

Meiosis & Sexual Reproduction

Meiosis & Sex



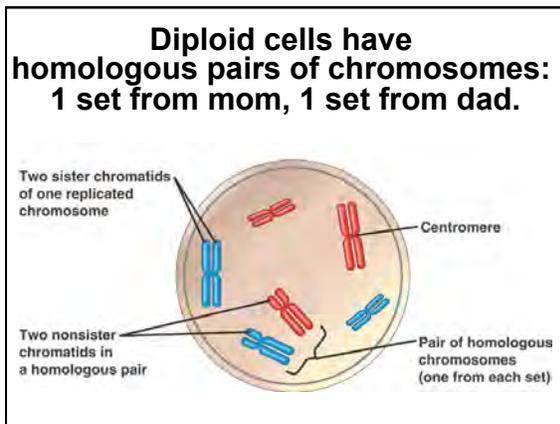
Sexual reproduction creates new combinations of alleles.

Cells Arise From Preexisting Cells

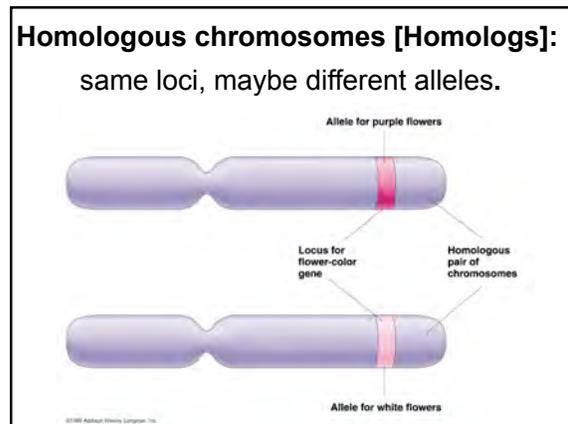
- i. **Asexual (Mitotic) Reproduction**
 - a. Mitosis: production of two identical nuclei
 - b. Cytokinesis: physical division of the cell into two
- ii. **Sexual (Meiotic) Reproduction**
 - a. Meiosis: production of four *non*-identical nuclei
 - b. Cytokinesis: physical division of the cell
 - c. Fertilization: fusion of two sex cells
 - d. Syngamy: fusion of two nuclei




Diploid cells have homologous pairs of chromosomes: 1 set from mom, 1 set from dad.



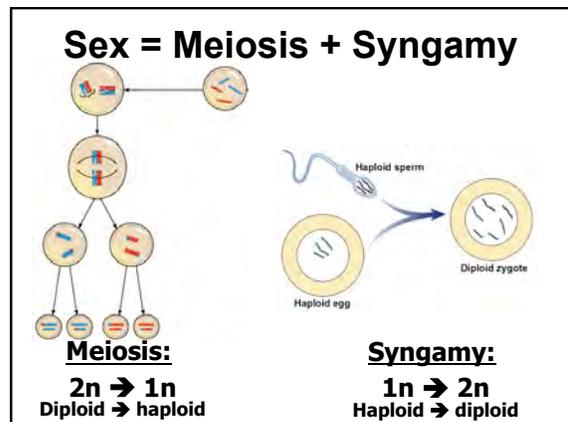
Homologous chromosomes [Homologs]:
same loci, maybe different alleles.



Meiosis: *Reductive* Division
— Reduces Chromosome Number in Half

- * Meiosis has 2 consecutive divisions
 - **Meiosis I**: Homologous pairs separate
 - **Meiosis II**: Sister chromatids separate
- * Each division has a prophase, metaphase, anaphase and a telophase

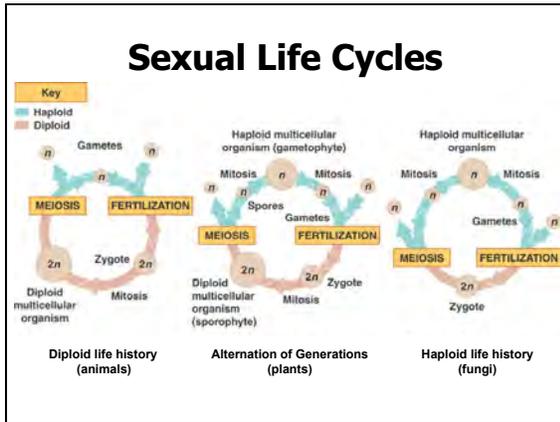
Sex = Meiosis + Syngamy



Meiosis:
 $2n \rightarrow 1n$
Diploid \rightarrow haploid

Syngamy:
 $1n \rightarrow 2n$
Haploid \rightarrow diploid

Meiosis & Sexual Reproduction



Chromosomes Matched in Homologous Pairs (Homologs)

