SEPTEMBER 11

INTRODUCTION TO GENETICS BIOL-FRSC 2050H

Fall Semester 2015
Trent University, Peterborough, ON

Cornelya Klütsch
Janet Yee
Debbie Lietz

INTRODUCTION - MITOSIS / MEIOSIS

Contacts

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Contacts

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contact for problems/concerns regarding labs

- Please include the course name/number in the subject line and give your name plus student number in the email

Biology 2050 H Lab Schedule

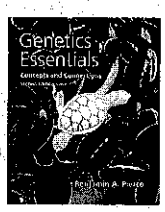
	Date		Lab Topic	D103	D105
Lab 1	Wednesday Sept 16	9:00	Mitosis & Meiosis	F01	F03
	Wednesday Sept 16	13:00		F05	F07
	Wednesday Sept 16	17:00			F09
Lab 1	Wednesday Sept. 23	9:00	Mitosis & Meiosis	F02	F04
	Wednesday Sept. 23	13:00		F06	F08
	Wednesday Sept. 23	17:00			F10
Lab 2	Wednesday Sept. 30	9:00	Mendelian Genetics	F01	F03
	Wednesday Sept. 30	13:00		F05	F07
	Wednesday Sept. 30	17:00			F09
Lab 2	Wednesday Oct. 07	9:00	Mendelian Genetics	F02	F04
	Wednesday Oct. 07	13:00		F06	F08
	Wednesday Oct. 07	17:00			F10

- You can only attend the lab you have signed up for
- Assignments must be handed in at the end of each lab

F02

Required textbook

- Genetic Essentials: Concepts & Connections 2nd edition (2013) by Benjamin Pierce. WH Freeman, New York.
- 1st edition of this textbook allowed
- Textbook will be used in lab sections
- Worked problems and concept checks

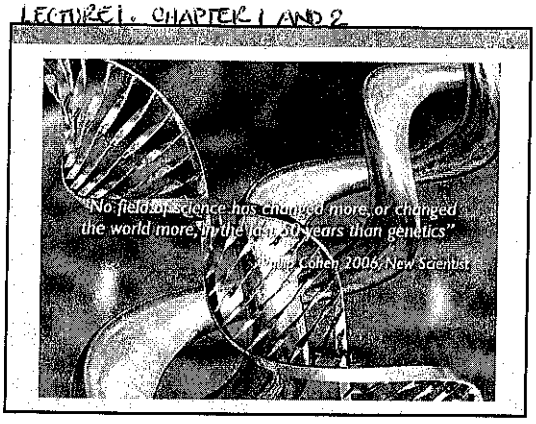


Evaluation

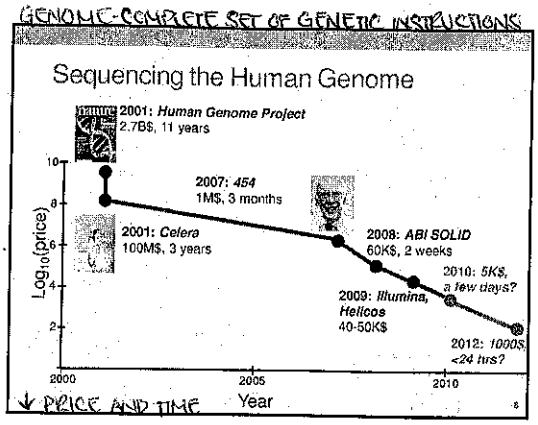
Type of Assignment	Weighting	Due Date
Quiz 1	11.5%	Fri., Oct. 02
Test 1 (all material in Dr. Klütsch's section)	26%	Fri., Oct. 23
Quiz 2	10%	Fri., Nov. 20
Test 2* (all material in Dr. Yee's section)	26%	Dec. 5 – 20*
iClicker	1.5%	Dr. Yee's section only
Labs (5 labs each worth 5%)**	25%	See Lab Schedule
Total	100%	

- There are **no makeup quizzes/tests** scheduled!
- Quizzes/tests are **not transferable** – you can't get higher % in one of Dr. Yee's tests to make up for missed quizzes/tests

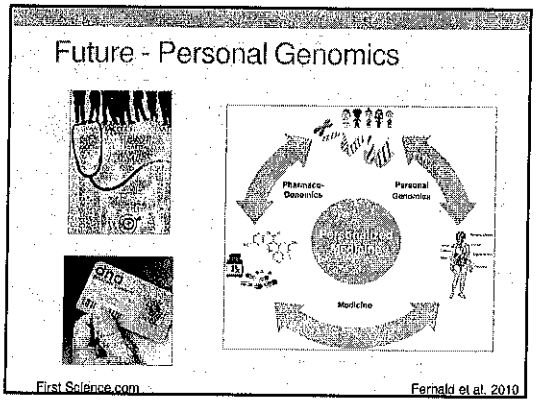
LECTURE 1. CHAPTER 1 AND 2.



