Review of Mitosis and Meiosis

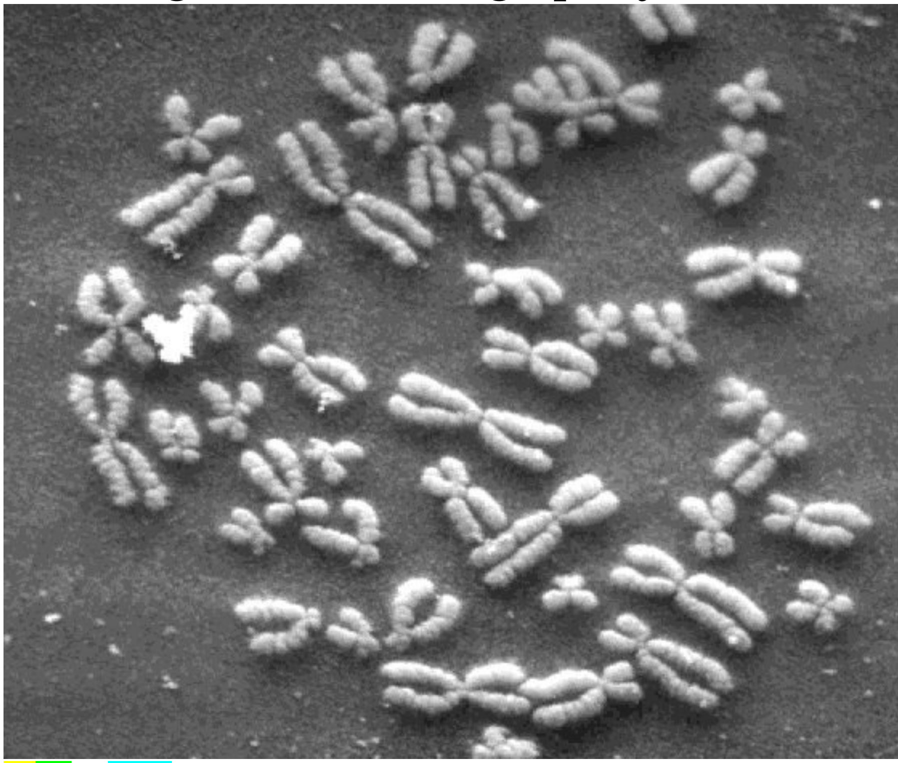
NOTE: Since you will have already had an introduction to both mitosis and meiosis in Biol 204 & 205, this lecture is structured as a review. See the text for a more thorough discussion of these processes. Your obligation for Biol 321 is to understand chromosome movements during these processes and all material in this lecture

Jargon Review

Genomes, Chromosomes & Genes

- The ***genome*** is the total genetic content of a single set of ***chromosomes***
- **Genomes** are organized into DNA polymers (often of different lengths) also known as ***chromosomes***
- ***Genes*** are stretches of DNA located at specific positions along the length of the DNA polymer (chromosome)

Scanning electron micrograph of human chromosomes



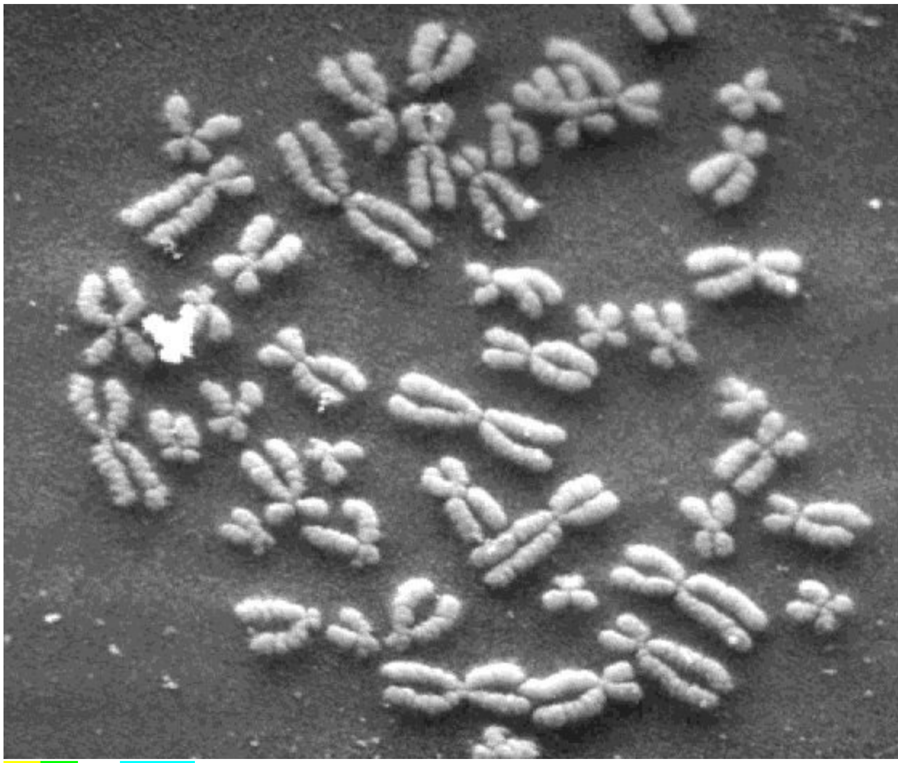
metaphase chromosome spread
Note variation in size and centromere position

