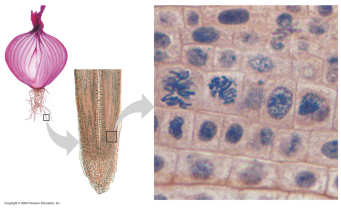
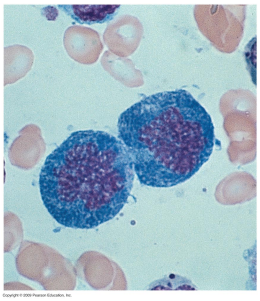
Modern Biology
Ch. 8 NOTES
Mitosis and Meiosis





Opening Essay
Describe the life-cycle phases of a multicellular organism. Explain how asexual reproduction can be used to save a plant species from extinction.

LT1 Why do cells divide?

Connections Between Cell Division and Reproduction

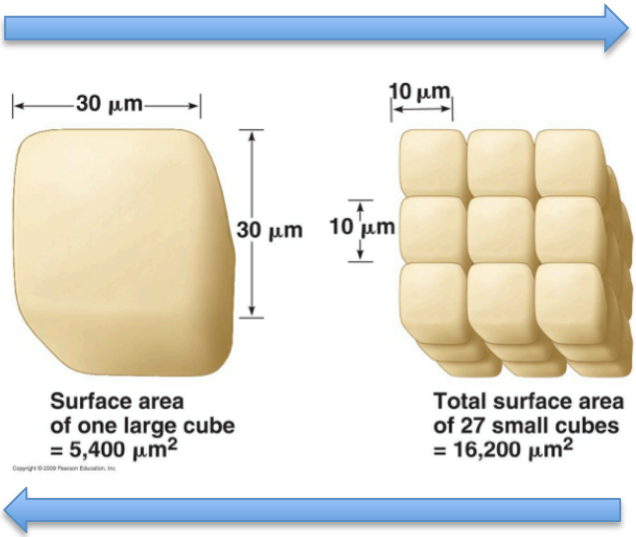
8.1 Compare the parent-offspring relationship in asexual and sexual reproduction.

- ✍ Asexual reproduction produces genetically identical offspring that inherit all of their DNA from a single parent.
- ✍ The offspring of sexual reproduction show a family resemblance, but siblings vary because they inherit different combinations of genes from the two parents.

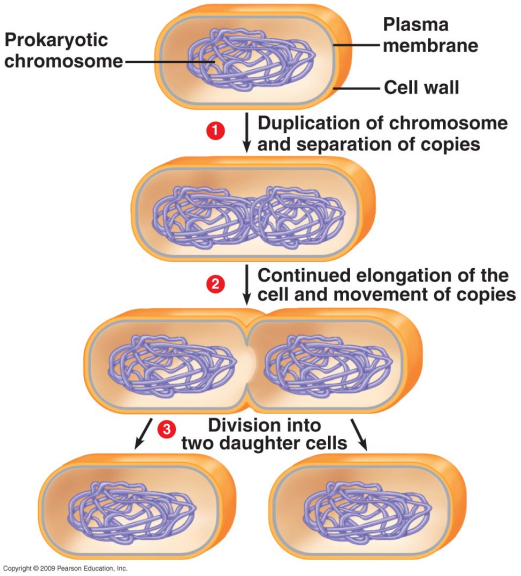
8.2 Explain why cell division is essential for eukaryotic and prokaryotic life.

In order for life to continue, cells and organisms must be replaced.

For organisms to grow, their cells must become more numerous, not just bigger.



- When cells divide, their surface area (supply of nutrients across the plasma membrane) decreases slower, by length^2 while volume (metabolic demand) decreases faster by length^3.
- Division gives the cell a much more favorable surface area to volume ratio.

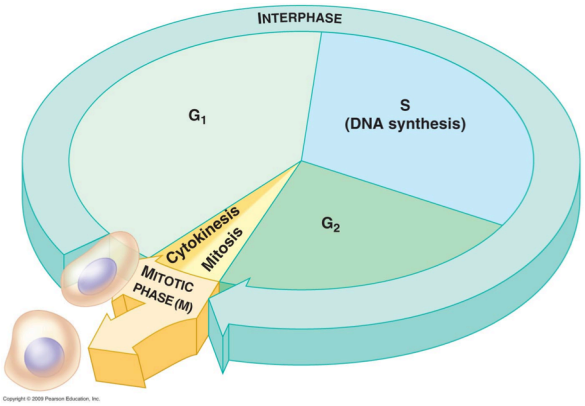


8.3 Explain how daughter prokaryotic chromosomes are separated from each other during binary fission.

1. As the chromosome is duplicating, one copy moves toward the opposite end of the cell.
2. Meanwhile, the cell elongates.
3. Plasma membrane pinches double-sized cell into two.