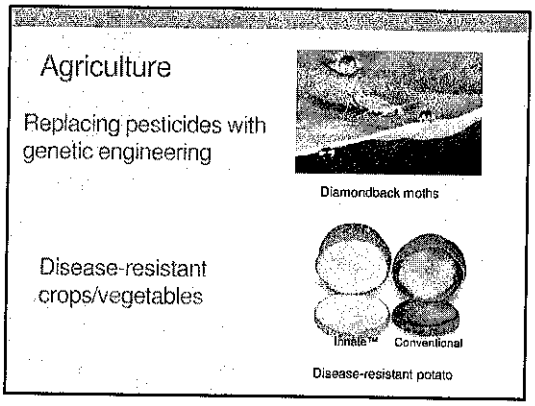
GENOME-COMPLETE SET OF GENETIC INSTRUCTIONS

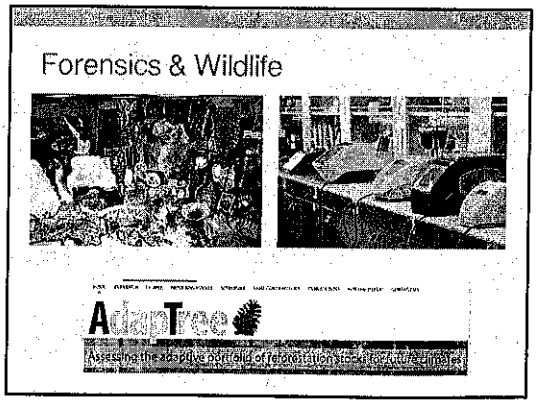


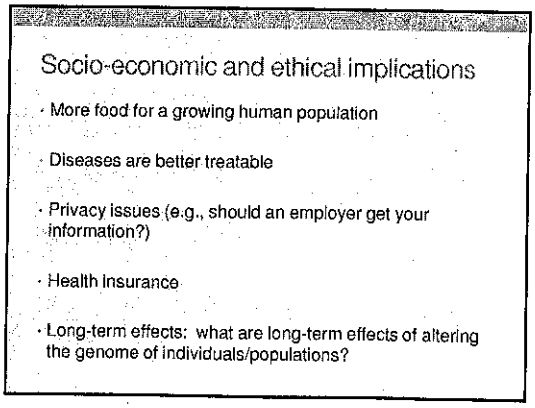
↓ PRICE AND TIME



GENE THERAPY - THE DIRECT ALTERATION OF GENES TO TREAT HUMAN DISEASES.





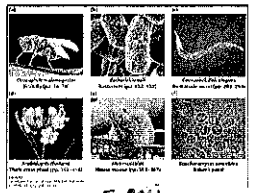


ALL ORGANISMS ARE SIMILAR GENETIC SYSTEMS. AND GENETIC VARIATION IS THE FOUNDATION OF THE DIVERSITY OF ALL LIFE.

1. ALL LIFE FORMS ARE GENETICALLY RELATED
2. RESEARCH FINDINGS ON ONE'S ORGANISM GENE FUNCTION CAN OFTEN BE APPIED TO OTHER ORGANISMS.
3. GENES FROM ONE ORGANISM CAN OFTEN EXIST AND THRIVE IN ANOTHER ORGANISM.

Model organisms

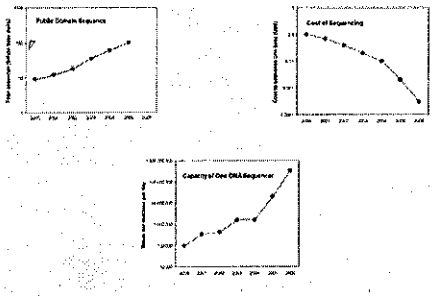
- Short generation time
- Manageable number of offspring
- Lab environment
- Low cost
- (small genome and/or large databases)



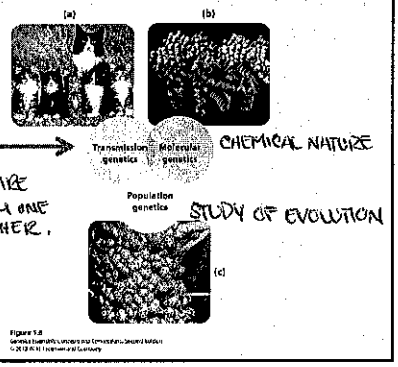
FRUIT FLY, E. COLI, NEMATODE (ROUNDWORM), THALE-CRESS PLANT, MOUSE, BAKER'S YEAST.

CHAPTER 1 INTRODUCTION OF GENETICS

Next Generation Sequencing



DIVISIONS OF GENETICS

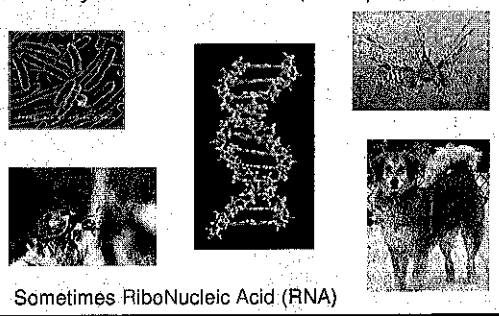


HEREDITY.
- HOW TRAITS ARE PASSED FROM ONE GEN TO ANOTHER.