2n=46 in humans = shorthand way of describing chromosome content)

The number *following* the n = ?

The number *preceding* the n = ?

n = ?



Metaphase chromosome spread
Note variation in size and centromere position

2n=46 in humans

(shorthand way of describing chromosome content)

The number *following* the n indicates the total number of chromosomes found in a somatic cell

The number *preceding* the n indicates the number of genome copies (or number of copies of each chromosome or each chromosome set)

1n = haploid 2n = diploid 3n= triploid

4n = tetraploid 6n= hexaploid

n = number of chromosomes in one genome copy or one set of chromosomes

Organisms vary with respect to the

- **Number of genome copies**
- **Size of genome**
- **Number of DNA polymers/chromosomes that the genome is divided into**
- **The number of genes encoded in a genome copy**

Winners in the min and max categories

http://www.vivo.colostate.edu/hbooks/genetics/medgen/basics/minmax_chromos.html

2n=2 for Myrmecia pilosula females
(1n=1 for males)

jack jumper ant

 # chromosomes/cell = 1260 for Ophioglossum reticulatum
84 n =1260 n (x)= 15

Adder's tongue fern

Transmission of genetics programs over the millennia has required two basic steps

1. ***Copying step*** **(replication of the DNA molecule or RNA molecules for some classes of viruses)**
2. ***Distribution step*** **(getting the duplicated information *properly* distributed to the progeny)**

The distribution step varies with different types of genomes

How are genomes distributed?

Eukaryotic nuclear genes: **chromosomal movements in mitosis and meiosis**

Eukaryotic cytoplasmic genes: partitioning of cytoplasm and organellar distribution (mitochondria and chloroplasts)

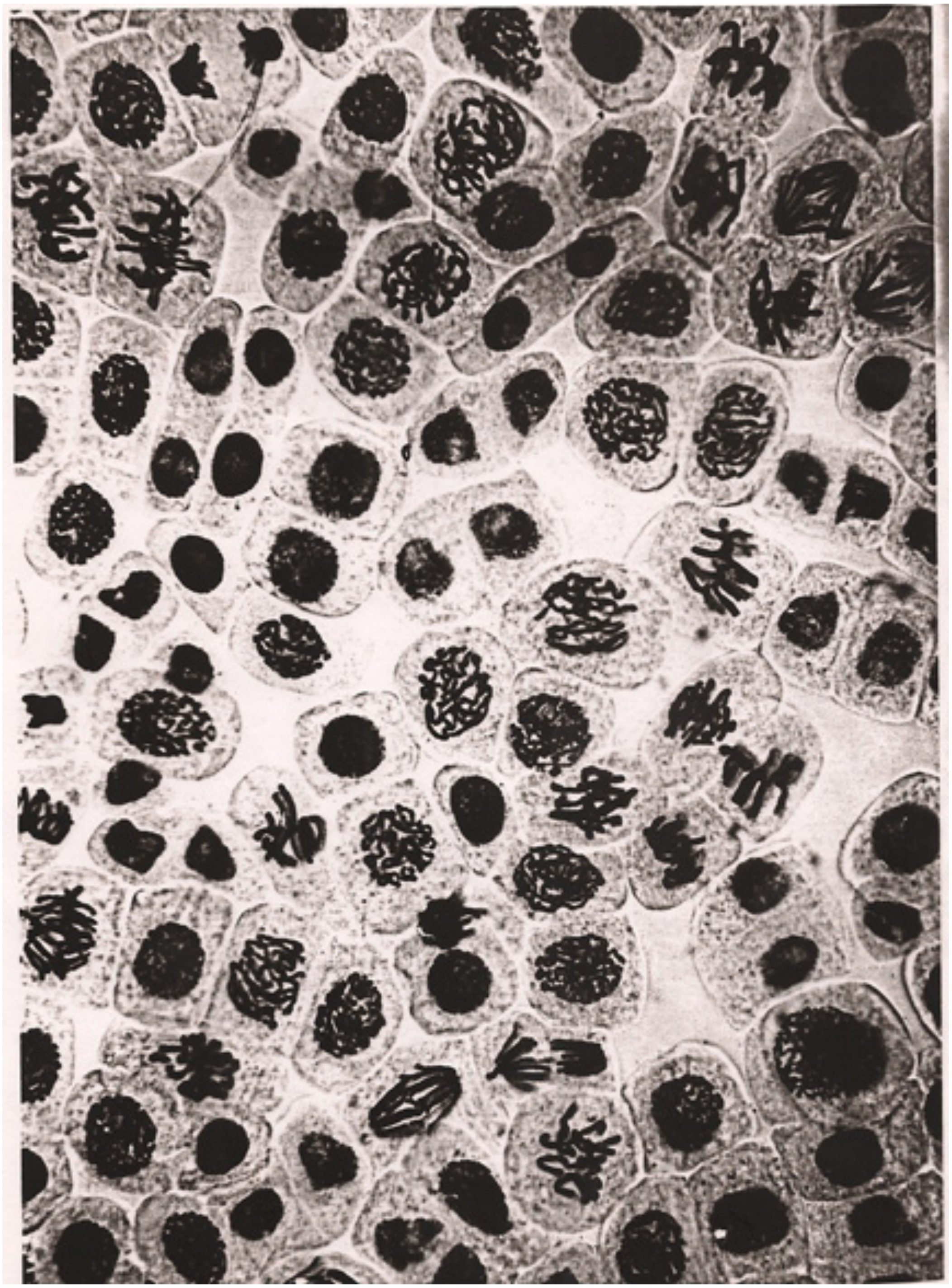
Prokaryotic chromosomal genes: binary fission for vertical transmission (and various mechanisms for horizontal transmission)