LT2 The Cell Cycle
LT2a-c

8.5 Identify when DNA is replicated, chromosomes are sorted, and two new cells are formed.
Describe the stages of the cell cycle.
Use the Cell Cycle Activity online.



INTERPHASE:
- Takes up 90% of the cell cycle
- Growing stage
- Cell roughly doubles everything in cytoplasm
- precisely replicates its DNA.
- Time of very high metabolic function

Subphases

G_1:
- "First Gap"
- cell grows
- chromosomes are single

S:
- Chromosome duplication
- cell grows

G_2:
- "Second Gap"
- cell grows
- chromosomes are identical sister chromatids.

MITOTIC PHASE or M PHASE:
cell division
10% of cell cycle
Stages:
Mitosis: Nuclear Division (of chromosomes)
Cytokinesis: Cytoplasm Division

LT2d Why is cancer considered a disease of the cell cycle?

8.10 Explain how cancerous cells are different from healthy cells.
Cancer is a disease of the cell cycle.
- Cancer cells do not respond normally to cell cycle control system, i.e. G_1, G_2 checkpoints leading to G_0 or "time out.
- Cells divide out of control
- Can invade other tissues preventing normal functioning
- Can kill organism (1 in 5 people in U.S.)
- Cell transformation to abnormal.
- Abnormal cells are killed by immune system
- May evade immune system and multiply
- Tumors are abnormally growing mass of body cells.

8.10 Distinguish between benign and malignant tumors.
Benign Tumor: remains at original site.
Malignant tumor cells spread to other tissues
- **Cancer Patients**: have malignant tumors
- **Metastasis**: cancer cells spread by circ. and lymphatic system

8.10 Explain the strategies behind some common cancer treatments.
Benign tumors
Surgery
Radiation (focused high-energy radiation)
Malignant Tumors:
Chemotherapy:
- disrupts specific steps in cell cycle
- negative affects on tissue with rapid cell division
  - intestinal cells → nausea
  - hair follicles → hair loss
  - immune cells → susceptibility to infection

LT3a,b Structure of Chromosomes

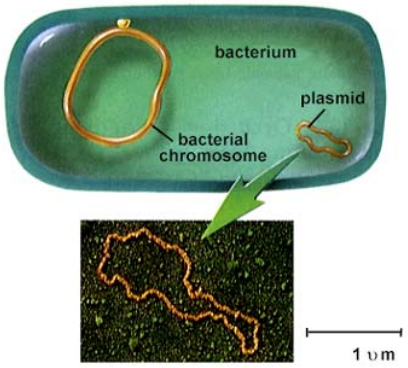
8.3–8.4 Compare the structure of prokaryotic and eukaryotic chromosomes.

Prokaryotes:

- Nucleoid Region
- Main chromosome: large, circular
- Plasmids: very small, circular, satellite DNA
- DNA + proteins

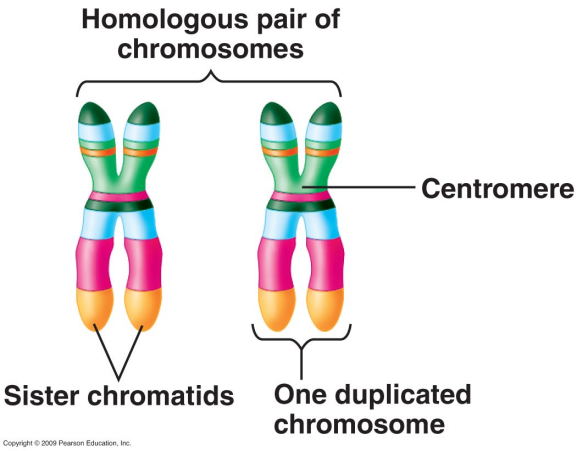
Eukaryotes:

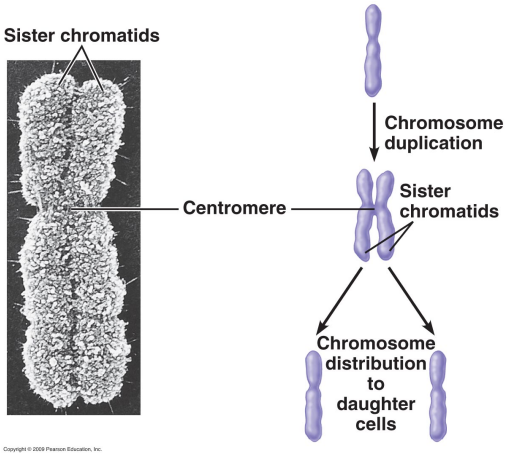
- located in:
  - nucleus
  - mitochondria (bacteria-like)
  - chloroplasts (bacteria-like)
- linear
- DNA + proteins, many more than prok., more complex
- Two forms:
  - chromatin: diffuse mass of long, thin fibers
  - distinct chromosomes: before cell division