CHEMICAL NATURE

STUDY OF EVOLUTION

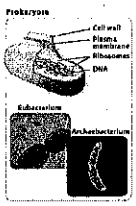
DeoxyriboNucleic Acid (DNA)



Sometimes RiboNucleic Acid (RNA)

DNA
↓ (TRANSCRIPTION)
RNA
↓ (TRANSLATION)
PROTEIN

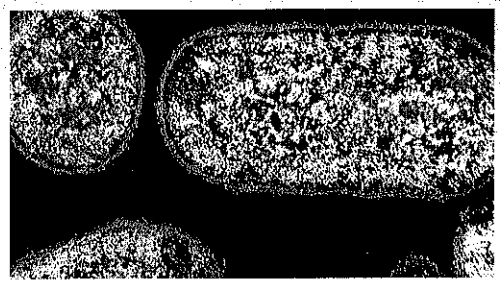
PROKARYOTIC CELLS.

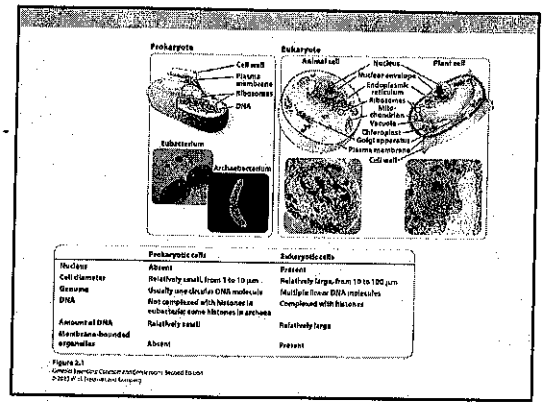


	Prokaryotic cells
Nucleus	Absent
Cell diameter	Relatively small, from 1 to 10 μm
Genome	Usually one circular DNA molecule
DNA	Not complexed with histones in eubacteria; some histone-like in archaea
Amount of DNA	Relatively small
Membrane-bounded organelles	Absent

- Unicellular, with no compartmentalized cell structure
- Prokaryotic DNA does not exist in the highly ordered and packed arrangement
- Made up of eubacteria and archaea

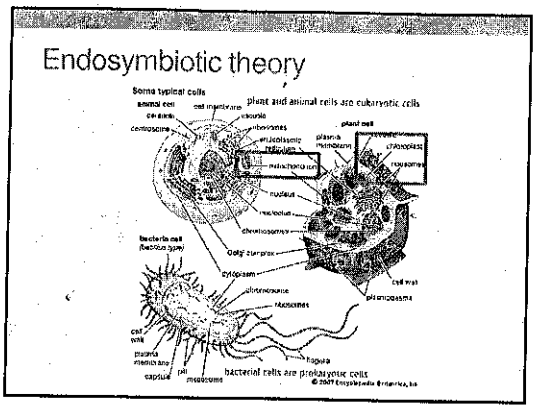
NO NUCLEUS.
- NO MEMBRANE-BOUND ORGANELLES.
- ONE CIRCULAR DNA MOLECULE.





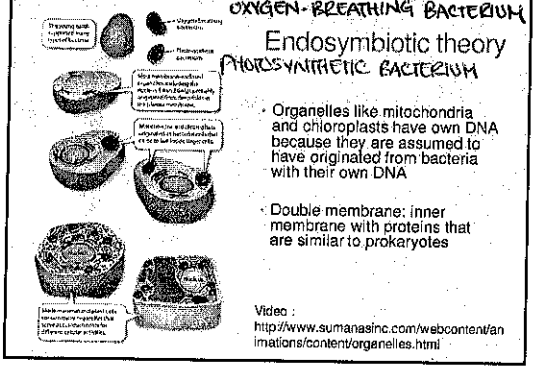
	Prokaryotic cells	Eukaryotic cells
Nucleus	Absent	Present
Cell diameter	Relatively small, from 1 to 10 μm	Relatively large, from 10 to 100 μm
Genome	Usually one circular DNA molecule	Multiple linear DNA molecules
DNA	Not complexed with histones in eubacteria; some histones in archaea	Complexed with histones
Amount of DNA	Relatively small	Relatively large
Membrane-bounded organelles	Absent	Present