Virus genomes: packaged in virus particle which then bursts or buds from host cell

In the nucleus of eukaryotic cells, the distribution process occurs in the form of 2 different types of cell division

***Mitosis** is a conservative propagation of genetic information:* the daughter cells have the same genetic composition as the mother cell = asexual reproduction

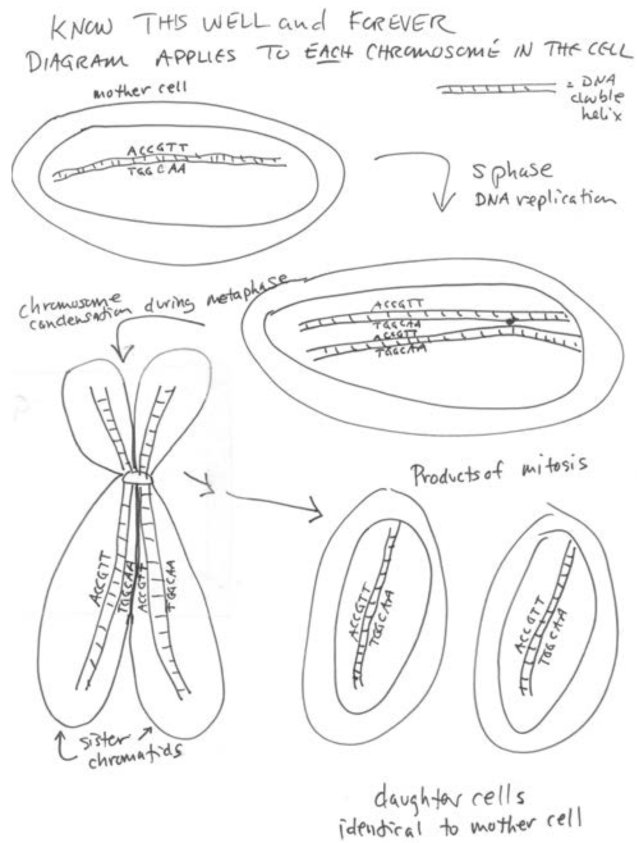
***Meiosis** is a non-conservative propagation of genetic information:* the products of meiosis have half the DNA content (half the number of chromosomes) and a different genetic composition than the mother cell = sexual reproduction



review stages of mitosis and the cell cycle

At the end of prophase of mitosis each duplicated chromosome is maximally condensed

- Each chromosome consists of ***2 identical halves*** known as ***sister chromatids***
- Each chromatid contains one continuous double-stranded DNA molecule coiled into a compact form
- Sister chromatids are held together at a constriction called the ***centromere***



Connecting the dots: semi-conservative DNA replication, sister chromatids and mitosis

Meiosis I (reductional division)

- Homologous chromosomes are separated into different cell
- Each daughter cell contains one duplicated copy of each type of chromosome: *the number of chromosomes is cut in half)*

