APRIL 2, 2012 Biology 321

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)

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 next page examines a shorthand way of describing chromosome content and genome copy number

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)

n = ?

The number *preceding* the n = ?

The number *following* the n = ?

metaphase chromosome spread
Note variation in size and centromere position

2n=46 in humans

(shorthand way of describing chromosome content)

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

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

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

Handing down DNA/chromosomes/genomes throughout the millennia

Transmission or propagation of any genetic program requires two basic steps:

1. ***Copying step*** **(replication of the DNA molecule)**
2. ***Distribution step*** **(getting the duplicated information *properly* distributed to the progeny)**

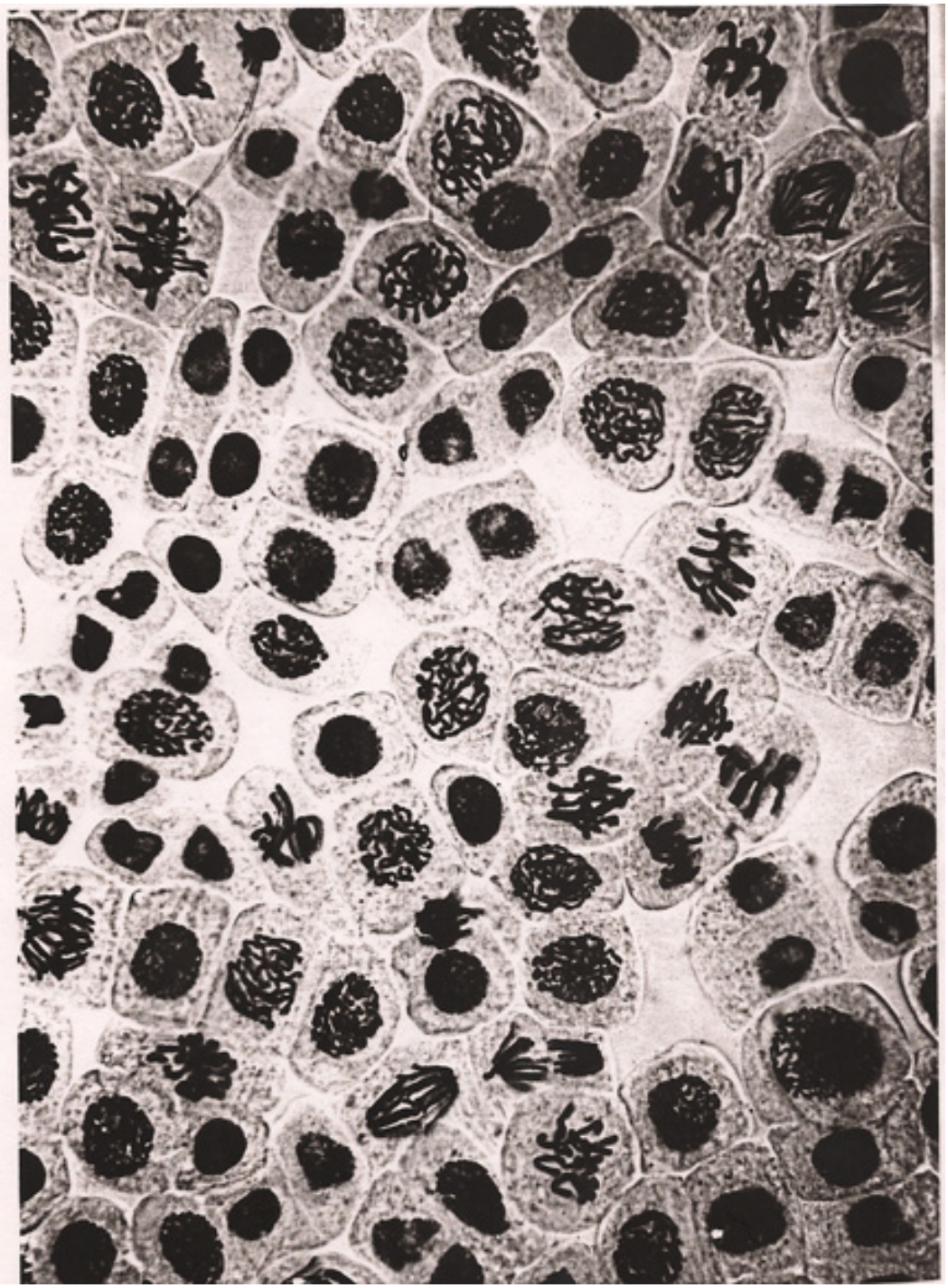
How old are these copying and distribution processes?