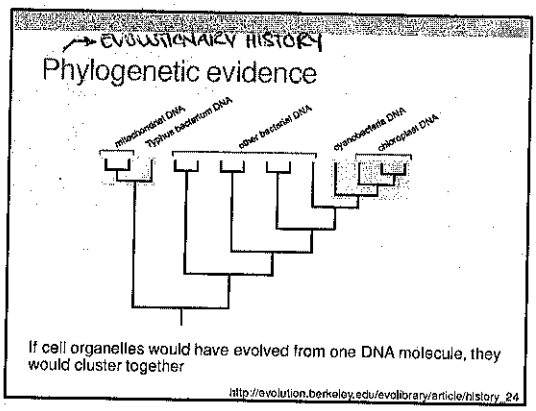
Figure 3.1



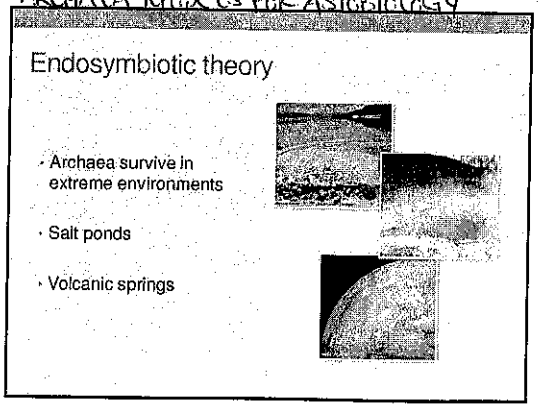
↳EVOLUTIONARY THEORY THAT EXPLAINS THE ORIGIN OF EUKARYOTIC CELLS FROM PROKARYOTES

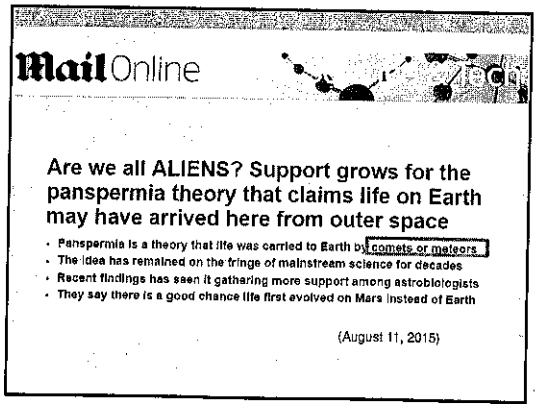
LARGE HOST CELL INGESTED BACTERIA





ARCHAEA MODELS FOR ASTROBIOLOGY





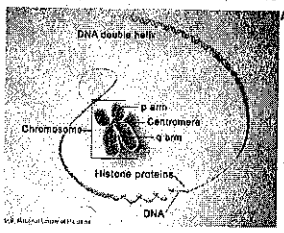
GENOTYPE GENES THAT DETERMINE TRAIT
PHENOTYPE TRAIT THAT THEY PRODUCE.

9/12/2015

CHAPTER 2 CHROMOSOMES AND CELLULAR REPRODUCTION

Eukaryotes: Chromosomes

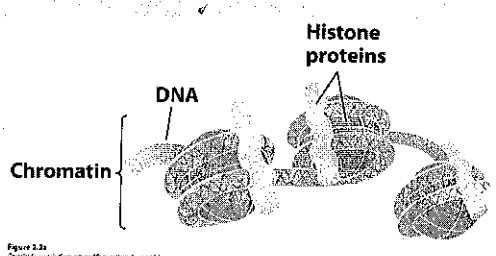
MADE UP OF NUCLEIC ACIDS AND PROTEINS



- Chromosomes are the central packaged units by which DNA is transmitted to new cells or generations

GENES ARE LOCATED IN THE CHROMOSOMES.

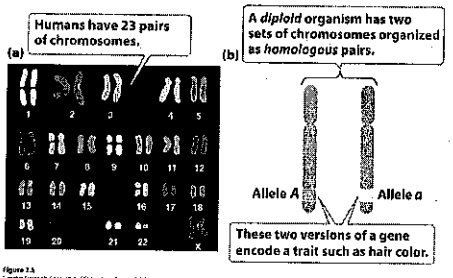
2.1 PROKARYOTIC AND EUKARYOTIC CELLS DIFFER IN A NUMBER OF GENETIC CHARACTERISTICS



LINEAR DNA

NUMBER AND APPEARANCE OF CHROMOSOMES IN THE NUCLEUS OF A EUKARYOTIC CELL.

- **Karyotype: complete set of chromosomes**

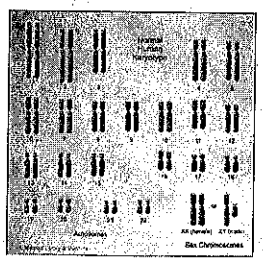


Chromosome number in different species

Common Name	Species	Diploid number	Common Name	Species	Diploid number
Animals (2n)			Plants (2n)		
Human	*Homo sapiens*	46	Corn	*Zea mays*	20
Monkey	*Macaca mulatta*	42	Potato	*S. tuberosum*	48
Dog	*Canis familiaris*	78	Green algae	*A. mediterranea*	20
Cat	*Felis domesticus*	38			
Mouse	*Mus musculus*	40	Fungi (2n)		
Frog	*Rana pipiens*	26	Yeast	*S. cerevisiae*	32
Fruit fly	*Drosophila melanogaster*	8	Fungi (1n)		Haploid number
Flatworm	*Planaria torva*	16	Mold	*Penicillium species*	4

HOMOLOGOUS PAIR 2 CHROMOSOMES USUALLY ALIKE IN STRUCTURE AND SIZE. EACH CARRIES GENETIC INFO FOR THE SAME SET OF HEREDITARY CHARACTERISTICS.