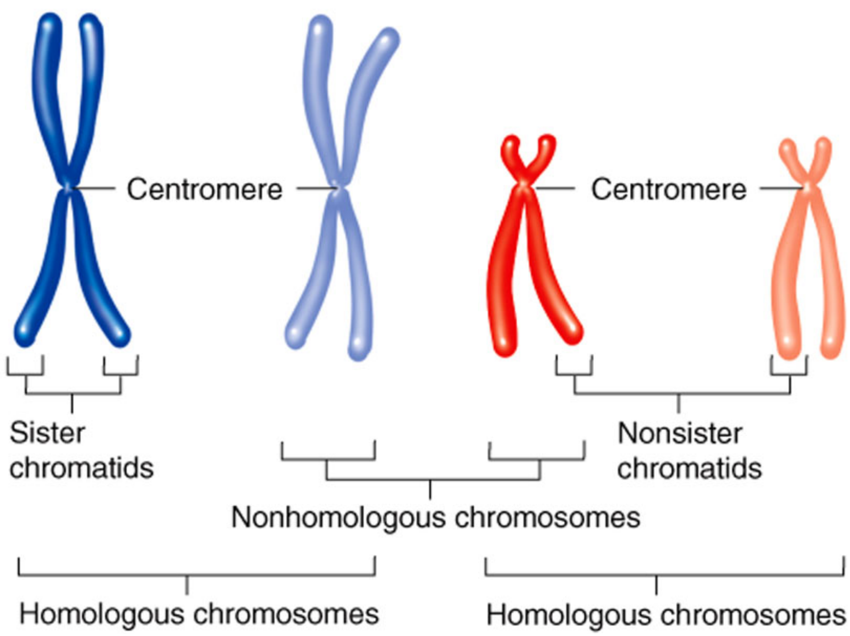
What events occur during prophase of the first meiotic division that do not occur during prophase of mitotis?

<u>synapsis:</u> **close pairing of homologs during prophase of Meiosis I**

What is a homolog?