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

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

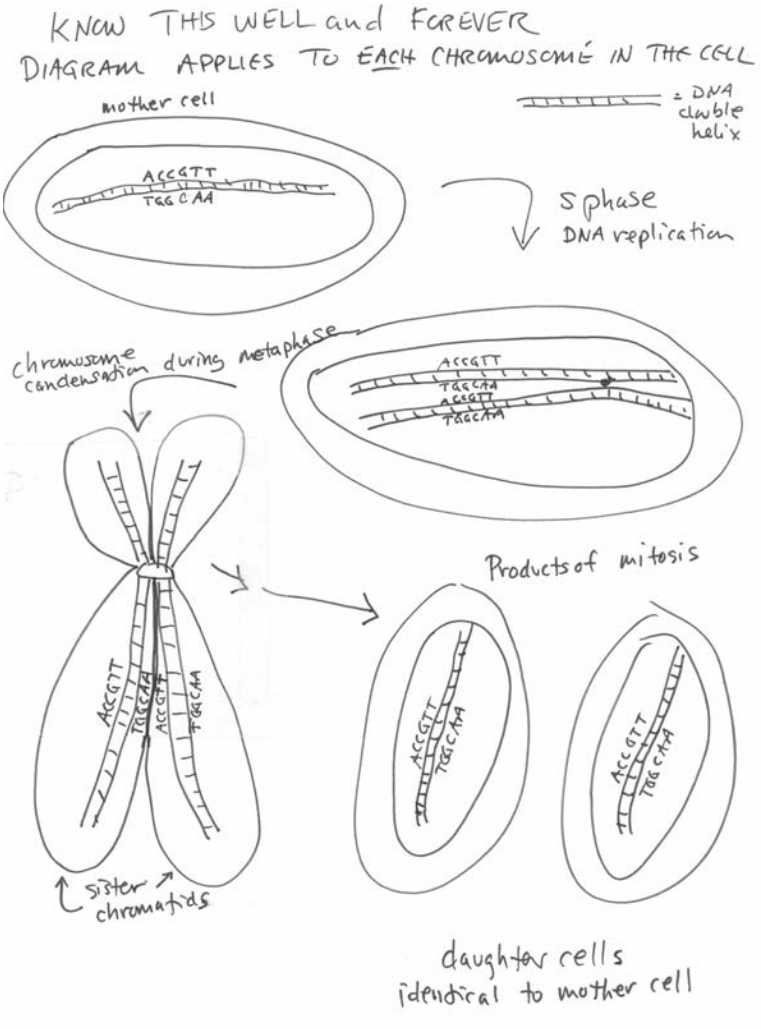
Review cell cycle and stages of mitosis



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)*

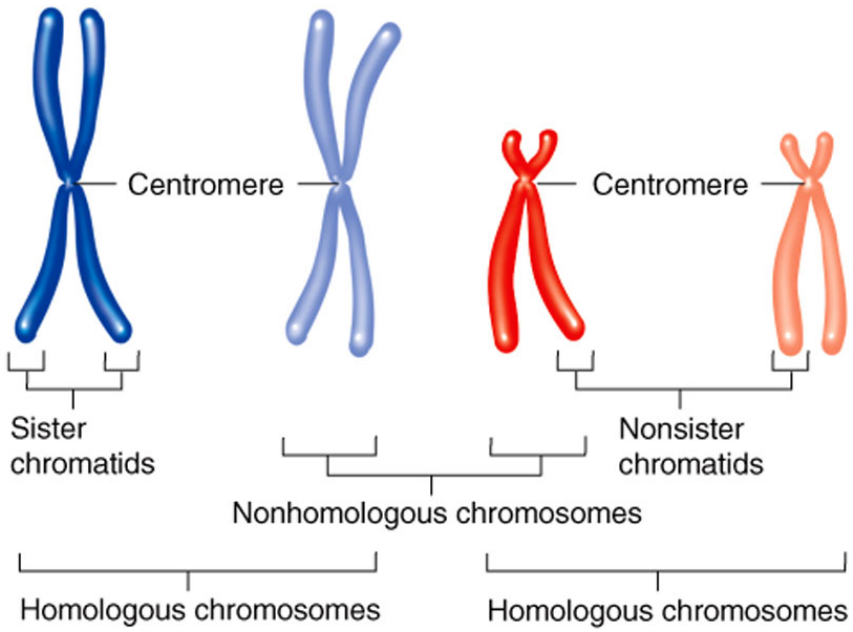
What events occur during prophase of the first meiotic division that do not occur during prophase of mitotis?

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

What is a homolog?