- * Human **somatic** (body) cells
 - 23 pairs = 46 chromosomes
 - Homolog = same size, shape, centromere, and genes
- * Pairs #1 - 22 = **Autosomes**
 - Both male and female
- * Pair #23 = **Sex Chromosomes**
 - Determine gender
 - XX = female, XY = male

Human karyotype

Somatic (body) cells are Diploid Gametes (sex cells) are Haploid

- * **Diploid (2n)**
 - Two of each kind of chromosome
 - Humans 2n = 46
- * **Haploid (n)**
 - One of each kind of chromosome
 - Humans n = 23
- * Haploid **gametes** are produced by **meiosis**
 - Male gamete = sperm
 - Female gamete = egg (ovum)

The human life cycle

Meiosis I

Prophase I

- * Chromosomes condense
- * Nuclear envelope dissolves
- * Spindle forms
- * **Tetrads form**
 - of paired homologs
 - 2 dyads → 1 tetrad
 - "Crossing over"
 - homologous chromosomes swap portions

Stages of meiosis

Meiosis I

Metaphase I

- * Homologous pairs line up on spindle equator

Stages of meiosis

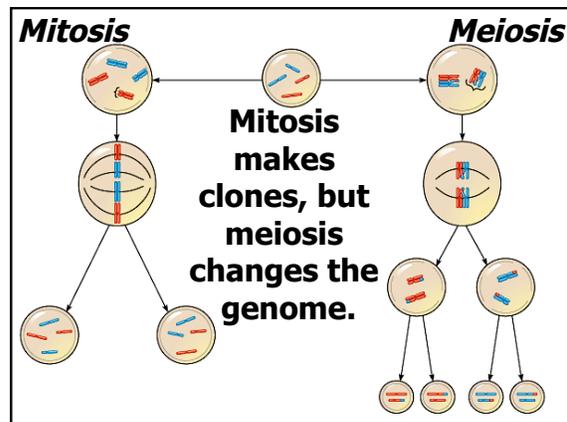
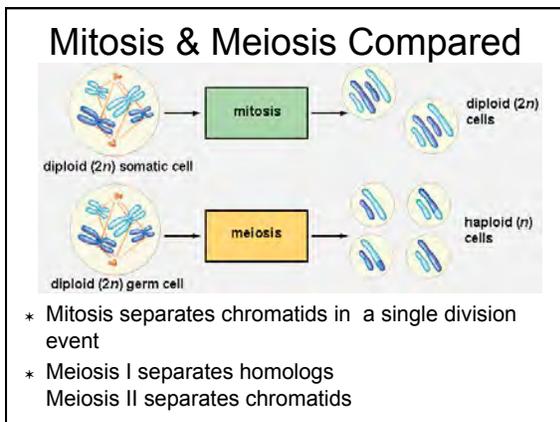
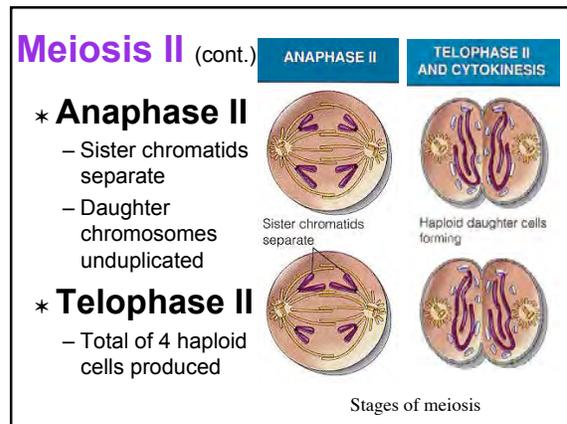
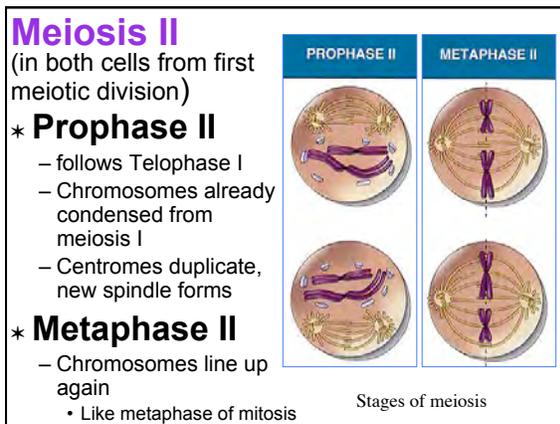
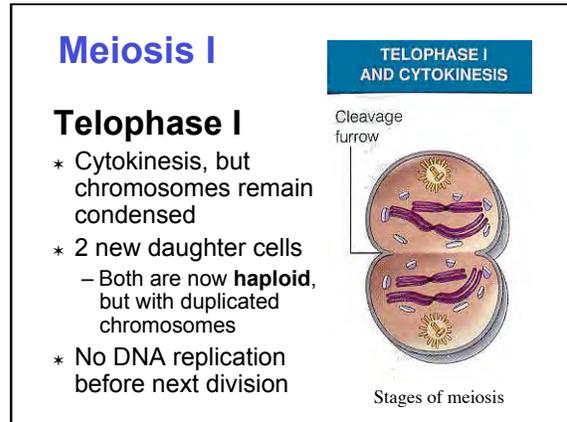
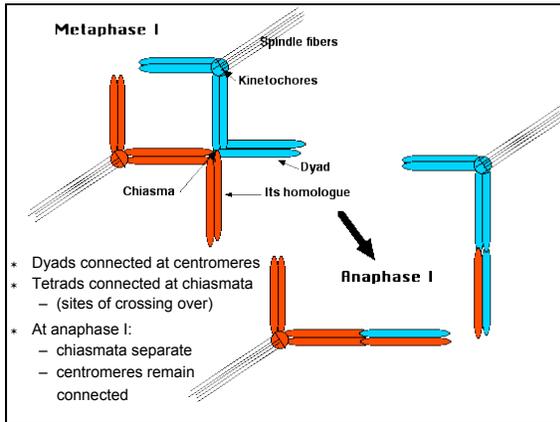
Meiosis I