Autosomes and sex chromosomes



- **Autosomes**: Paired chromosomes with the same length/shape

Example: body size, hair colour

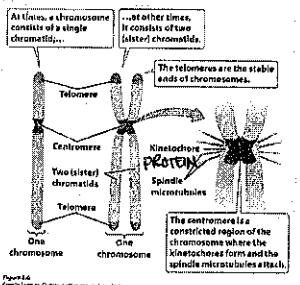
- **Sex chromosomes**: (ALLOSOME)

Chromosome pair that differs in size/shape

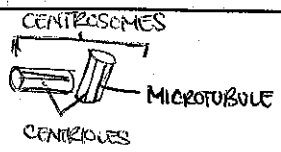
Sex determination

XX FEMALE XY MALE

Chromosomes



FUNCTIONAL CHROMOSOMES
- CENTROMERES, TELOMERES, AND ORIGINS OF REPLICATION



FOR ANY CELL TO REPRODUCE SUCCESSFULLY
1. GENETIC INFO. MUST BE COPIED
2. COPIES OF GENETIC INFO. MUST BE SEPARATED FROM EACH OTHER
3. THE CELL MUST DIVIDE

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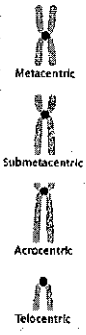
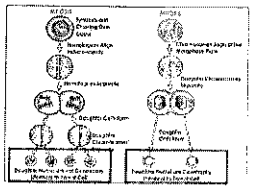
Chromosomes types



- Metacentric: centromere in the middle
- Submetacentric: between middle and end
- Acrocentric: close to the end
- Telocentric: at the end

How is DNA transmitted?

- Mitosis: cell division – production of two cells that are identical to the parent cell
- Meiosis: production of 4 cells with ½ the number of chromosomes as the parent cell that are genetically different

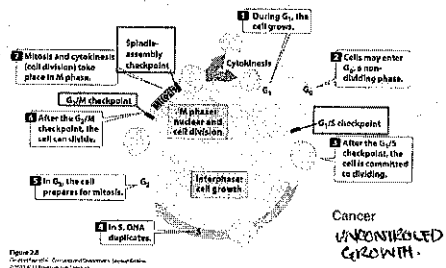


Mitosis (chapter 2)

PROKARYOTIC CELL REPRODUCTION
- CIRCULAR CHROMOSOME REPLICATED
- ORIGIN OF REPLICATION

MITOSIS - EUKARYOTIC CELL REPRODUCTION
- REQUIRES MULTIPLE DNA MOLECULES

Mitosis – cell cycle



Cancer
UNCONTROLLED GROWTH.

FAIL CHECKPOINT - APOPTOSIS

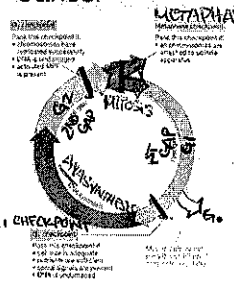
METAPHASE CHECKPOINT
PASS THIS CP IF:
- ALL CHROMOSOMES ARE ATTACHED TO SPINDLE APPARATUS.

G1 CHECKPOINT
- CELL SIZE IS ADEQUATE
- NUTRIENTS ARE SUFFICIENT
- SOCIAL SIGNALS ARE PRESENT
- DNA IS UNDAMAGED

G2 CHECKPOINT
- CHROMOSOMES HAVE REPLICATED SUCCESSFULLY
- DNA IS UNDAMAGED
- ACTIVATED MPF* IS PRESENT.

MATURATION PROMOTING FACTOR.

Cancer



METAPHASE CHECK POINT
- Early cancer treatment:
- Colchicine - INHIBITS MICROTUBLE POLYMERIZATION
- Interrupts cell cycle
- Cells are unable to divide
- Toxic side effects

THE THREE CELL-CYCLE CHECKPOINT

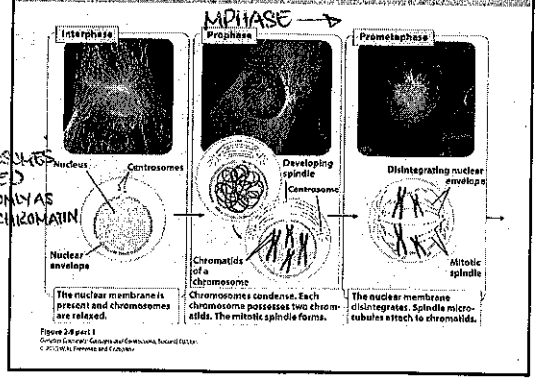
Source: Mastering Biology (Pearson 2011)