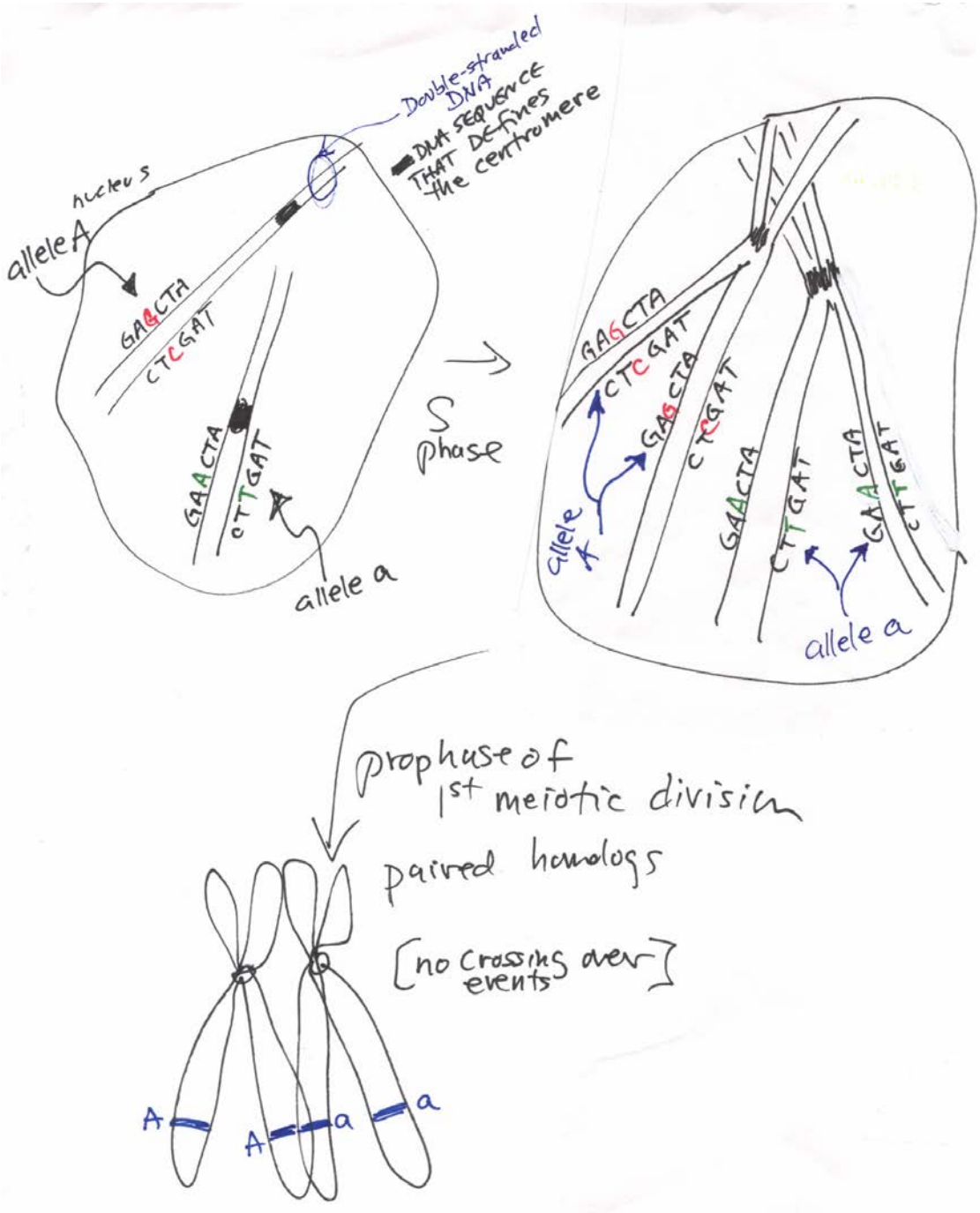
Homologous chromosomes

- 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]