Anaphase I

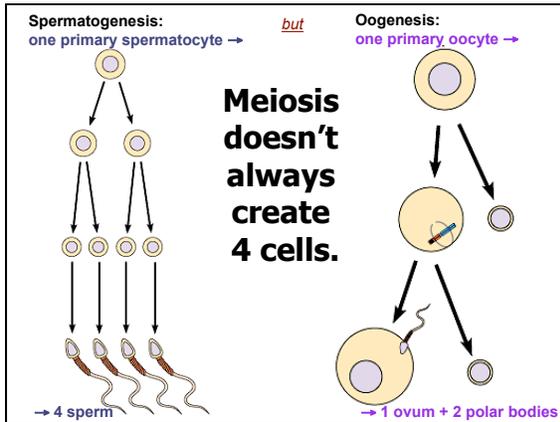
- * Homologous pairs separate
- * Chromosomes are still duplicated

Stages of meiosis

Meiosis & Sexual Reproduction

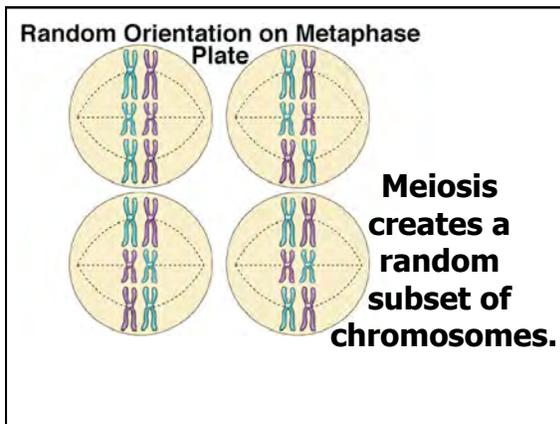


Meiosis & Sexual Reproduction



Sexual Reproduction Produces Genetic Variation

- * Variation arises from
 - I. Independent chromosome assortment in meiosis
 - II. Crossing-over between homologous chromosomes in meiosis
 - III. Random process of fertilization



Homologous Chromosomes Can Carry Different Versions of Genes

- * Homologous chromosomes come from different parents
- * Different versions of same gene = **Alleles**
 - Ex. Brown coat, white coat

