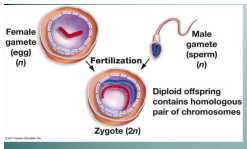
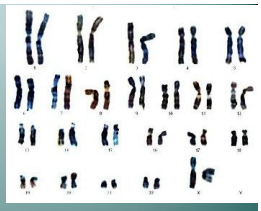
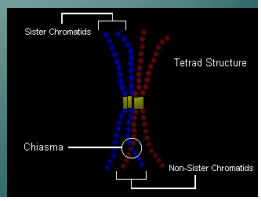


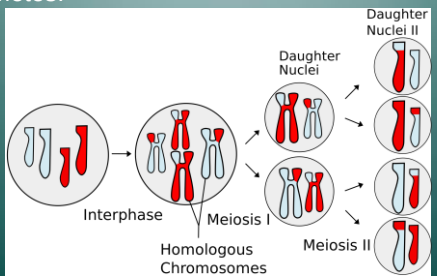


Genetics
3.3- Meiosis



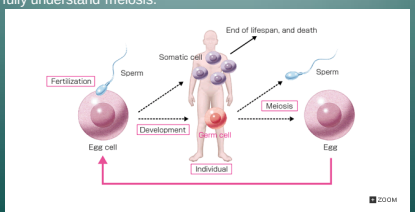
Essential idea:

- Alleles segregate during meiosis allowing new combinations to be formed by the fusion of gametes.



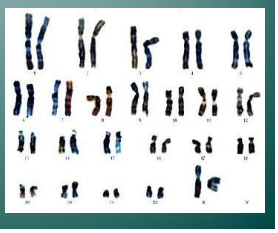
Nature of science:

- Making careful observations
  - Meiosis was discovered by microscope examination of dividing germ-line cells. (1.8)
    - Early microscopes made observations of chromosomes difficult.
    - Choice of organism, tissue, slide preparation and interpreting microscope images are difficult to do.
    - Therefore it took years of careful examination by scientists to discover and fully understand meiosis.



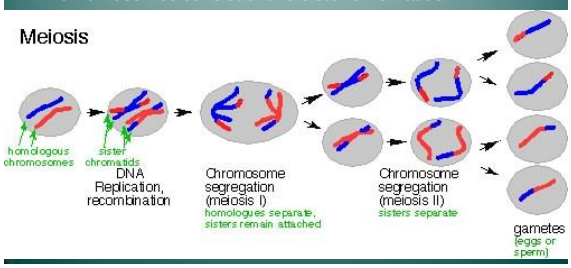
Theory of knowledge:

- In 1922 the number of chromosomes counted in a human cell was 48. This remained the established number for 30 years, even though a review of photographic evidence from the time clearly showed that there were 46.
- For what reasons do existing beliefs carry a certain inertia?



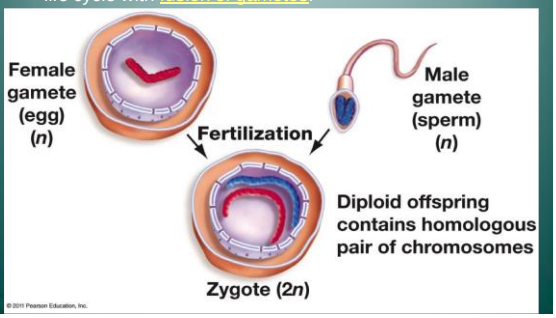
Meiosis

- One diploid (2n)nucleus divides by meiosis to produce four haploid (1n) nuclei.
- DNA is replicated before meiosis so that all chromosomes consist of two sister chromatids



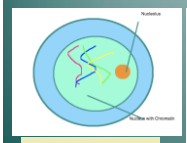
Meiosis

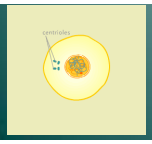
- The halving of the chromosome number allows a sexual life cycle with fusion of gametes.