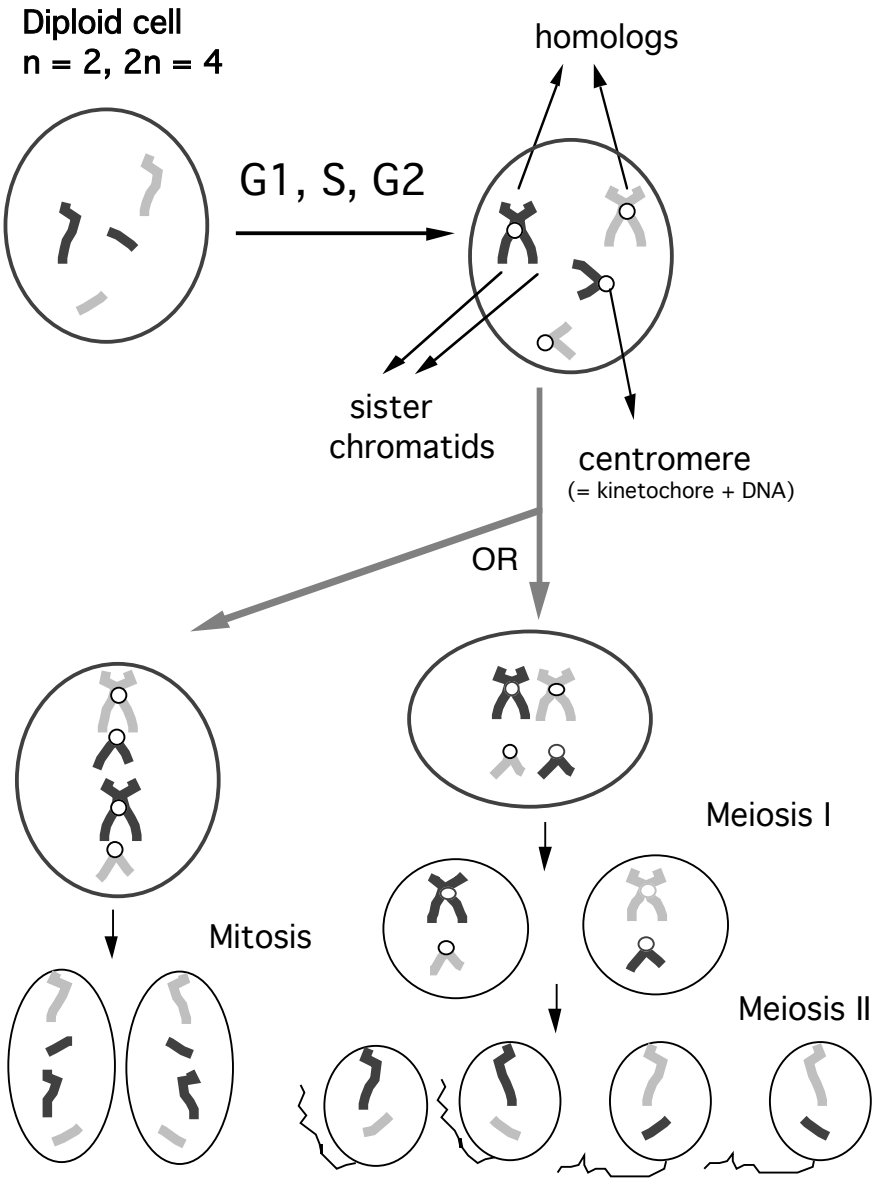


KNOW THIS WELL & FOREVER

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

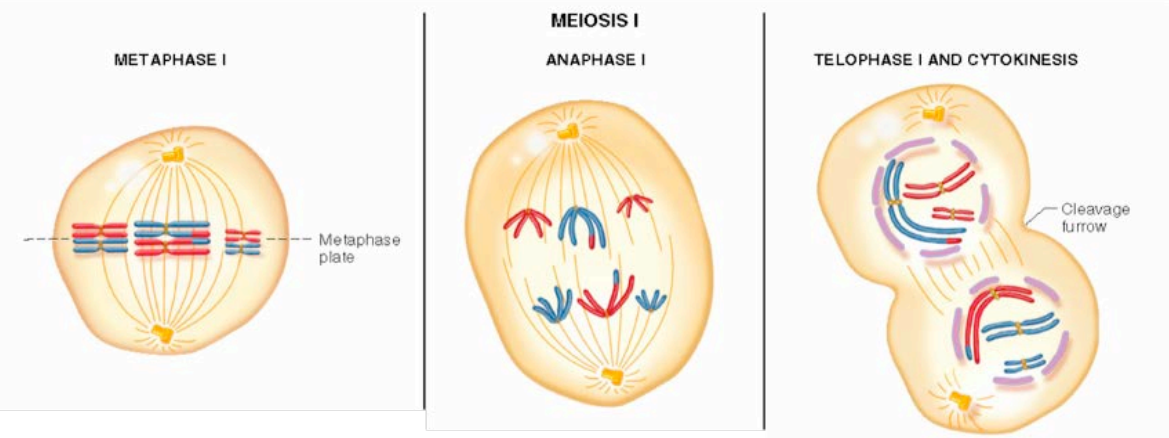


Summary of chromosome movements in mitosis and meiosis