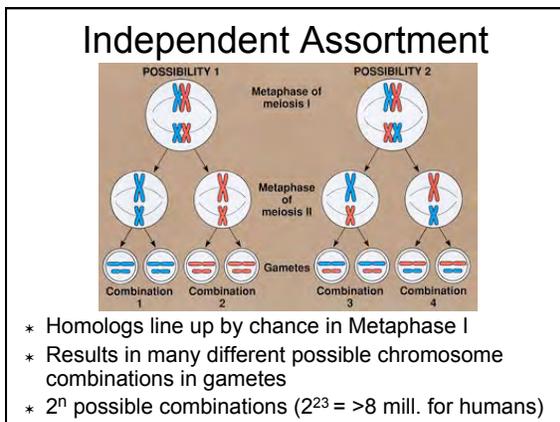
Homologous Chromosomes

Coat-color genes: Brown (C), White (c)
Eye-color genes: Black (B), Pink (b)

Chromosomes of the four genes

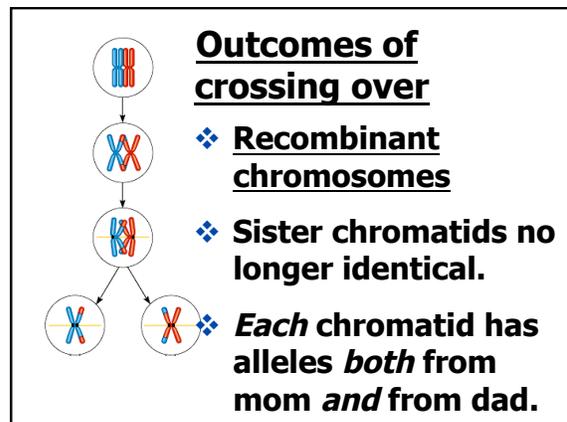
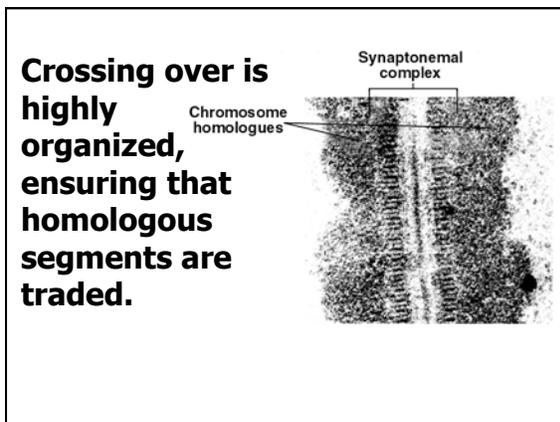
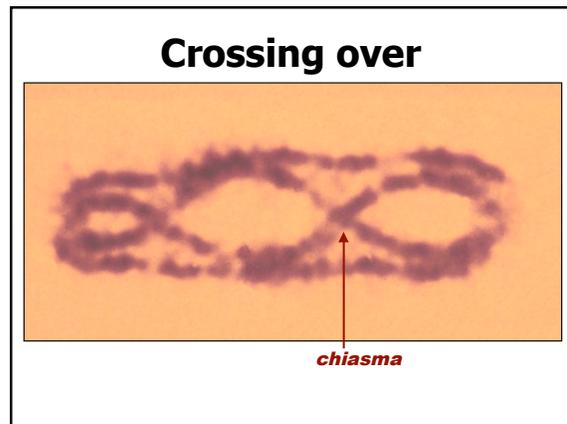
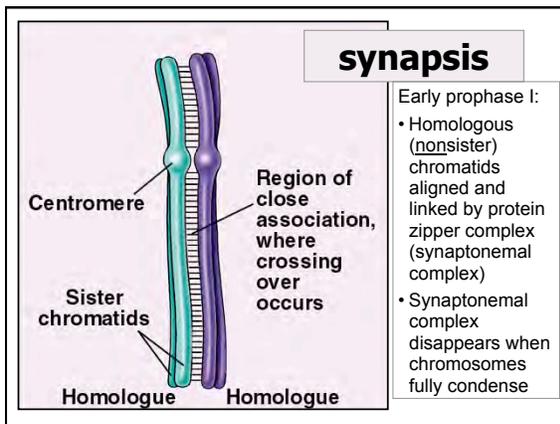
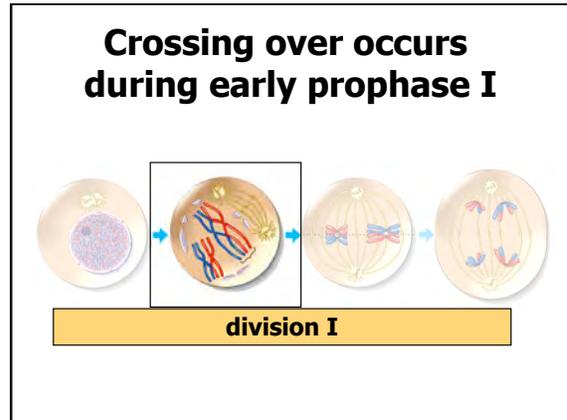
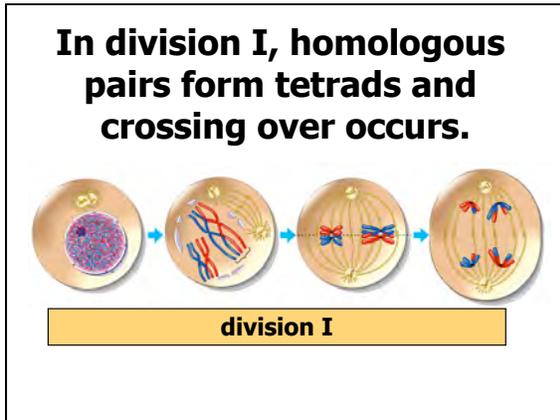
Brown coat (C); black eyes (B) **White coat (c); pink eyes (b)**