VOCABULARY OF CELL DIVISION

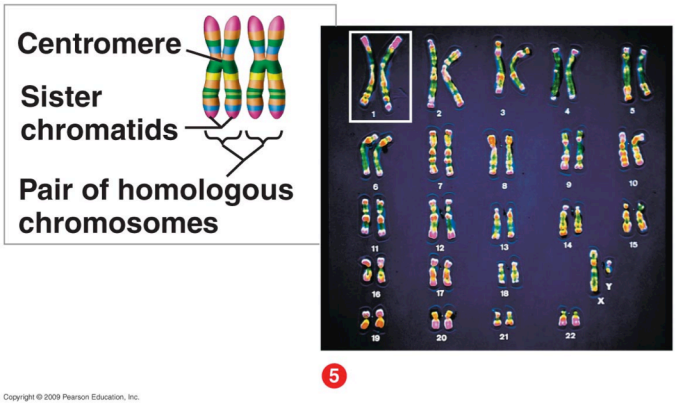
Chromatin	diffuse mass of long, thin fibers of DNA when cell is "reading" DNA to make proteins.
Chromosome	Condensed form of DNA
Chromatids	Identical sister chromatids are result of DNA Synthesis during the cell cycle
Centromere	Protein that holds sister chromatids together, site for spindle fiber attachment. Split apart in Anaphase (mitosis) / Anaphase II (meiosis)
Centrioles	Animal cell organelle composed of cylinders of microtubule triplets. Usually has a centrosome with a pair of centrioles involved in cell division.
Centrosome	Microtubule organizing center.
Cytokinesis	Division of the cytoplasm to form two separate daughter cells. Occurs in Telophase. Mitosis and cytokinesis make up the mitotic (M) phase of the cell cycle.
Cell plate	A double membrane across the midline of a dividing plant cell, between which the new cell wall forms during cytokinesis.





LT3c Autosomes vs. sex chromosomes

Sex chromosomes is only the 23rd pair.
Autosomes are all the other pairs: 1-22



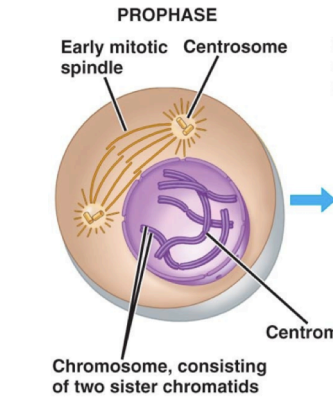
Animation of Mitosis esp. metaphase/anaphase (Saved to: MacHD, cschmittloyd, downloads) [Google: Drew Berry, Astonishing Molecular Machines. Download and show clip from 5:00 min. - 9:30 min.]
Or click the

link::http://www.youtube.com/watch?v=dMPXu6GF18M&noredirect=1

LT4a-c

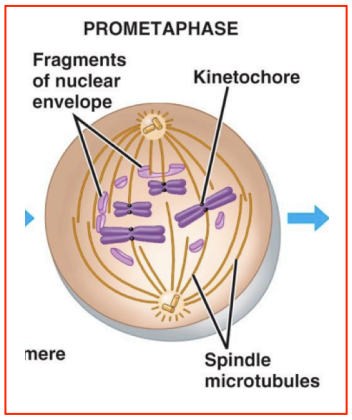
8.6 Recognize the phases of mitosis from diagrams and micrographs. fig. 8.6 p. 130-131. Use the Mitosis Video Activity online.

8.6 List the phases of mitosis and describe the events characteristic of each



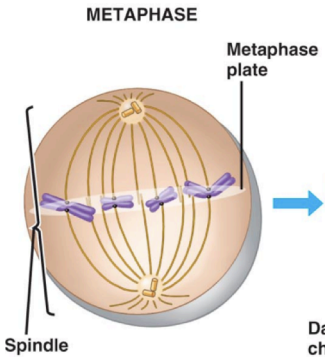
PROPHASE

1. Chromatin → Chromosomes
2. Nucleoli disappear
3. Mitotic spindle appears
4. Centrosomes migrate to poles



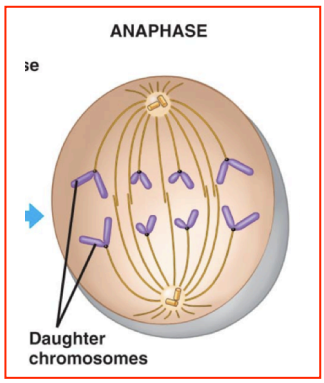
PROMETAPHASE

1. Nuclear Envelope disappears
2. Spindle fibers attach to centromere
3. Others attach to each other (pole to pole)
4. Protein "motors" move chromosomes to center of cell.