Animation illustrating the differences between mitosis & meiosis:
http://www.pbs.org/wgbh/nova/miracle/divide.html

Metaphase, Anaphase and Telophase of Meiosis I



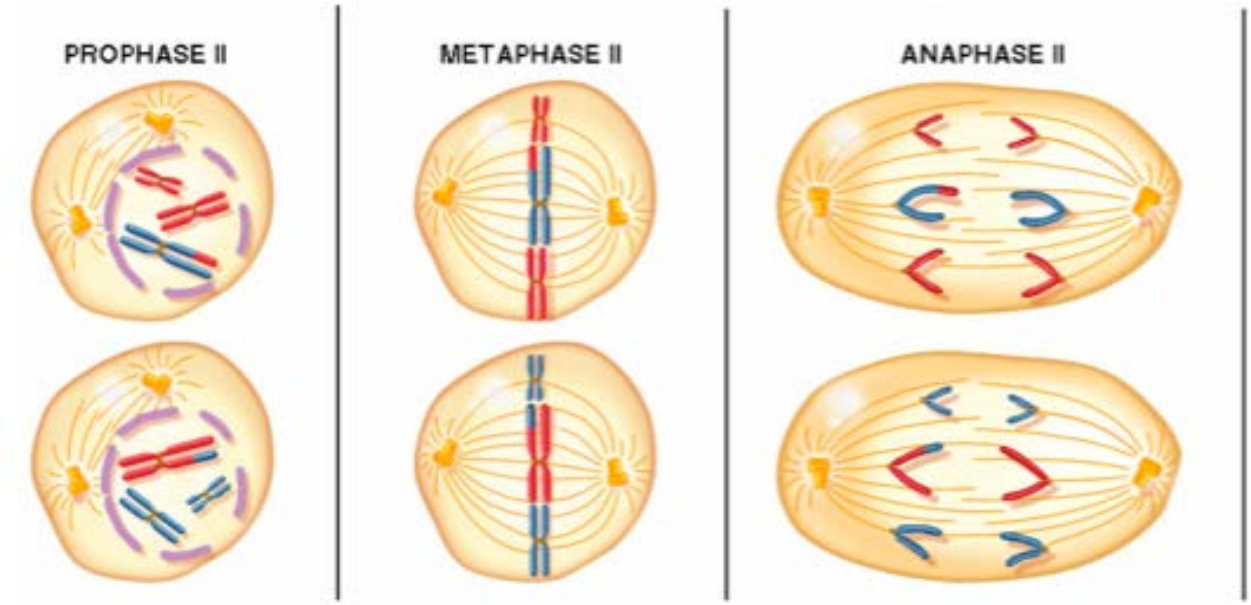
How many genome copies?
How many chromosomes per genome (per set)