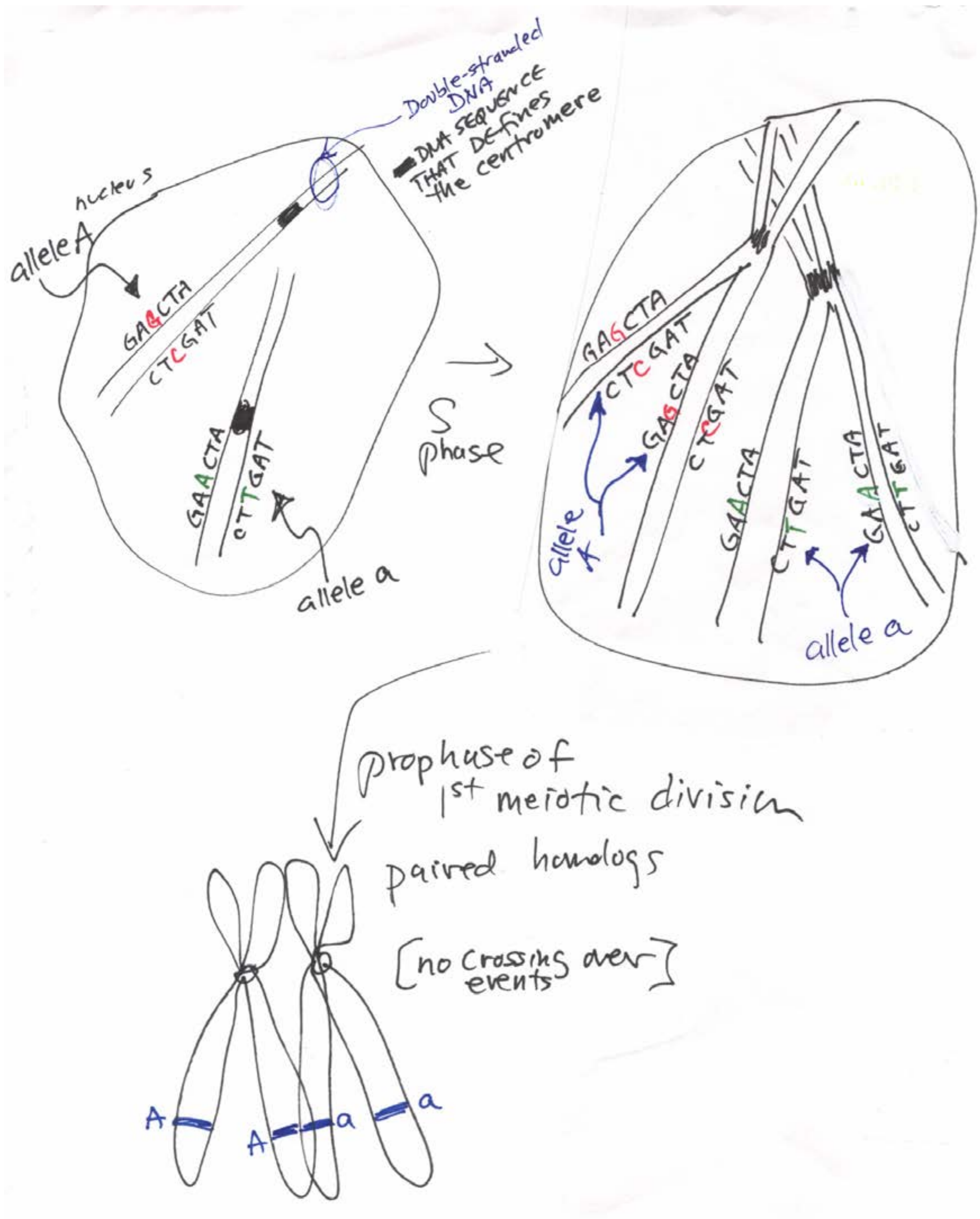
Homologous chromosomes

- chromosomes that pair with each other during meiosis
- chromosomes that possess the same genes at corresponding positions
- homologs may carry different alleles of a given gene)
- [non-homologous chromosomes carry different genes]

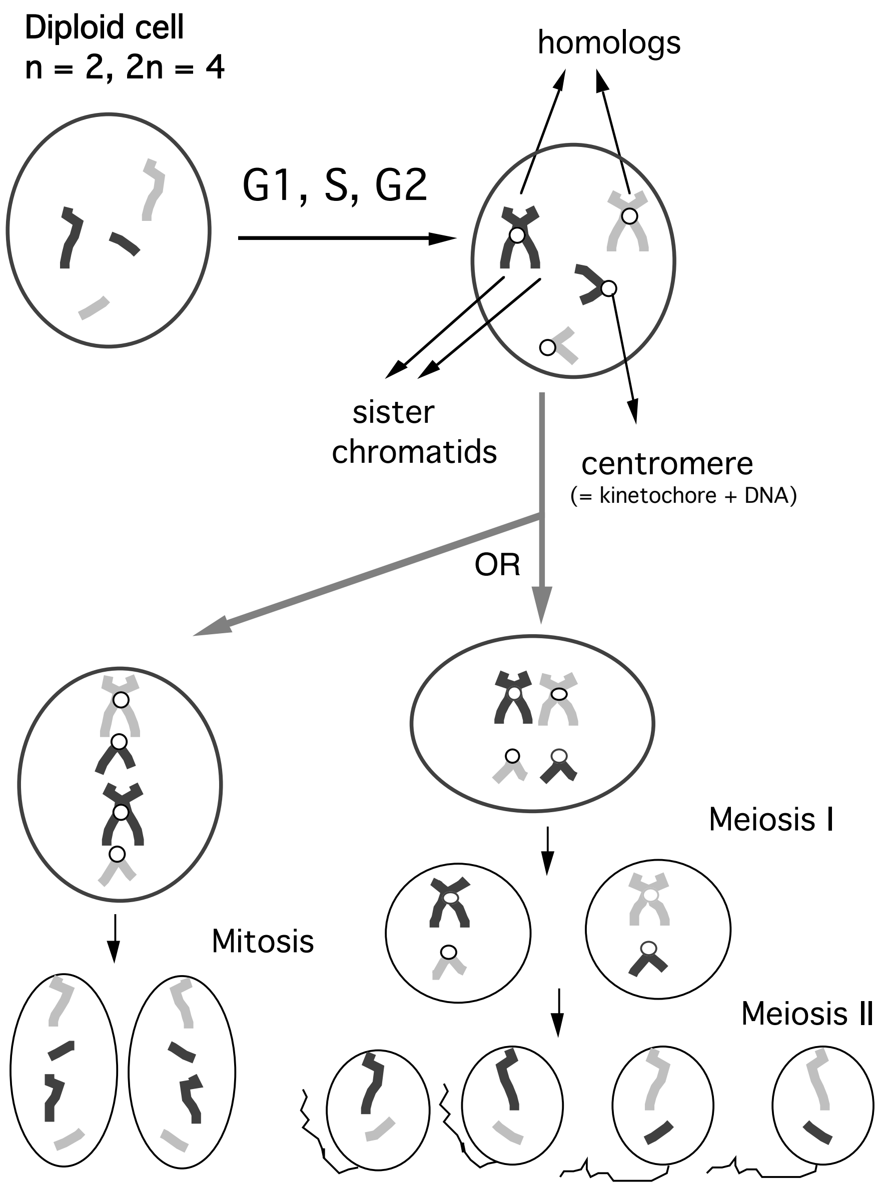


KNOW THIS WELL & FOREVER

Connecting the dots: DNA polymers, alleles, sister chromatids, homologous chromosomes