Different info on homologous chromosomes



Meiosis I creates new genomes 2 ways:

- ❖ **New combinations of alleles on each chromosome.**
 - Crossing over
- ❖ **New combinations of chromosomes.**
 - Independent assortment



Meiosis & Sexual Reproduction

Non-identical recombinant sister chromatids

In humans, typically 1–3 crossings-over per chromosome in a meiotic division.

In division II, no-longer-identical sister chromatids are separated.

division II

OOGENESIS

Dictyate oogenesis in mammals, birds, & chondrichthyes

- Arrested at Prophase I
 - after synapsis, but before final condensation
 - In humans – from 20 weeks gestation until stimulated by menstrual cycle
- Arrested at Metaphase II
 - until fertilization occurs

Alterations of Chromosome Number and Structure

- * Errors in meiosis can lead to gametes with
 - Aneuploidy
 - (Abnormal number of chromosomes)
 - Alteration of chromosome structure

Aneuploidy

- * **Trisomy 21**
 - = An extra copy of chrom. 21
- * **Down Syndrome**
 - Most common birth defect
 - * Chance increases with age of mother

Down syndrome

Aberrations of Chromosome Structure

Errors in Crossing-over

- * **Deletions and duplications**
 - “Cat-cry” syndrome, deletion in chrom 5
- * **Translocation**
 - CML, most common of leukemia cancers

Translocation of CML

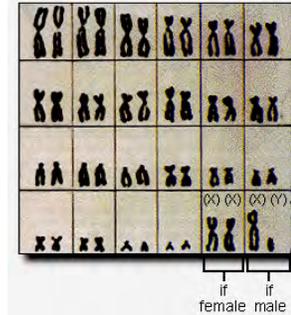
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Random Fertilization

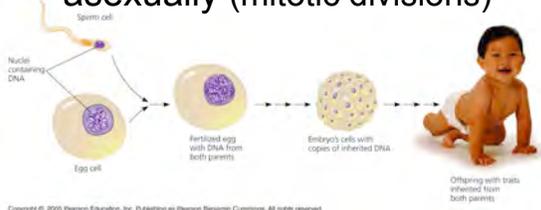
- * Fertilization is a random process
- * A gamete from one individual unites with one from another individual
- * Given that a man can produce 2^{23} genetically different sperm, and a woman can produce 2^{23} genetically different ova:
- * One mating couple can produce a diploid zygote with any of **>70 trillion** combinations of chromosomes! ($2^{23} \times 2^{23}$)
- * (Not even counting variation from crossing-over!)

one pair of the 23 are sex chromosomes

- * Random fertilization determines sex of the zygote
- * XX = female
- * XY = male
- XY is NOT a homologous pair



After fertilization, somatic cells reproduce asexually (mitotic divisions)



- * Differentiation: **all cells genetically identical**, but with **different gene expression**