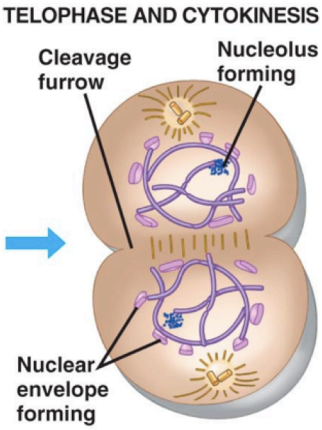
METAPHASE

1. "Chromosomes met at metaphase"
2. Centromeres of all chromosomes are lined up on the metaphase plate (equatorial plane)
3. Sister chromatids face opposite poles.
4. Microtubules attached to one sister chromatid all go to one pole.



ANAPHASE

1. Begins when the two centromeres of each chromosome come apart, separating identical sister chromatids.
2. Chromatid → Chromosome.
3. Motor proteins "walk" the daughter chromosomes, centromere-first, along the microtubules toward opposite poles shortening microtubules.
4. Polar fibers elongate, stretching the cell.



TELOPHASE

1. Cell elongation continues. (Prophase run backwards.)
2. Nuclear envelopes reform.
3. Nucleolus reappears.
4. Chromosomes → chromatin.
5. Mitotic spindles disappear.

CYTOKINESIS

Division of cytoplasm

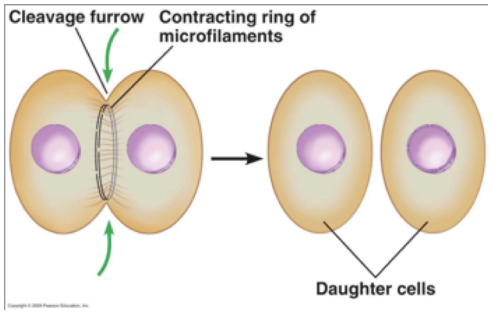
LT4d Types of cells that undergo mitosis

8.11 Describe the functions of mitosis.

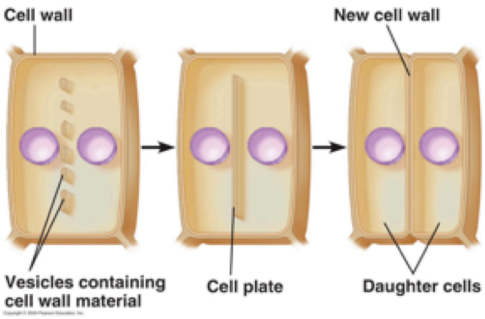
- **Growth:** all organisms begin as a zygote or fertilized egg. Mitosis of that first cell gives rise to clones that make up the rest of the organism's body.
- **Maintenance**: Some examples: skin cells slough off, RBC's live 3 months, intestinal cells divide rapidly to replace older cells.
- **Repair**: damaged cells ranging from skinned knees to post-surgical healing is repaired by mitosis.
- **Asexual reproduction**: some organisms can make new individuals (clones) by mitosis.

LT4e 8.7 Compare cytokinesis in animal and plant cells.

Animals: Cleavage Furrow



Plants: Cell Plate formation.



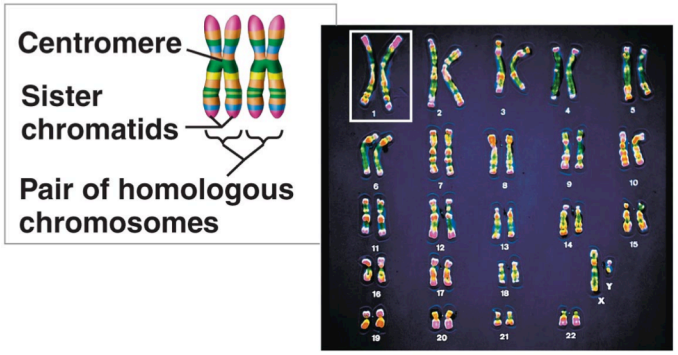
LT5

Meiosis and Crossing Over

8.12 Explain how chromosomes are paired. Distinguish between autosomes and sex chromosomes.

Somatic Cells

- body cells
- 23 pairs of chromosomes
- (pairs = 2) (23 = n) (2n = 46)



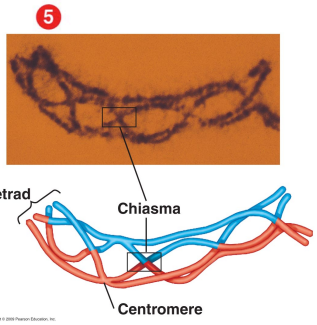
Homologous Chromosomes

- Each parent donates one set of chromosomes (n)
- Fertilization brings both together: n + n = 2n
- Restores original number.
- Two sets of chromosomes or 2n.
- Example: #1 chrom. from mom
  #1 chrom. from dad
- These are homologous chromosomes.