G0 PHASE STABLE, NONDIVIDING PERIOD

INTERPHASE
- G1 GROWTH / DEVELOPMENT, G1 CP
- S SYNTHESIS OF DNA
- G2 PREPARATION FOR DIVISION, G2 CP

2.2 CELL REPRODUCTION REQUIRES THE COPYING OF THE GENETIC MATERIAL, SEPARATION OF THE COPIES, AND CELL DIVISION.

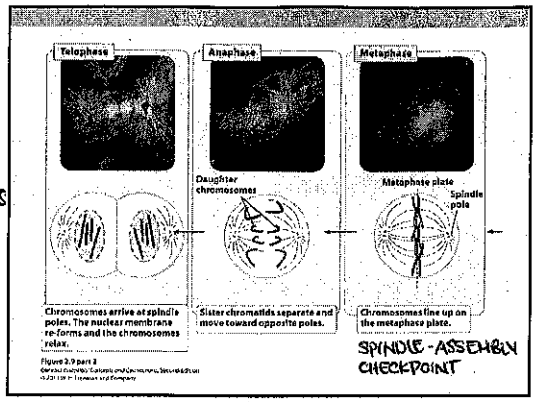
CHROMOSOMES RELAXED VISIBLE ONLY AS DIFFUSE CHROMATIN



PROPHASE BECOME VISIBLE UNDER A LIGHT MICROSCOPE
- CHROMOSOMES CONDENSE, MITOTIC SPINDLE FORMS

PROMETAPHASE NUCLEAR ENVELOPE DISINTEGRATES
- SPINDLE MICROTUBULES ANCHOR TO KINETOCHORES

CYTOKINESIS
- CYTOPLASM DIVIDES
- CELL WALLS FORMS IN PLANT



SPINDLE-ASSEMBLY CHECKPOINT

10 MINUTE BREAK

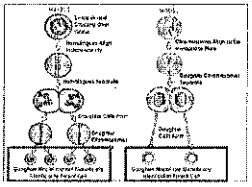
2.3 SEXUAL REPRODUCTION PRODUCES GENETIC VARIATION THROUGH THE PROCESS OF MEIOSIS

MEIOSIS

SEXUAL REPRODUCTION
1. MEIOSIS
2. FERTILIZATION

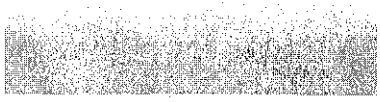
How is DNA transmitted?

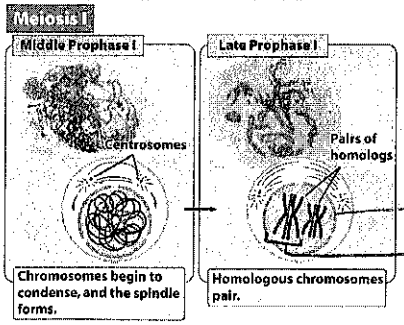
- Mitosis: cell division – production of two cells that are identical to the parent cell
- Meiosis: production of 4 cells with ½ the number of chromosomes as the parent cell that are genetically different



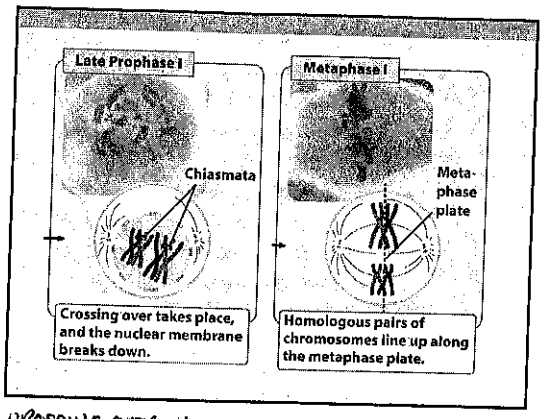
INTERPHASE 2N
PROPHASE I 4N
METAPHASE I 4N
ANAPHASE I 4N
TELOPHASE I CYTOKINESIS
PROPHASE II 2N
METAPHASE II 2N
ANAPHASE II 2N
TELOPHASE II CYTOKINESIS N

Meiosis (chapter 2)

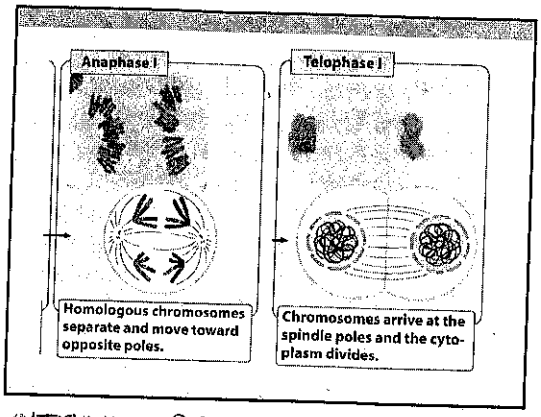




PAIR UP AND BEGIN SYNAPSIS, VERY CLOSE ASSOCIATION
4 CHROMATIDS (BIVALENT OR TETRAD)