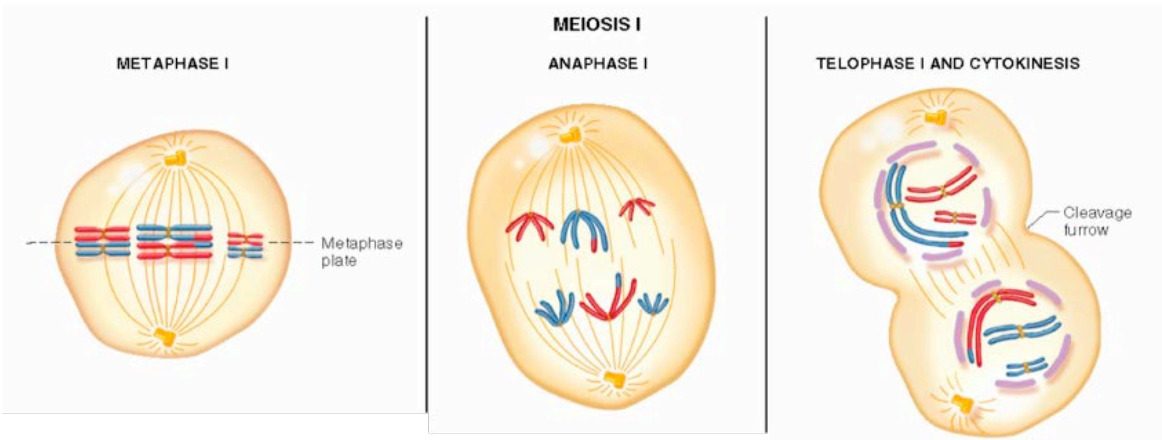
Summary of chromosome movements in mitosis and meiosis



Animation illustrating the differences between mitosis & meiosis:

http://www.pbs.org/wgbh/nova/miracle/divide.html

Metaphase, Anaphase and Telophase of Meiosis I



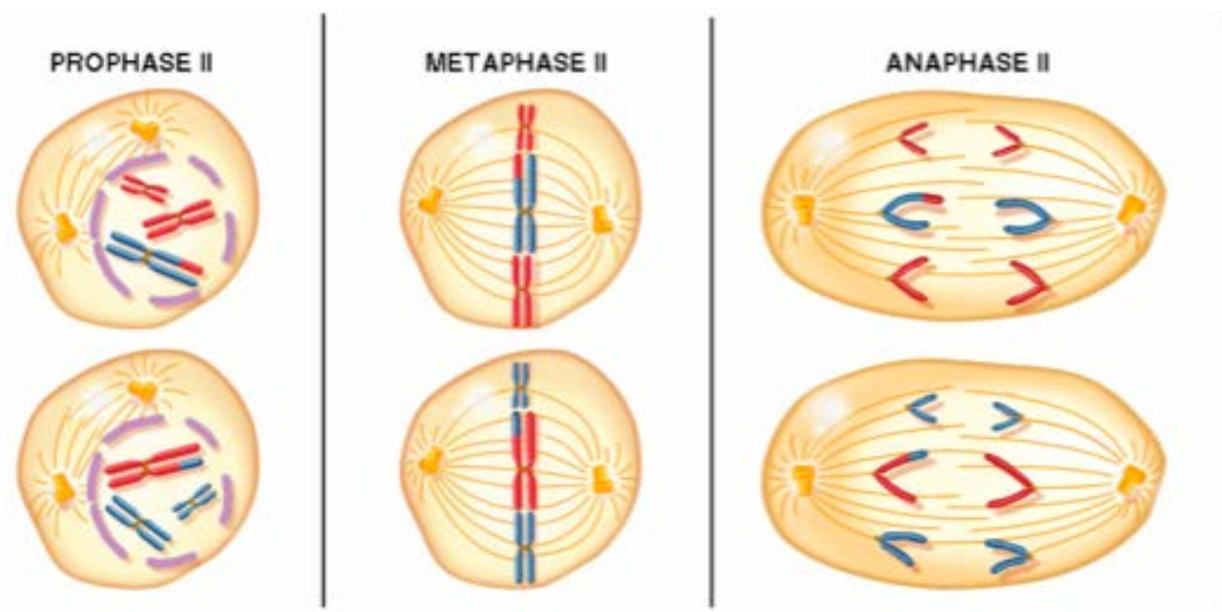
How many genome copies?
How many chromosomes per genome (per set)

Shorthand for genetic content of this organism's cells?