Shorthand for genetic content of this organism's cells?

__ n = __

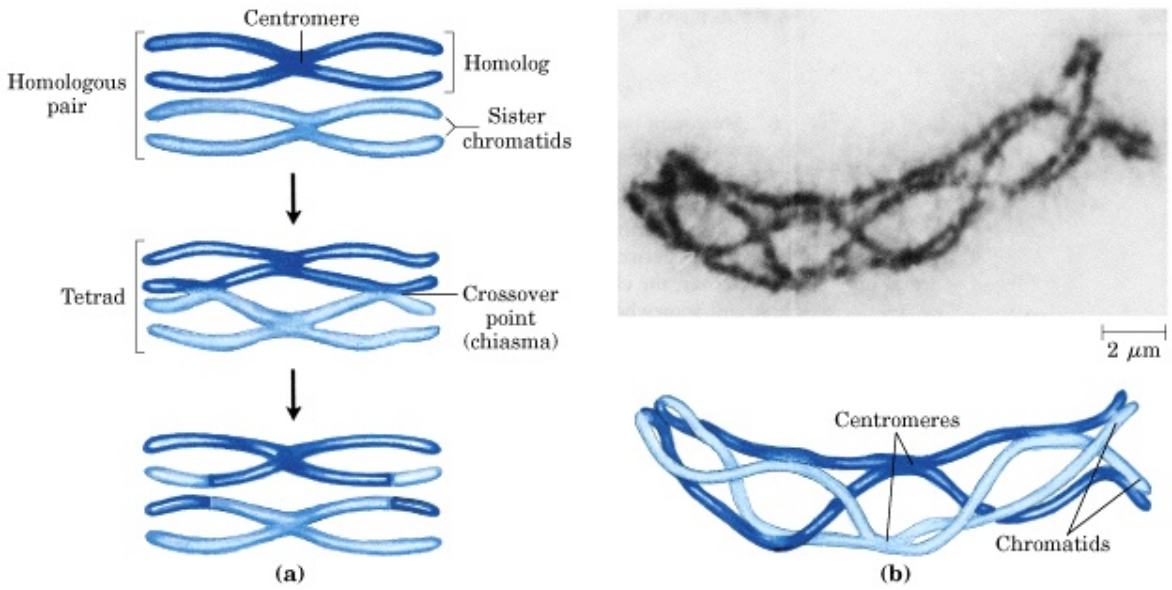
Meiosis II (equational division)