Autosomes: All the chromosomes except the sex chromosomes

Sex Chromosomes:

- In humans, the 23rd pair of chromosomes.
- Carry genes for traits other than sex determination.
- XX = female
- XY = male
- Because males have two versions of sex chromosomes they determine the sex of the offspring.

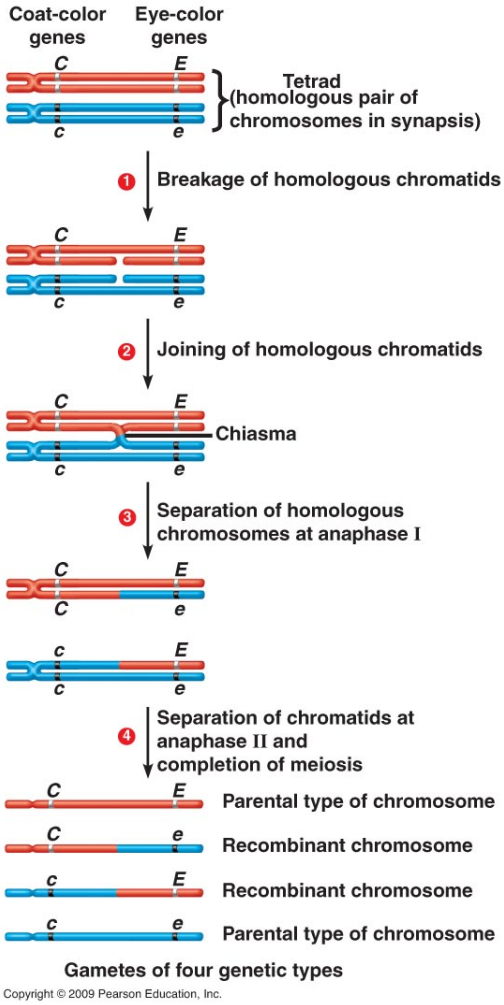


MEIOSIS

8.13 Distinguish between somatic cells and gametes and between diploid cells and haploid cells.

Somatic Cells: body cells (2n = diploid)
Gametes: eggs and sperm (n = haploid or monoploid)
Diploid Cells: 2n (chromosomes as homologous pairs)
Haploid Cells: n (one of each homologous pair)
Fertilization: n + n = 2n (zygote)

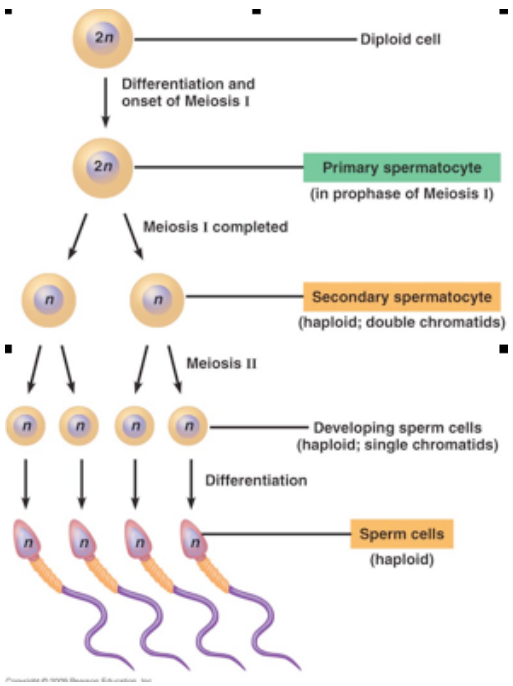
Work through the study sheet "Sex Cells, Sex Chromosomes and Somatic Cells and Autosomes" from Weebly.

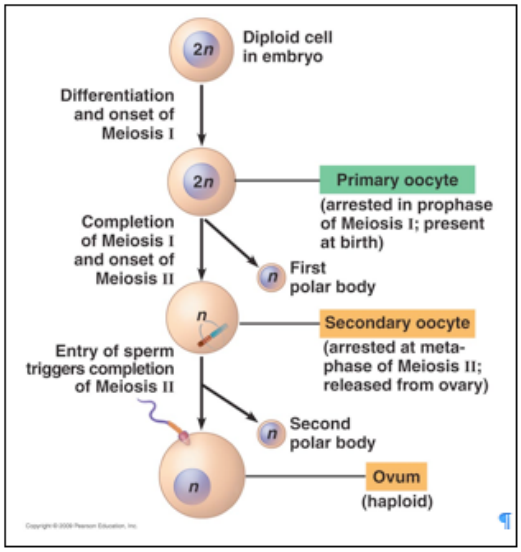


LT5a Similarities and Differences between MI and MII
LT5b When and how the number of chromosomes is reduced in meiosis.