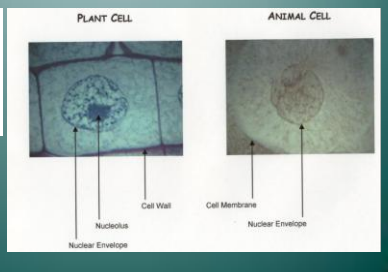


Meiosis I

- Interphase I
  - Chromatin replicates
  - Centrioles replicate(2 Pairs)

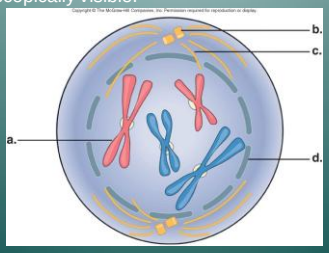






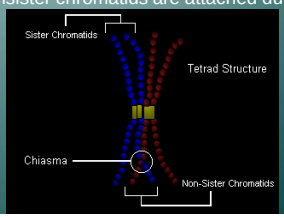
Meiosis I

- Prophase I
  - Nucleolus disappears; nuclear envelope fragments; centrosomes migrate away from each other; and spindle fibers assemble.
  - Chromatin condenses and sister chromatids become microscopically visible.



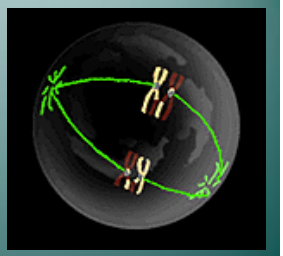
Meiosis I

- Prophase I
  - Homologous chromosomes undergo **synapsis** (pair up) forming tetrads.
  - Homologous chromatids exchange genetic material by "crossing over" which increases genetic variation in the resultant gametes.
  - Homologues are temporarily held together at **chiasma**, regions where the nonsister chromatids are attached due to crossing-over.



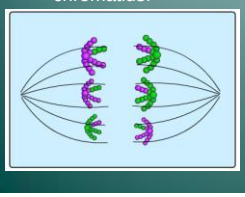
Meiosis I

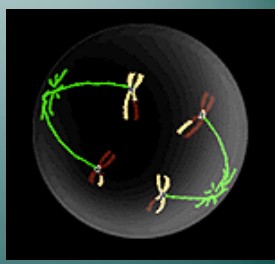
- Metaphase I
  - Tetrads held together at chiasmata are aligned on the metaphase plate.
  - Orientation of pairs of homologous chromosomes prior to separation is random.
  - Kinetochores attach to centrioles to centromeres.



Meiosis I

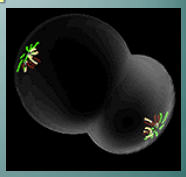
- Anaphase I
  - The homologues of each tetrad separate and move toward opposite poles.
  - Each chromosome still has two sister chromatids.

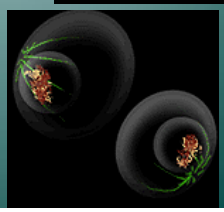




Meiosis I

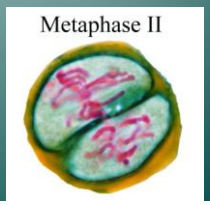
- Telophase I and Cytokinesis.
  - Cleavage furrows or cell plates form.
  - Forms 2 haploid cells
  - Separation of pairs of homologous chromosomes in the first division of meiosis halves the chromosome number.





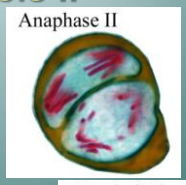
Meiosis II

- Prophase II
  - If cell underwent interkinesis, then nuclei disperse.
  - Spindle forms.
- Metaphase II
  - Haploid number of chromosomes align at metaphase plate.
  - Kinetochores of sister chromatids point to opposite poles.

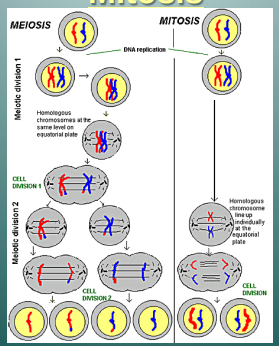


Meiosis II

- Anaphase II
  - Centromeres divide
  - Sister chromotids move toward the poles.
- Telophase II and cytokinesis
  - Nuclei form at opposite poles
  - There are four haploid cells.



Comparison of Meiosis with Mitosis



Significance of Meiosis

- Fusion of gametes from different parents promotes genetic variation.
- Variation provides for adaptations to changing environment.
- Asexual organisms depend primarily on mutations to generate variation
- Keeps chromosome numbers constant in species
- Ensures daughter cells receive one of each kind of gene

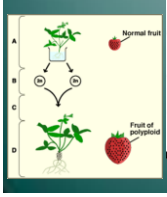
Common Name	Genus and Species	Diploid Number
Buffalo	*Bison bison*	60
Cat	*Felis catus*	38
Cattle	*Bos taurus, B. indicus*	60
Dog	*Canis familiaris*	78
Donkey	*E. asinus*	62
Goat	*Capra hircus*	60
Horse	*Equus caballus*	64
Human	*Homo sapiens*	46
Pig	*Sus scrofa*	38
Sheep	*Ovis aries*	54