- 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

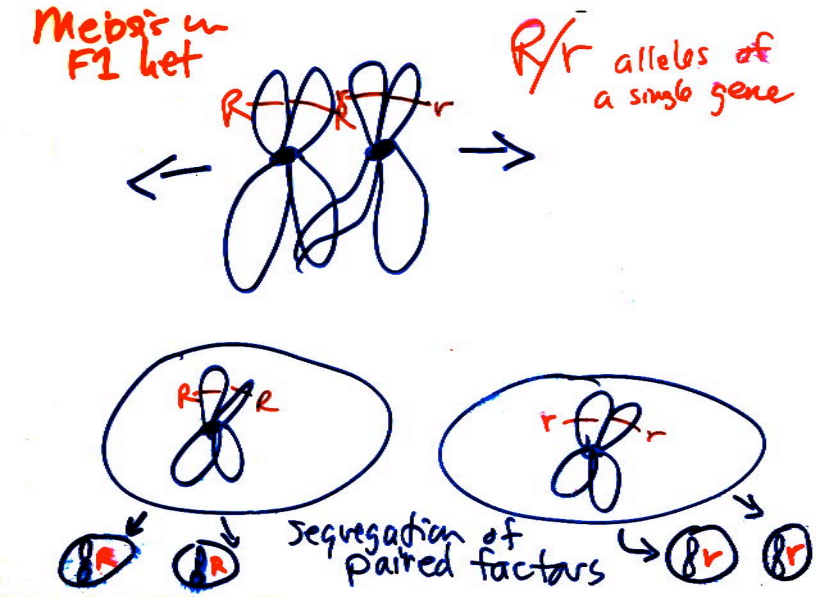
Walter Sutton was a Kansas farm boy and in 1902 was the first person to point out that:

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

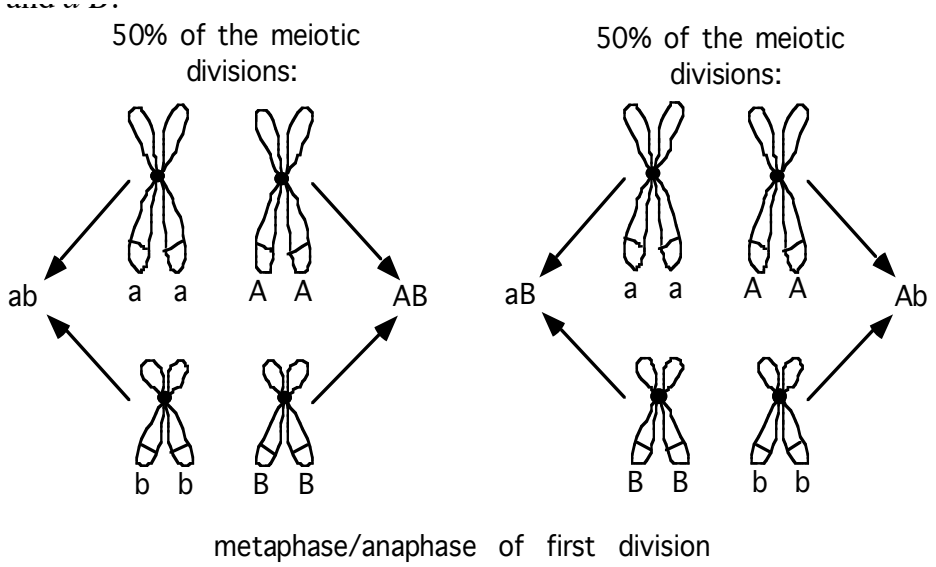
- by the pairing of homologs during prophase of the first meiotic division
- and the separation of homologs into different daughter cells in anaphase of the first meiotic division

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* heterozyote 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

State a general rule of thumb to answer this question:

What organisms will show Mendelian patterns of inheritance?

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

Do mitosis and meiosis account for the propagation of all genetic information represented by Life on Earth?

What are the exceptions?

Genes NOT propagated by meiosis will NOT show Mendelian patterns of inheritance

***Prokaryotes*:** binary fission
***Eukaryotes*:** mitochondrial and chloroplast DNA
***Viruses*:** parasitize cells

Gratuitous naked male with duplicated, condensed chromosome (scanning electron micrograph) and random model organisms. From ***All Genomes Great and Small Nature 5/23/02***

What happens during meiosis in a polyploid organism that has an even number of genome copies?

What happens if there is a segregation mistake during meiosis?

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 article on 321 web site: http://fire.biol.wwu.edu/trent/trent/banana.pdf

Inside a wild banana