Laboratory 3: Mitosis and Meiosis

*compare the events of mitosis in plant cells with those of animal cells
*demonstrate a procedure to stain tissue for the identification of cells in the various stages of mitosis
*calculate the relative duration of the phases of mitosis
*manipulate chromosome models to demonstrate the events of meiosis I and II
*calculate the map distance between a gene for ascospore color and the centromere of the same chromosome
*explain how meiosis and crossing over result in the different arrangements of ascospores within asci
*describe the role of meiosis and mitosis in the formation of the ascospores within the asci of *Sordaria fimicola*
*use chromosome models to demonstrate segregation and independent assortment in the process of meiosis
*discuss how crossing over can introduce additional genetic variability into the products of meiosis

mitosis = identical replication of the chromosomes from a nucleus through the stages prophase, metaphase, anaphase, telophase/ two identical daughter nuclei (diploid or haploid) for growth, repair, asexual reproduction
meiosis = reduction of a replicated diploid nucleus into four non-identical haploid nuclei through two sets of divisions/ for gamete or spore production

To study mitosis, observe microscopically the fastest mitosing tissue possible (in an onion, the root tip!). Chromosome squash will show cells in all cell cycle phases (remember interphase is G1, S, G2):

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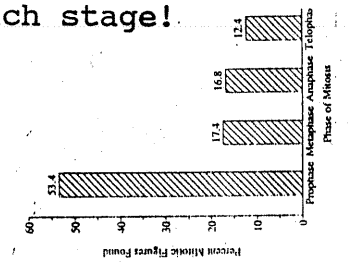
Time estimates are made by counting 100 cells or several "fields of view" at and assuming the % cells observed in each stage is an accurate representation of the actual amount of time spent in each stage!

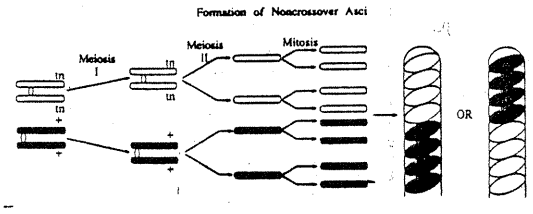
	Number of Cells				Percent of Total Cells Counted
	Field 1	Field 2	Field 3	Total	
Prophase	42	37	34	113	53%
Metaphase	7	17	13	37	17%
Anaphase	15	11	10	36	17%
Telophase	7	10	9	26	13%

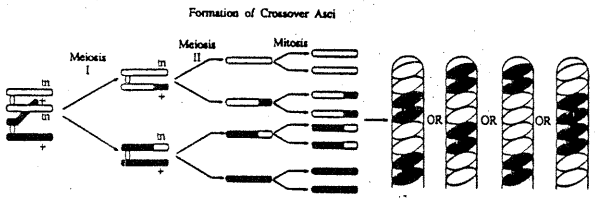
212 total cells counted...



Animal cell mitosis differs only in presence of centrioles at ends of spindles, and in cytokinesis after telophase -- they form a cleavage furrow rather than a cell plate.

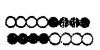
Meiosis produces genetic variation in the population because of independent assortment of chromosomes during meta- and anaphase I, and because of crossing over of homologous chromosomes during prophase I in synapsis. In the fungus *Sordaria*, meiosis followed by quick mitosis forms eight haploid ascospores contained within a sac called an ascus (rather like a sack of seeds). See the two possibilities below of crossover and non-crossover asci:





If asked to determine the "map distance" between the gene for spore coat and the centromere,

a. calculate the % crossover by dividing number of crossover asci by total number of asci
b. then divide the percent of crossover asci by 2 (remember, only half the spores in a sac are really crossovers!)

Number of 4:4 Asci	Number of Asci Showing Crossover	Total Asci	% Asci Showing Crossover Divided by 2	Gene to Centromere Distance (Map Units)
			$17.3/2 =$	
62	13	75	8.7%	8.7

BIOLOGY
SECTION II
Time—1 hour and 30 minutes

Directions: Answer all questions.

Answers must be in essay form. Outline form is not acceptable. Labeled diagrams may be used to supplement discussion, but in no case will a diagram alone suffice. It is important that you read each question completely before you begin to write. Write all your answers on the pages following the questions in the pink booklet.

1. Meiosis reduces chromosome number and rearranges genetic information.

   (a) **Explain** how the reduction and rearrangement are accomplished in meiosis.

   (b) Several human disorders occur as a result of defects in the meiotic process. **Identify** ONE such chromosomal abnormality; what effects does it have on the phenotype of people with the disorder? **Describe** how this abnormality could result from a defect in meiosis.

   (c) Production of offspring by parthenogenesis or cloning bypasses the typical meiotic process. **Describe** either parthenogenesis or cloning and **compare** the genomes of the offspring with those of the parents.

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Question 1

(a) **Explain** how the reduction and rearrangement are accomplished in meiosis.
(5 points maximum)

REDUCTION
1 point: **(homologous) chromosomes pair, then separate** and move to opposite poles during 1st meiotic division
1 point: **chromatids separate** during 2nd meiotic division

1 point: two rounds of cell (nuclear) division but only one replication of the chromosomes
OR

REARRANGEMENT
1 point: **crossing over** (in proper context)
1 point: **random alignment (independent assortment)** of tetrads
1 point: **elaboration (e.g.: correct mechanism/description or consequences** of one of the above) *

*NOTE: Diagrams that are clearly labeled and are described in the essay portion are acceptable and may receive a point

(b) Several human disorders occur as a result of defects in the meiotic process. **Identify** ONE such chromosomal abnormality; what effects does it have on the phenotype of people with the disorder? **Describe** how this abnormality could result from a defect in meiosis.
(4 points maximum)

CHROMOSOMAL ABNORMALITY
1 point: **Identify** one condition by name or description
(e.g.: Down or trisomy 21; Turner or XO; fragile X; cri-du-chat or 5p-; etc.)
1 point: **Phenotype** of the example given above

DESCRIBE
1 point: **Name or identify the meiotic event** (e.g.: nondisjunction, unequal crossing over, inversion, mispairing)
1 point: **Description** of the meiotic event *

(c) Production of offspring by parthenogenesis or cloning bypasses the typical meiotic process. **Describe** either parthenogenesis or cloning and **compare** the genomes of the offspring with those of the parents.
(3 points maximum)

CLONING OR PARTHENOGENESIS
1 point: **Definition**
- **Parthenogenesis**: development of an unfertilized egg into an adult; often the adult is haploid

OR

- **Cloning**: using a somatic cell or cells from a multicellular organism to make one or more genetically identical individuals (or inducing a diploid body cell of an organism to revert to its embryonic state and then develop into a complete adult organism without fertilization)

1 point: **Description** of an example or the process in a plant or animal (parthenogenesis is rare in plants)
1 point: **Comparison** of the genomes of offspring and parents (e.g. identical for cloning)