Significance of Meiosis

- Independent assortment provides 2^n possible combinations of chromosomes in daughter cells.
  - In humans with 23 haploid chromosomes, $2^n = 2^{23} =$ 8,388,608 possible combinations.
- Variation is added by crossing-over; if only one crossover occurs within each tetrad, 4^{23} or 70,368,744,000,000 (70 trillion) combinations are possible.
- Fertilization also contributes to genetic variation; $(2^{23})^2 =$ 70,368,744,000,000 possible combinations without crossing-over.
- With fertilization and crossing-over, $(4^{23})^2 =$ 4,951,760,200,000,000,000,000,000,000 combinations are possible.

Nondisjunction

- Failure of chromosomes to separate
- Monosomy: missing one chromosome
- Trisomy: three of one type of chromosome.
- Polyploidy
  - More than two complete sets of chromosomes
  - Create triploids [3n], tetraploids [4n], etc.
  - A major evolutionary mechanism in plants.



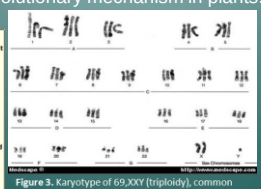
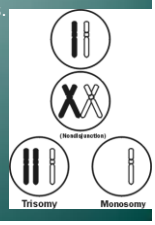
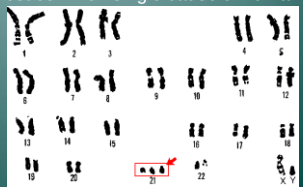


Figure 3. Karyotype of 69,XXY (triploidy), common finding in spontaneous abortion.



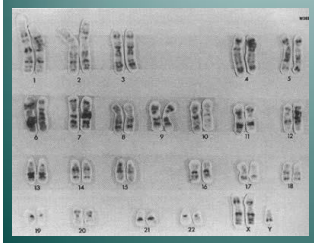
Down Syndrome (Trisomy 21)

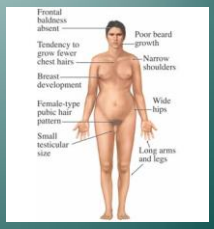
- Application: Non-disjunction can cause Down syndrome and other chromosome abnormalities
- Nondisjuction at 21
- Appearance includes; excess skin at the nape of the neck, flattened nose, single crease in the palm of the hand, small ears, small mouth, upward slanting eyes
- Down syndrome is the most common single cause of human birth defects.



Klinefelter Syndrome (XXY)

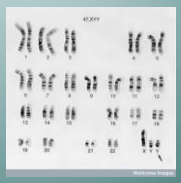
- Nondisjuction of sex chromosomes
- Feminization, sterile, underdeveloped testes.

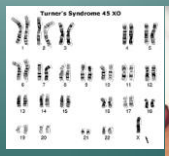


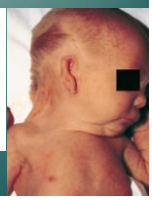


Other Nondisjunction Disorders

- Jacob's Syndrome
  - XYY males
  - Learning problems at school
  - Delayed emotional maturity
  - Tall, thin, acne
  - Not overly aggressive
- Turner's Syndrome
  - XO females
  - Short, webbed neck, no puberty.



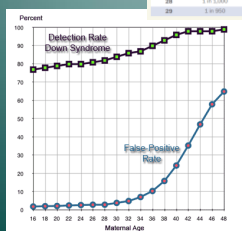




Application:

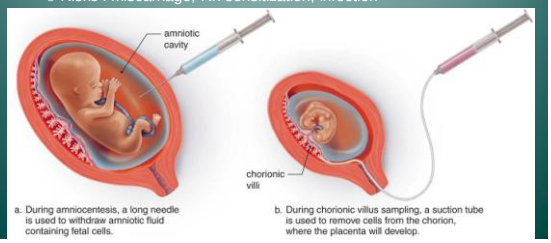
- Studies showing age of parents influences chances of nondisjunction.

