MEIOSIS
(me-oh-sis)

Another quality hands on teaching system in the genetics series

Designed by teachers! Tested by Teachers!

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Meiosis Teacher Manual

Thank you for the purchase of the Meiosis Kit. This kit was designed and developed for use in the science classroom by science teachers. Teaching abstract concepts can be a real challenge. Take out the challenge and replace it with interest when you use these tactile and visual aids. This product will make it easier for you to teach, and for your students to learn, Meiosis.

The primary purpose of this manual is to supplement the included CD with additional background information for the teacher. The included CD will be the most useful for getting you started with using the kit. If you are already knowledgeable in the subject matter, going directly to the CD may be the best place to start. Return to the manual for additional background information and teaching tips. Reverse the order if you are new to the subject matter.

I. Teacher Introduction
A. Setting the Stage for Learning

Questioning is one way to get students engaged before they begin to learn. The question "why do we need to learn this" can be anticipated and needs to be answered. In the case of meiosis there are many interest invoking questions that the instructor can use to initiate discussion or student investigation. Ask students questions that might stimulate their natural curiosity, such as:

1. ***Why do I have some physical characteristics that resemble my relatives and features that do not?***
…..Posing this question will engage student thinking about physical characteristics as hereditary traits.
Further questions might include:

- Where did the "Smith smile" come from or the "Jones nose". Invite students to discuss examples of some physical characteristics in their families.

2. ***My brother is a lot bigger than me. People say he resembles my father. We really don't look anything alike. Why?***

…..Posing this question will simulate thinking around the idea that siblings even of the same sex, have characteristics that differ.
Concepts introduced might include:

- The randomness of the meiotic process.
- Millions of sperm and eggs, yet each gamete with a unique genetic makeup.

3. ***Why is it that one sibling in a family gets a genetic linked disease while others do not?***

…..Posing this question will engage student thinking about the inheritance of genetic diseases and conditions.
Concepts introduced might include:

- Dominant and recessive alleles
- Only one "good" copy of a gene needed
- Nondisjunction

…..Invite students to report back to the class about these conditions and to discuss their relationship to meiosis.

- Down Syndrome- trisomy of chromosome 21
- Patau Syndrome- trisomy of chromosome 13
- Edward Syndrome- trisomy of chromosome 18
- Klinefelter Syndrome- extra X chromosomes in males - ie XXY, XXXY, XXXXY
- Turner Syndrome- lacking of one X chromosome in females - ie XO
- Triple X syndrome- an extra X chromosome in females
- XYY Syndrome- an extra Y chromosome in males

4. ***Why can I recognize my friend in a crowd even when I see her in places I didn't expect?***

…..Posing this question will engage student thinking about the uniqueness of each individual living thing. Cross-over , recombination and independent assortment of homologous chromosomes result in a great diversity of genotypes in the population. This produces genetic variation in gametes that promote genetic and phenotypic variation. Getting students to think about recognition of individuals in a large population provides awe inspiring

evidence for the seemingly limitless amount of variation meiosis can produce.

Concepts introduced might include:

- The probability of two individuals having exactly the same genetic makeup.
- Identical vs.fraternal twins.
- Nature vs. Nurture

I. Teacher Introduction
B. Prerequisite Knowledge

Students should understand these concepts before beginning the study of meiosis:

- The structure and function of the cell
- The structure and function of DNA
- Basic Mendelian genetics
- Mitosis and the cell cycle-order United Scientific Kit (MIT-Kit)

Continuation of learning in genetics should include:

- Protein Synthesis – order United Scientific Kit (PSY-Kit)
- Recombinant DNA, Genetic Engineering – order United Scientific Kit (DNA-Kit)

I. Teacher Introduction
C. Basic Concepts

This manual will focus on human meiosis. Humans follow the *gametic life cycle* as opposed to producing spores or other means of reproduction. In our species a diploid zygote grows to a diploid adult by repeated mitotic divisions. The organism's diploid germ-line stem cells undergo meiosis to create haploid gametes (sperm in males and ova in females), which unite to form the zygote.

Mitosis creates two cells that are genetically identical to the parent. These cells are referred to as *somatic* or body cells. Meiosis creates germ or *sex* cells that are genetically unique from the parent and from other sex cells.

The cellular processes leading to meiosis are identical to interphase in mitosis. In meiosis interphase is followed by meiosis I and then meiosis II.

Meiosis I consists of male and female homologous chromosomes coming in close proximity within the nucleus of the diploid parent cell. Each homolog replicates itself to form two sister chromatids. Chromatids swap genetic content in Prophase I and divide to produce two daughter cells that are genetically distinct from each other and from the original diploid cell.

In Meiosis II, chromatids from the two cells created in Meiosis I separate creating four genetically distinct haploid daughter cells. Meiosis I and II are each divided into prophase, metaphase, anaphase, and telophase stages, similar to mitosis in the cell cycle. Therefore, meiosis includes the stages of meiosis I (prophase I, metaphase I, anaphase I, telophase I), and meiosis II (prophase II, metaphase II, anaphase II, telophase II).

Meiosis produces genetic diversity in two ways:

(1) independent alignment and subsequent separation of homologous chromosome pairs during the first meiotic division. This random separation allows an independent selection of male and female homologs, after genetic exchange, into each gamete.

(2) physical exchange of homologous chromosomal regions by cross-over and recombination of male and female chromatids during prophase I results in new combinations of DNA within chromosomes.