__ n = __

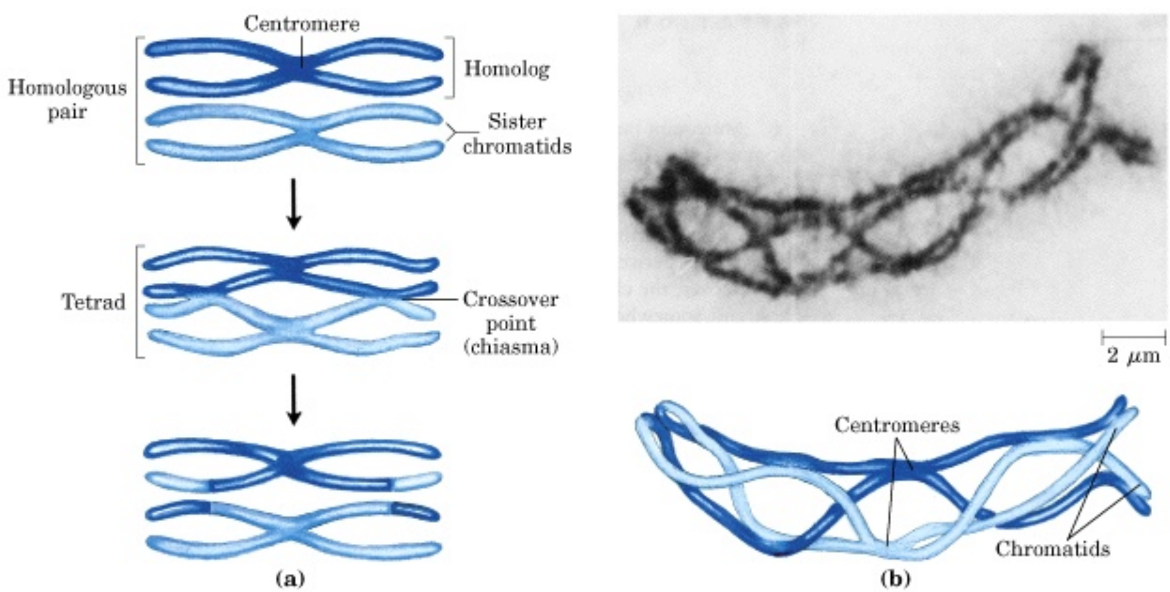
Meiosis II (equational division)

- Sister chromatids are separated into different cells
- Meiosis II is *sort of like a mitotic division, BUT the sister chromatids in mitosis are genetically identical (assuming no errors during DNA replication or other mishaps to the DNA*
- ***In contrast, after prophase of Meiosis I, sister chromatids are not typically genetically identical -- WHY NOT?***



crossing over:

- a precise breakage and reunion event that occurs between two non-sister chromatids
- pieces of the DNA strands in the two chromatids are exchanged
- paired homologs (also known as bivalents are held together at the chiasmata)



Note: we will look at the genetic implications of crossing-over in detail later in the quarter

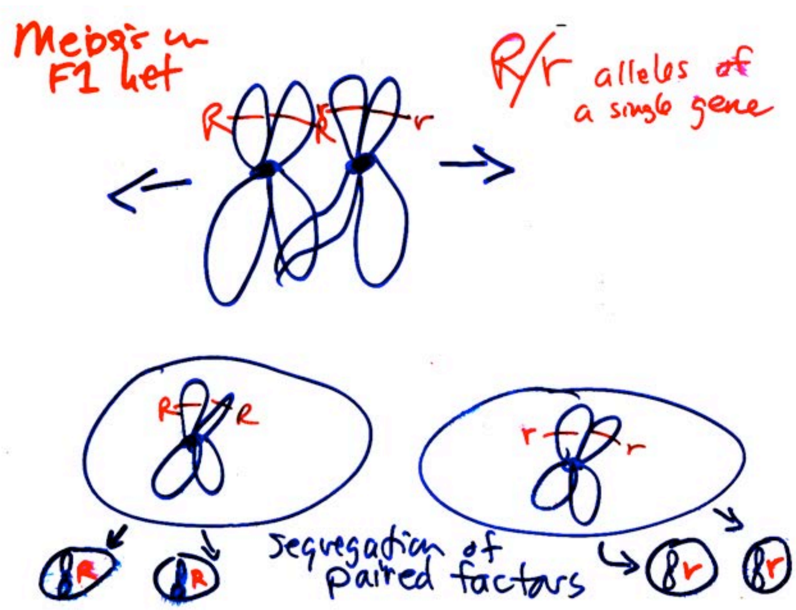
Walter Sutton was a Kansas farm boy and in 1902 was the first person to point out that:

Chromosomes "obey" Mendel's rules of segregation and independent assortment

Interested in the History of genetics?
check out this web site:
http://www.genomenewsnetwork.org/resources/timeline/index.php

Chromosomes "obey" Mendel's rules of segregation and independent assortment:

Mendel's principle of segregation: Paired hereditary factors (R and r alleles in this diagram) segregate into different gametes



Segregation of alleles into different gametes is ensured

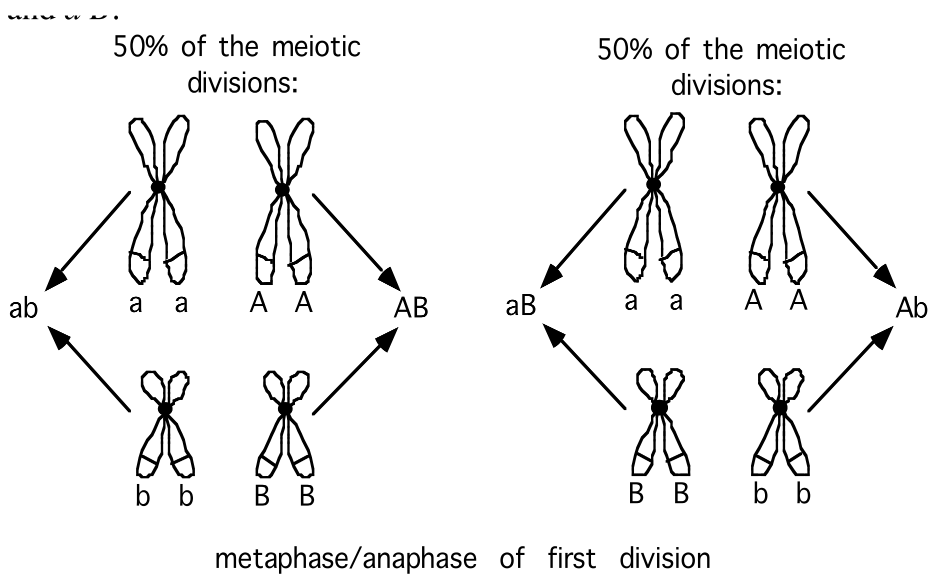
- by the pairing of homologs during prophase of the first meiotic division
- and the separation of homologs into different daughter cells in anaphase of the first meiotic division

What does Mendel's principle of independent assortment say about the pool of gametes produced by an AaBb heterozyote?

Genotypes and proportions?

What events in meiosis explain Mendel's principle of independent assortment?

An *AaBb* heterozygote will produce 4 gamete genotypes in equal proportions



NOTE: Genotype of F1 can be written as either ***AaBb* or *A/a; B/b***

/ separates alleles on homologous chromosomes

; separates alleles on non-homologous chromosomes

What organisms will show Mendelian patterns of inheritance?

State a general rule of thumb to answer this question

Since meiosis provides the physical basis for Mendel's genetic principles, all organisms that have meiosis as part of their lifecycle will show Mendelian patterns of inheritance

Does this include haploid organisms?

A haploid organism is any organism (such as some fungi and algae) that has a conspicuous haploid phase

Complications to Meiosis

What is a Polyploid?

What happens during meiosis in polyploidy organisms?

What piece of information do you need to address this question?

What happens during meiosis in a polyploid organism that has an odd number of genome copies? The problems with 3n (triploid) bananas……who haven't had sex in decades-- see this link: http://fire.biol.wwu.edu/trent/trent/banana.pdf

Inside a wild banana

*Science*Shot: Will the Genome Save the Banana?

by Kai Kupferschmidt on 11 July 2012, 1:00 PM | 2 Comments

Reports of the banana's demise may have been greatly exaggerated. At least that's the hope of a team of scientists, which has finally sequenced the genome of the fruit and is counting on it to yield new resistance genes to protect it from two fungal foes: Panama disease and black sigatoka. More than half the world's bananas and almost all of the ones exported to the United States and Europe belong to the Cavendish variety (left). That plant has no seeds and does not sexually reproduce, meaning all are genetically identical and equally susceptible to the fungi threatening them. The Cavendish also has three sets of chromosomes, which makes its genome enormously difficult to sequence. Instead, in the new study reported online today in *Nature*, the researchers sequenced the genome of a variety called DH Pahang (right). It is one of three bananas that contributed to the Cavendish, and it is highly resistant to the strain of Panama disease threatening the Cavendish. What's more, as the seeds show, it has an intact sex life, meaning it can be used for breeding a new variety—perhaps one that's hardier than today's bananas.