Maternal Age	Incidence of Down syndrome	Maternal Age	Incidence of Down syndrome	Maternal Age	Incidence of Down syndrome
20	1 in 2,000	30	1 in 900	40	1 in 100
21	1 in 1,700	31	1 in 800	41	1 in 80
22	1 in 1,500	32	1 in 720	42	1 in 70
23	1 in 1,400	33	1 in 606	43	1 in 50
24	1 in 1,300	34	1 in 150	44	1 in 40
25	1 in 1,200	35	1 in 350	45	1 in 30
26	1 in 1,100	36	1 in 300	46	1 in 25
27	1 in 1,050	37	1 in 250	47	1 in 20
28	1 in 1,000	38	1 in 200	48	1 in 15
29	1 in 960	39	1 in 150	49	1 in 10



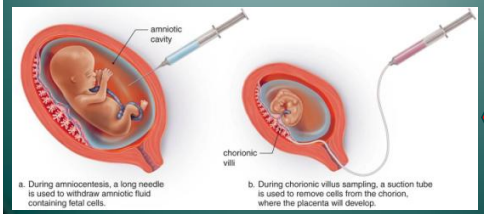
Application:

- Description of methods used to obtain cells for karyotype analysis e.g. chorionic villus sampling and amniocentesis and the associated risks.
  - Chorionic Villus Sampling
    - Risks : miscarriage, Rh sensitization, infection



Application:

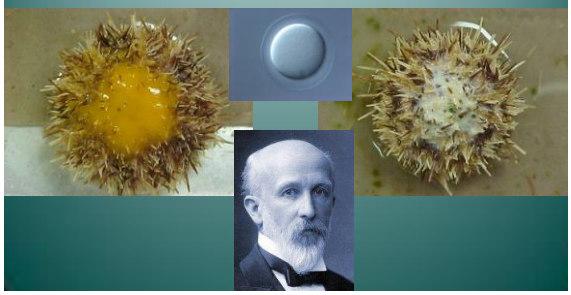
- Description of methods used to obtain cells for karyotype analysis e.g. chorionic villus sampling and amniocentesis and the associated risks.
  - Amniocentesis
    - Risks: miscarriage, Rh sensitization, infection, leaking amniotic fluid, needle injury, infection transmission



End

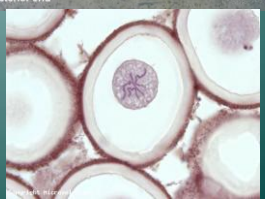
Discovery of Meiosis

- 1876 - German biologist Oscar Hertwig recognized the role of the cell nucleus during inheritance and chromosome reduction during meiosis from work on Sea Urchins.



Discovery of Meiosis

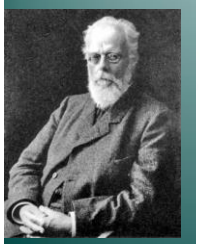
- 1883 - Belgian zoologist Edouard Van Beneden discovered in the roundworm Ascaris how 4 chromosomes organize during meiosis.

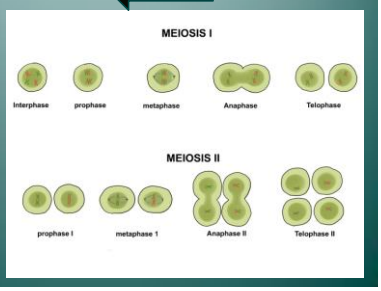


Discovery of Meiosis

- 1890 - German biologist August Weismann theorize that two cell divisions were necessary to transform one diploid cell into four haploid cells.

Back





Fertilization

- Involves the fusion of two gametes
- Increases genetic variation in populations by providing for new combinations of genetic information in the zygote
- Restores the diploid number of chromosomes.

Back

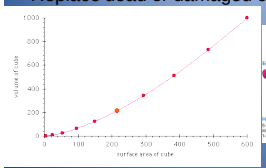
Chromosome Numbers of Some Common Organisms

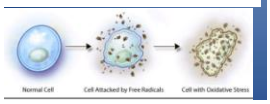
Organism	Body Cell (2n)	Gamete (n)
Human	46	23
Garden pea	14	7
Fruit fly	8	4
Tomato	24	12
Dog	78	39
Chimpanzee	48	24
Leopard frog	26	13
Corn	20	10

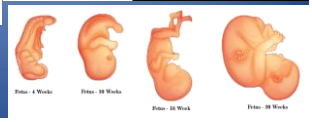
Remember 1.6 Notes

Purpose of Cell Division

- Reduce SA/V ratio (increases efficiency).
- Asexual reproduction.
- Growth (size) and Development (differentiation)
- Replace dead or damaged cells.



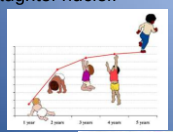




Remember 1.6 Notes

Mitosis

- Mitosis plays a role in growth, repair, and asexual reproduction
- Mitosis is division of the nucleus into two genetically identical daughter nuclei.



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