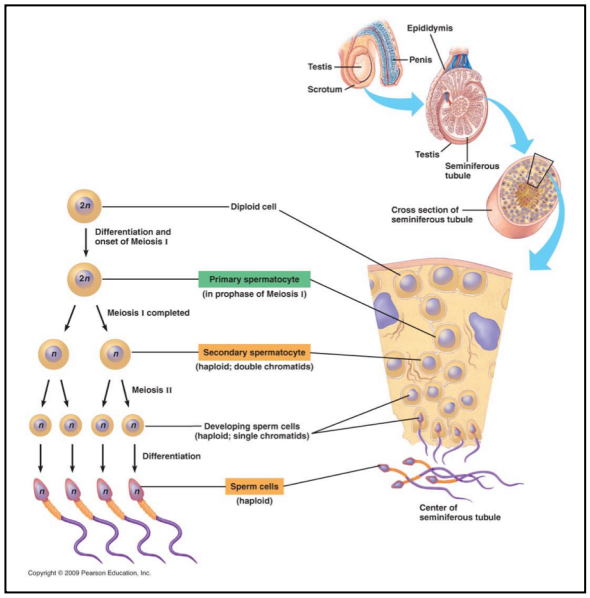
	Phases	Events
Meiosis I (homologs separate)	Prophase I 2 x 2n	▪ 90% of time, most complex ▪ Chromatin condenses into distinct chromosomes ▪ Synapsis & Crossing Over ▪ Nucleoli disappear ▪ Centrosomes move poleward ▪ Spindle forms between centrosomes ▪ Nuclear envelope disappears ▪ Tetrads moved by fibers to middle
	Metaphase I	Tetrads move to center Form <u>double file</u> Spindles attach to each homolog from opposite poles
	Anaphase I 2 x 1n	<u>Homologous pairs separate</u>, move to opposite poles. **Reduction in chromosome number** Sister chromatids but only one homolog
	Telophase I & Cytokinesis	Chromosomes reach poles. Cell Divides 2 haploid cells result
		No S phase
Meiosis II (chromatids separate / mitotic)	Prophase II	○ Spindle forms and moves chromosomes to middle
	Metaphase II	○ Chromosomes aligned on metaphase plate ○ <u>Single file</u>
	Anaphase II 1 x 1n	○ Centromeres of <u>sister chromatids separate</u>, become daughter chromosomes. ○ Move to opposite poles.
	Telophase II & Cytokinesis	○ Nuclei form at the cell poles, cytokinesis occurs at the same time. ○ 4 daughter cells (gametes)

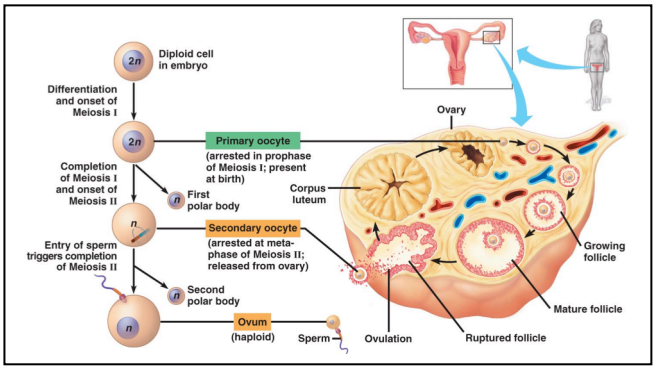
LT5c What type of cells undergo meiosis?





LT5c What type oc cells undergo meiosis?





	Male	Female
timing in life:	Puberty to death	MI before birth, MII at fertilization
number of resulting cells	4	1
contents of gametes	Nucleus (DNA), few, if any, organelles	Nucleus, organelles (mtDNA), mRNA stockpile.
location in body	testes	ovaries
frequency of nondisjunction in relation to age	No correlation	Incidence greatly increases after age 38, "biological clock."

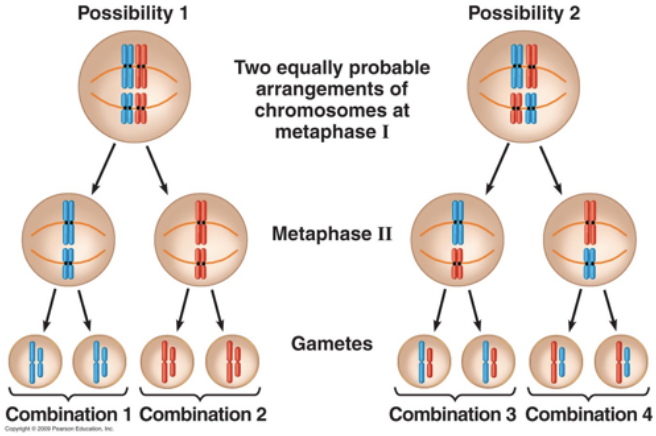
LT5d Meiosis produces genetic variation

8.16–8.18 Explain how independent orientation of chromosomes at metaphase I, random fertilization, and crossing over during prophase I of meiosis contribute to genetic variation in sexually reproducing organisms.