CROSSING OVER HOMOLOGOUS CHROMOSOMES EXCHANGE GENETIC INFORMATION

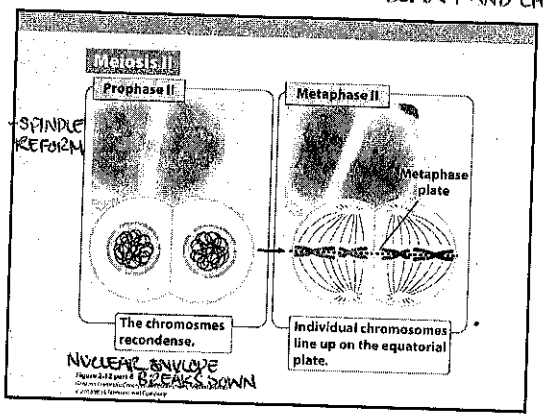


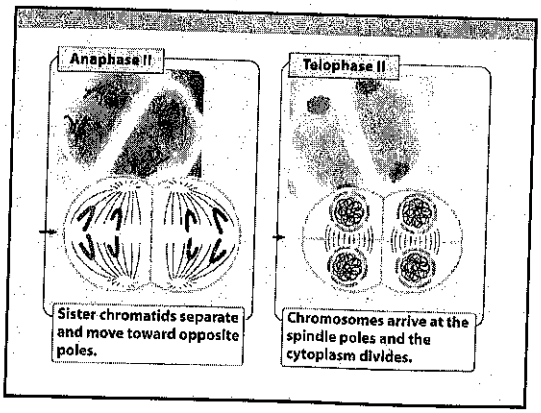
INTERKINESIS PERIOD BETWEEN MEIOSIS I AND II
- NUCLEAR MEMBRANE RE-FORMS AROUND THE CHROMOSOMES, SPINDLES BREAK DOWN, AND CHROMOSOMES RELAX

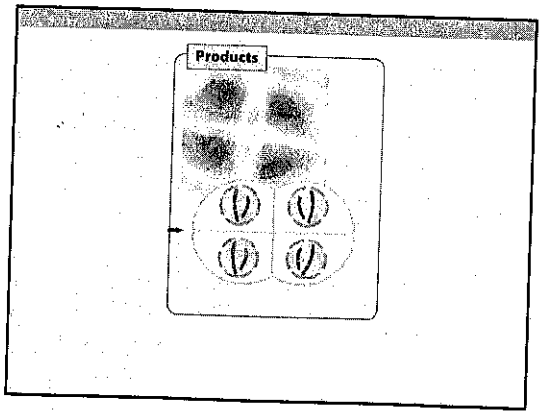
Meiosis II

- Prophase II
- Metaphase II
- Anaphase II
- Telophase II

IN INTERKINESIS SOME CELL TYPES CHROMOSOMES REMAIN CONDENSE, SPINDLES DOES NOT BREAK DOWN
↳ METAPHASE II







SOURCES OF GENETIC VARIATION IN MEIOSIS

Genetic variation

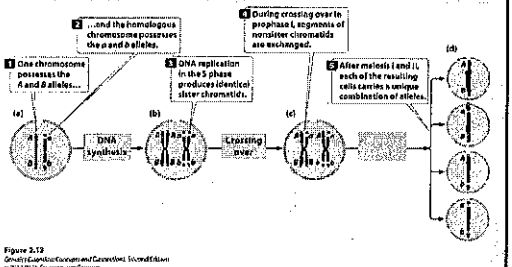
- Individual chromosomes line up in mitosis, whereas homologous chromosome pairs line up in meiosis

↓

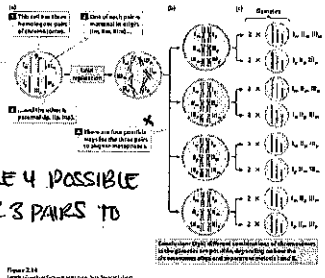
Genetic variation

- Crossing over in late prophase I
- Independent assortment during metaphase I

Recombination – crossing over



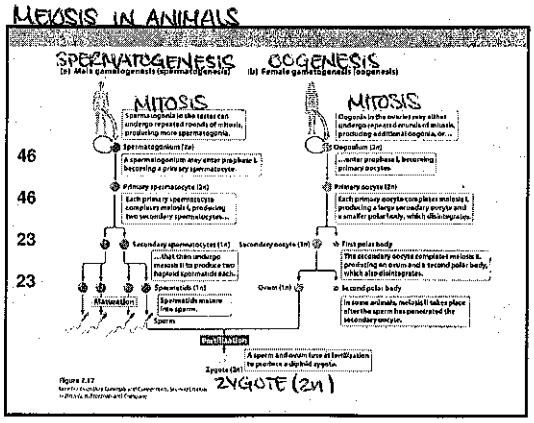
Random assortment



THERE ARE 4 POSSIBLE WAYS FOR 3 PAIRS TO ALIGN.

