid, or haploid chromosome numbers?

b. How many chromosomes are in the sperm of a fruit fly?

c. Which organisms have genome sizes similar to humans (Mb size is multiplied by 1 million for total size)
Mitosis – cell division process to replicate cells
  - Ex. Skin cells do this

Meiosis – cell division process to generate unique haploid cells
  - Ex. Spermatogenesis, oogenesis
• BE ABLE TO DISTINGUISH BETWEEN MITOSIS AND MEIOSIS

• Somatic cells = body cells (2 trillion in adult)
  o two sets of chromosomes (pairs = diploid)
  o Produced by mitosis - 1 diploid cell $\rightarrow$ 2 identical diploid cells

  o Skin cells produced by mitosis

• Gametes sperm and eggs
  o have one set = haploid
  o Produced by meiosis - 1 diploid cell $\rightarrow$ 4 unique cells
  o Occurs only in ovaries, testes

Egg cell (oocyte) is a gamete produced by meiosis
Identical cells
Diploid

Unique cells
Haploid
Assignment: Read the textbook and study the previous slides to answer the following

QUESTION 4

a. Which of the cells below are diploid? (there are 6)
   - fruit fly wing cell
   - haploid cell
   - gamete from a fern plant
   - fertilized whale egg
   - cell produced by meiosis
   - sperm of frog
   - monkey liver cell
   - plant pollen (contains sperm)
   - fish somatic cell
   - human embryo cell
   - cell with 2 sets of chromosomes
   - unfertilized bird egg

b. Which of the following terms are associated with mitosis (there are 6)
   - sperm
   - diploid
   - unique cells
   - 1 set of chromosomes
   - somatic
   - ovary
   - liver cell
   - 4 daughter cells
   - genetically identical
   - 2n
   - 46 chromosomes
   - gametes
Cell Division also includes:

- **Nuclear division** = division of the nucleus
- **Cytokinesis** = division of cytoplasm

View video to compare

http://www.youtube.com/watch?v=rgLJRv0X_qo&NR=1

- When both have occurred, there are 2 new cells, each identical to the “parent” cell
The cell cycle = time from new cell to when it divides

**Interphase** ~ 90% of a cell’s time
cell is doing its normal activity during this time

**Mitosis** -
~ 40 min
cell is involved in replicating to make 2 new cells

A cartoon showing the time cell spends in interphase and mitosis. Note that mitosis is short
Now, we will examine the individual steps in the cell cycle. Give yourself enough time to understand each step before proceeding.
INTERPHASE (~90% of the cell’s time in the cell cycle, not part of mitosis)

- G1 phase – cell grows, gets ready
- S phase – DNA replicates
- G2 phase – cell grows, gets ready

Watch the cell cycle video
[http://www.youtube.com/watch?v=O3_PNiLWBjY](http://www.youtube.com/watch?v=O3_PNiLWBjY)
• Signs of interphase?
• Note the **distinct nuclear membrane**
• Note that the chromosomes inside the nucleus are not visible (they are too thread-like at this stage to see)
S phase of Interphase

- Chromosomes replicate to form:

- **Sister chromatids** = 2 for each chromosome, they are attached at the **centromere** (constricted region)

![Image of human chromosome](image.png)

This is one chromosome that has replicated into a pair of sister chromatids.
All 46 chromosomes in a human cell have been replicated to form sister chromatids held together at the centromeres.
Question 5

a) Number of chromosomes in a human sperm or egg cell
b) Number of chromosomes in a human fertilized egg
c) Total number of sister chromatids in a human cell after S phase of Interphase (not sister chromatid pairs, individual sister chromatids)
PHASES OF MITOSIS

- Prophase
- Metaphase
- Anaphase
- Telophase

- Cytokinesis (division of cytoplasm) by late telophase
I. Prophase of Mitosis

A. Chromosomes condense = they become thicker and shorter
B. Nuclear membrane breaks apart
C. Mitotic spindle forms from centrioles

WATCH THE PROPHASE VIDEO
http://www.youtube.com/watch?v=BFDsIhv3SZU
A chromosome in prophase is composed of 2 identical sister chromatids held together at the centromere.
Note the **absence of a nuclear membrane** in the cell that has entered prophase.

The nuclear membrane is breaking up.

A fish cell
Prophase of mitosis

This is a slide of onion cells with chromosomes stained red.

View: condensed chromosomes in prophase and absence of nuclear membrane.

Cannot see the mitotic spindle in this photo.
The mitotic spindle in prophase

- Remember the centrioles
- They have replicated and moved to opposite sides (poles) of the cell
- AND, microtubules have grown from them – the red lines – they attach to the centromeres of the sister chromatid pairs
- The microtubules are called spindle fibers
Question 6

a. Are the two sister chromatids that compose a chromosome in prophase identical?

b. To what structure do the mitotic spindle microtubules attach on the chromosomes?

c. What are the components of the mitotic spindle?

d. What are centrioles composed of?

e. What is meant by “chromosomes condense”?