Independent orientation: fig. 8.16

Random fertilization:
Online Activity: The Origin of Genetic Variation

Crossing over: fig. 8.18a,b



LT5e Mutations

Alterations of Chromosome Number and Structure

8.19 Explain why karyotyping is performed.

Karyotype: An ordered display of magnified images of an individual's chromosomes arranged in pairs, starting with the longest. Also used: centromere position and banding pattern.

Why:

- Errors in meiosis can lead to gametes containing chromosomes in abnormal numbers or with major alterations in their structures.
- Fertilization with these gametes results in birth defects.
- Chromosomal abnormalities (not gene-level) can be detected with a karyotype.

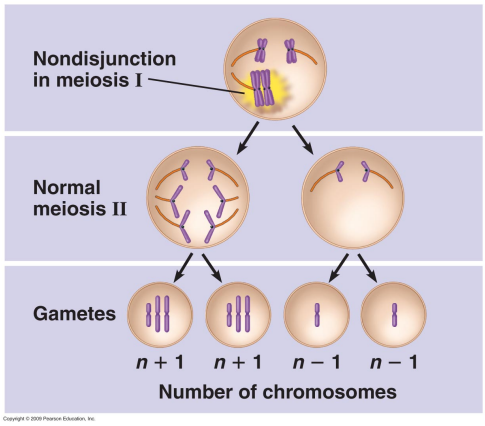
8.21 Define nondisjunction, explain how it can occur, and describe what can result.

Nondisjunction: When the members of a chromosome pair fail to separate as they should

How can it occur?

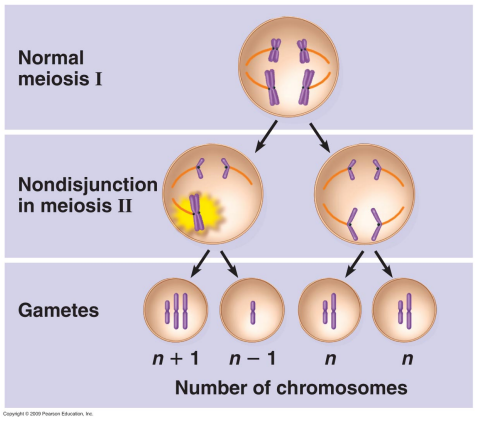
Meiosis I:

- A pair of homologous chromosomes does not separate during meiosis I.
- Even though the rest of meiosis occurs normally, all the resulting gametes end up with abnormal numbers of chromosomes.
- Two of the gametes have three chromosomes; the other two gametes have only one chromosome each.



Meiosis II:

- Meiosis I is normal
- But one pair of sister chromatids fails to move apart during meiosis II.
- Two of the resulting gametes are abnormal; the other two are normal.



8.22 Describe the consequences of abnormal numbers of sex chromosomes. Table 8.22

TABLE 8.22 ABNORMALITIES OF SEX CHROMOSOME NUMBER IN HUMANS

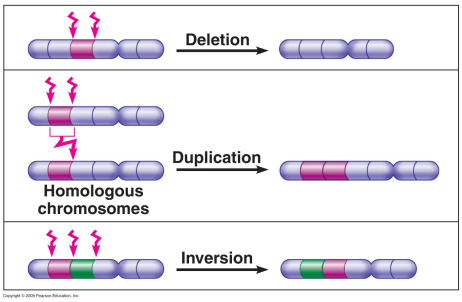
Sex Chromosomes	Syndrome	Origin of Nondisjunction	Frequency in Population
XXY	Klinefelter syndrome (male)	Meiosis in egg or sperm formation	1/2,000
XYY	None (normal male)	Meiosis in sperm formation	1/2,000
XXX	None (normal female)	Meiosis in egg or sperm formation	1/1,000
XO	Turner syndrome (female)	Meiosis in egg or sperm formation	1/5,000

Klinefelter's Syndrome: Males only, 40% survive gestation, feminization, hypogonadism, sterile.

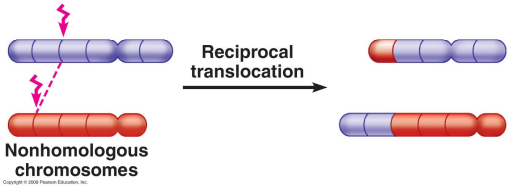
Turner's: Females only, short, thin, tissue between shoulders and head, infertile.