- **Crossing over** shuffles alleles on the same chromosome into new combinations
- **Independent assortment** shuffles alleles on different chromosomes

MEIOSIS IN ANIMALS



ZYGOTE (2n)

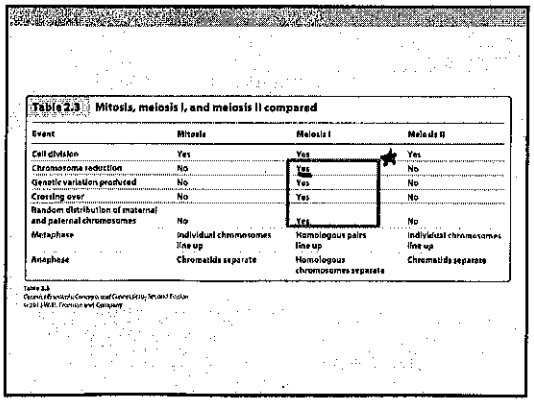


Table 2.3 Mitosis, meiosis I, and meiosis II compared

Event	Mitosis	Meiosis I	Meiosis II
Cell division	Yes	Yes	Yes
Chromosome reduction	No	Yes	No
Genetic variation produced	No	Yes	No
Crossing over	No	Yes	No
Random distribution of maternal and paternal chromosomes	No	Yes	No
Metaphase	Individual chromosomes line up	Homologous pairs line up	Individual chromosomes line up
Anaphase	Chromatids separate	Homologous chromosomes separate	Chromatids separate

- SPERMATOGONIUM (2n)
  - ↳ PROPHASE I, BECOME PRIMARY SPERMATOCYTE
- PRIMARY SPERMATOCYTE (2n)
  - ↳ MEIOSIS I, 2NDARY SPERMATOCYTE
- SECONDARY SPERMATOCYTE (1n)
  - ↳ MEIOSIS II, PRODUCE 4 HAPLOID
- SPERMATID (1n)

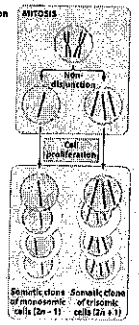
MATURATION

- OOGONIUM (2n)
  - ↳ PROPHASE I
- PRIMARY OOCYTE (2n)
  - ↳ MEIOSIS I < 2ND OOCYTE, 1ST POLAR BODY (DISINTEGRATES)
- SECONDARY OOCYTE (1n)
  - ↳ MEIOSIS II < OVUM
- OVUM (1n)

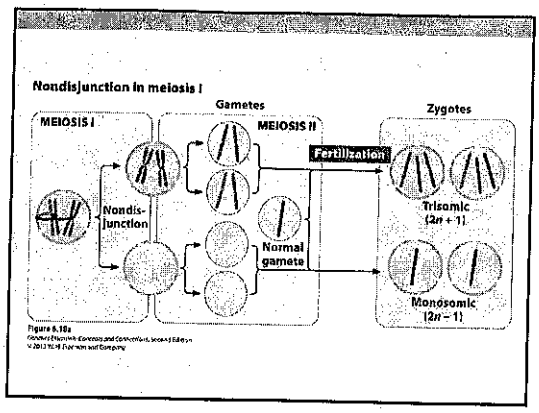
Errors in mitosis

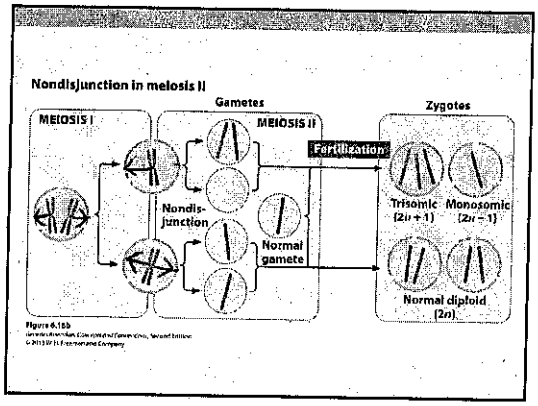
- Nondisjunction
- Mosaic genomes *
- Fatal if early in development

* DENOTES THE PRESENCE OF 2 OR MORE POPULATIONS OF CELLS W/ DIFF GENOTYPES IN ONE INDIVIDUAL



NONDISJUNCTION THE FAILURE OF HOMOLOGOUS CHROMOSOMES OR SISTER CHROMATIDS TO SEPARATE DURING CELL DIVISION





Types of Aneuploidy

PRESENCE OF AN ABNORMAL NUMBER OF CHROMOSOME

- **Nullisomy:** loss of both members of a homologous pair of chromosomes. $2n - 2$
  HUMANS WILL NOT SURVIVE NONDISJUNCTION
- **Monosomy:** loss of a single chromosome. $2n - 1$
  $n + 1 + n \rightarrow 2n + 1$
- **Trisomy:** gain of a single chromosome. $2n + 1$
  $n - 1 + n \rightarrow 2n + 1$
- **Tetrasomy:** gain of two homologous chromosomes. $2n + 2$ 48, XXXX SYNDROME

Multiple choice example questions

Which is the correct order of stages in the cell cycle?

(a.) G1, S, prophase, metaphase, anaphase
b. S, G1, prophase, metaphase, anaphase
c. prophase, S, G1, metaphase, anaphase
d. S, G1, anaphase, prophase, metaphase

Note that the term mitosis is not given here but the term cell cycle clearly identifies this question to refer to mitosis and not to meiosis.

Multiple choice example questions

How many chromosomes would have been in an oogonium that produced an ovum with 18 chromosomes?

- a. 2
- b. 9
- c. 18
- (d.) 36
- e. 72

ovum is haploid
oogonium is diploid
2x