WATCH THE PROPHASE VIDEO
http://www.youtube.com/watch?v=BFDSlHv3SZU
II. Metaphase of mitosis

- chromosomes (still in sister chromatid pairs) line up at the **metaphase plate**
- midway between spindle’s two poles

![Image of metaphase of mitosis in a fish cell]

- Centrioles with spindle fibers
- Chromosomes are lined up
- Fish cell
The chromosomes here do not look as neat – but their centromeres are in a line on the metaphase plate.
Assignment: Watch the metaphase video

http://www.youtube.com/watch?v=8C7Y1F1uyQs&feature=related

Question 7

a. How can you determine visually that a cell is in metaphase?
b. About how long in minutes or hours is metaphase?
c. Is the spindle apparatus (mitotic spindle) obvious during metaphase?
d. Are the sister chromatids still attached at the centromere during metaphase?
III. Anaphase

- sister chromatids separate! They split into individual chromosomes.
- Mitotic spindle shortens – to move newly separated chromosomes toward opposite ends of cell.
- This is tightly controlled – need a full set of chromosomes moving to each side!
Fish cell – note that a set of chromosomes, is moving to each end of the cell. The cell also is huge
Assignment: Watch the anaphase video http://www.youtube.com/watch?v=k3ECNH1MSCw&feature=related

Question 8

a. Once sister chromatids have split, what are they referred to as?
b. About how long does anaphase of mitosis take?
c. Does each side of the cell have a full set of chromosomes at the end of anaphase?
d. What happens to the mitotic spindle?
IV. Telophase of mitosis

- Identical nuclear membranes form around each set of chromosomes
- Chromosomes start to decondense
Cytokinesis

- Division of cytoplasm
- animal cells
  - cleavage furrow
- plant cells
  - cell plate
Cleavage furrow in dividing cell
Daughter cells

(b) Cell plate formation in a plant cell (TEM)

Vesicles forming cell plate

Wall of parent cell

New cell wall

Cell plate in plant cell
Assignment: Read textbook and study slides

Question 9

a. Identify the phase in A – D of this photo
b. List one feature that tells you the cell in in that particular phase of mitosis
A plant cell in interphase
prophase
metaphase
anaphase
Telophase and cytokinesis with cell plate
Onion cells in various stages of the cell cycle
Question 10  Fill in the appropriate phase of mitosis or interphase:

a.  DNA synthesis occurs: _____
b.  Interphase consists of subphases: _____ _____ _____
c.  Sister chromatids form: _____
d.  Stage that involves a cleavage furrow: _____
e.  Beginning of cell cycle: _____
f.  Sister chromatids separate: _____
g.  The nuclear membrane is visible: _____
h.  Chromosomes condense: _____
i.  Centromeres line up: _____
j.  1 cell divides into two cells: _____
k.  A distinct nuclear membrane is visible: _____

VIDEOS TO ASSIST YOU  next page
- [http://www.sumanasinc.com/webcontent/animations/content/mitosis.html](http://www.sumanasinc.com/webcontent/animations/content/mitosis.html) sumanas

- [http://www.youtube.com/watch?v=3kpR5RSJ7SA&feature=related](http://www.youtube.com/watch?v=3kpR5RSJ7SA&feature=related) ms stokes bio

- [http://www.youtube.com/watch?v=AhgRhXl7w_g](http://www.youtube.com/watch?v=AhgRhXl7w_g) pisgahscience

Evolution of Mitosis

- mitosis is thought to have evolved from binary fission

- Some protists exhibit cell division intermediate between binary fission and mitosis
• The next 2 slides are from the textbook and are summary slides of Interphase G1, S, G2 and M (mitosis)
**G₂ of Interphase**

- Centrosomes (with centriole pairs)

**Prophase**

- Chromatins (duplicated)
- Early mitotic spindle
- Aster
- Centromere
- Chromosome, consisting of two sister chromatids

**Prometaphase**

- Fragments of nuclear envelope
- Nonkinetochore microtubules
- Kinetochore
- Kinetochore microtubule
Metaphase

Anaphase

Telophase and Cytokinesis

Metaphase

Anaphase

Telophase and Cytokinesis

Cleavage furrow

Nucleolus forming

Metaphase plate

Centrosome at one spindle pole

Daughter chromosomes

Nuclear envelope forming

Spindle
The cell cycle is regulated by molecular controls

- Short cell cycle—ex. skin cell divides frequently
- Longer cycle—ex. brain cell
- Mitosis always takes about 40 minutes so the cell cycle differences are in interphase

Cycle completed in 24 hours in skin cell or years in brain cell
The red pieces represent times that the cell meets a checkpoint.

The G1 and G2 checkpoints are in interphase.
This is a slide of heart muscle tissue. The cells are in Go – they are functioning normally, just not dividing

- **QUESTION 12. Fill in the cell cycle stage or cell cycle checkpoint**
  
  a. List the 4 main phases of the cell cycle (do not include the C phase)
  
  b. What is the name of the phase in which cells that **do not pass** the G1 checkpoint enter?
  
  c. If the G1 checkpoint is passed, what then happens to the DNA chromosomes in the cell?
  
  d. What are the 4 sub-phases of mitosis?
  
  e. Once two new daughter cells are produced (after cytokinesis), which phase of the cell cycle do they each enter?