8.24 Describe the main types of chromosomal changes.

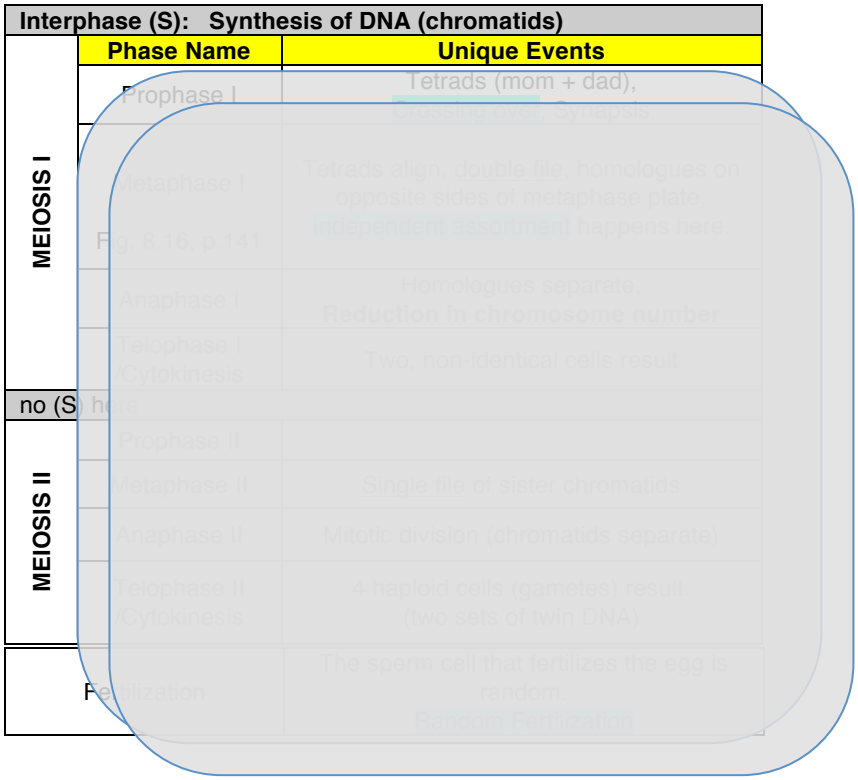
Alterations of chromosome structure involving one chromosome or a homologous pair



Chromosomal translocation between nonhomologous chromosomes.



LT6d Similarities and Differences between mitosis and meiosis



LT6 8.15 Describe the similarities and differences between mitosis and meiosis.

	SIMILARITIES	DIFFERENCES	
		MITOSIS	MEIOSIS
PURPOSE	To create Cells from cells	Growth, Maintenance, Repair, Asexual Reprod.	Gametes for sexual reproduction
Affect on Chromosome #		2n→2n	2n→n
Affect on Diversity of offspring		Clones (no affect)	Crossing over Independent Assortment Segregation of Alleles Random fertilization (increases greatly)
Chromosome Duplications	once		
Divisions		1	2
# of cells resulting		2	4
Phases	Same sequence		
Metaphase & Metaphase I	Align on Metaphase plate	Single file	Double file (tetrads)
Anaphase & Anaphase I		Sister chromatids Separate 2 x 2n → 1 x 2n 1 cell / 2 cells	Homologues separate 2 x 2n → 2 x 1n ◯ ◯
Anaphase II		---------	Chromatids Separate 2 x 1n → 1 x 1n ◯◯ ◯◯

AUTOSOMAL TRISOMIES OPTIONAL READING

Syndrome: A characteristic set of symptoms

NAME	FREQUENCY	N0TES	SYMPTOMS
Trisomy 8 Warkany Syndrome	Complete T8 is very rare	Pre-natally lethal Mosaicism possible	
Trisomy 9	rare	T9 one of the most frequent autosomal anomalies compatible with long survival rate. Mosaicism possible	Abnormal skull, nervous system, mental retardation, abnormal heart, kidneys, musculoskeletal system, overlapping fingers, rocker bottom feet, webbed neck.
Trisomy 13 Patau Syndrome	1/10,000	10% of infants reach 1 year 80% die in the 1st month	Cleft lip or palate Close-set eyes Decreased muscle tone Extra fingers or toes Hernias Hole, split or cleft in iris Low-set ears Severe mental retardation Scalp defects (absent skin) Seizures Skeletal (limb) abnormalities Small eyes Small head (microcephaly) Small lower jaw Undescended testicle
Trisomy 16		Most common chromosomal cause of miscarriage during 1st trimester	
Trisomy 18 Edward's Syndrome	1/6,000	10% of infants reach 1 year 80% die in the 1st month	kidney malformations Structural heart defects Intestines protruding outside the body Developmental delays Growth deficiency Small head Prominent back portion of head Low-set malformed ears Abnormally small jaw Cleft lip/cleft palate Widely –spaced eyes Drooping upper eyelids Short breast bone Clenched hands Absent radius
Trisomy 21 Down's Syndrome	1/700	Most common trisomy that infants can survive. Most common serious birth defect in the U.S.	Characteristic facial features Round face A skin fold at the inner corner of the eye Flattened nose bridge Small irregular teeth Short stature Heart defects Susceptibility to respiratory infections Leukemia Alzheimer's disease Shorter than normal life span
Trisomy 22 Cat eye Syndrome			