Counting the Chromosomes

Meiosis I is referred to as a reduction division. The rational for reduction is that the parent cell is diploid (2N) consisting of 23 **pairs** of homologous chromosomes in the parent cell. Division in meiosis I separates the recombined (after cross-over) parental homologs, resulting in two daughter cells said to be (N) with 23 **total** homologous chromosomes.
The confusion for students results from being told that the male and female homologs duplicate themselves and form a *tetrad* of 4 *chromatids* before cross-over and division occurs in meiosis I. Students rationalize that there is therefore no reduction of chromosomes. This misconception is really no more than a lack of understanding terminology.
One solution to this perceived contradiction is to expand the terminology:

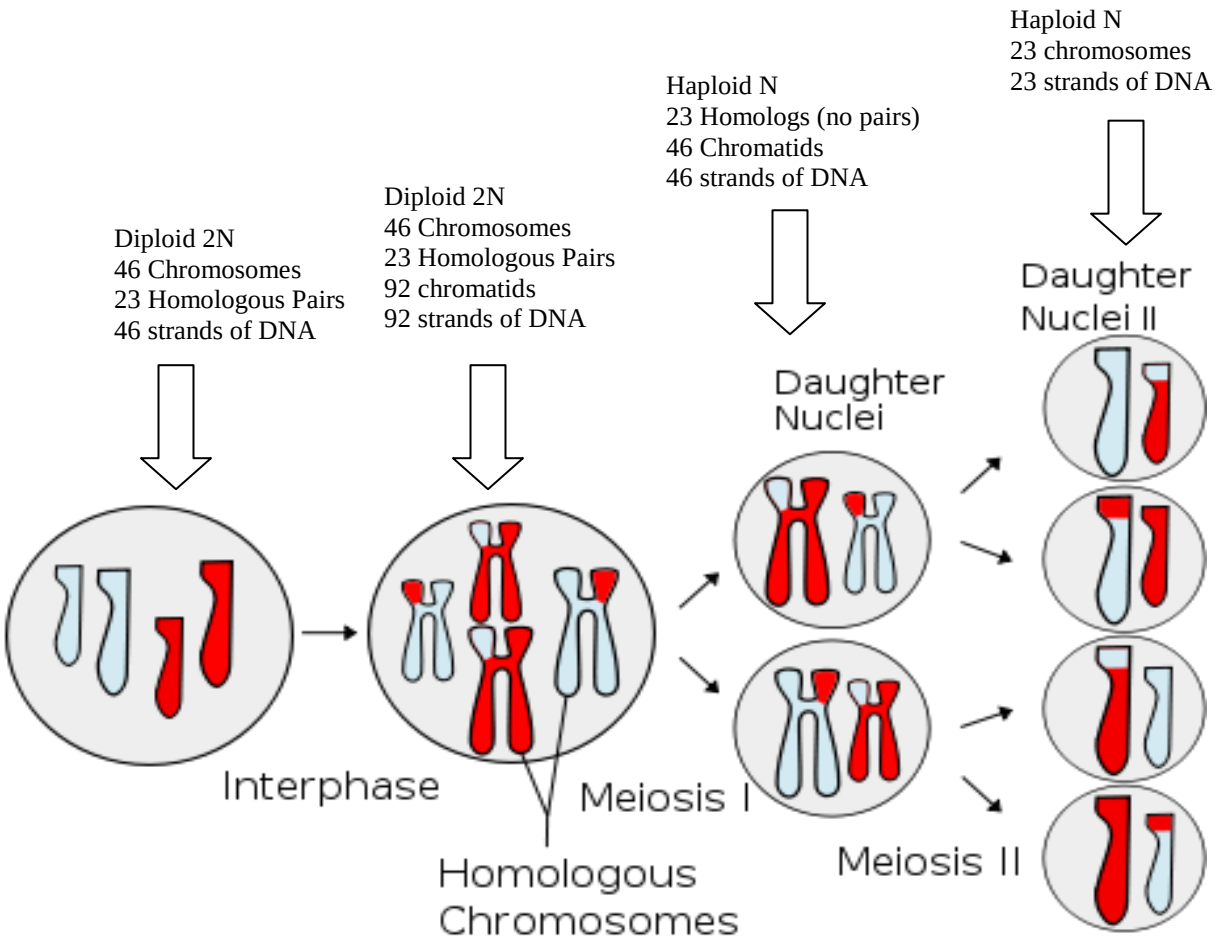
- The parent cell is 2N. It has 46 chromosomes. Twenty three pairs of homologous chromosomes. Twenty three male homologs and twenty three female homologs inherited from parental sperm and egg. There are no *chromatids*. Entering the term "*strands of DNA*" there are 46 *strands of DNA*

- In meiosis I, before division, the male and female homologs duplicate themselves but there are still only 46 chromosomes. Each homologous pair and the duplicates arrange themselves in close contact to form a *tetrad*. Each of the 23 tetrads are now composed of 4 *chromatids*. Thus there are 92 *chromatids*. Enter again the term "strands of DNA" and there are now 92 strands.

- After meiosis I division the resulting daughter cells contain only one homolog of the previous pair. This division occurs after cross-over so the homolog may be genetically distinct from any of the parental homologs. Only one homolog of the pair is present after the first division . The daughter cells are said to be haploid (N). In terms of "strands of DNA" and *chromatids* there are 46 in each of the daughter cells.

- It is not until the second division in meiosis II that each of the 4 haploid gametes each contain 23 chromosomes and 23 "strands of DNA"

Some teachers find a fun way to make sure that students understand the above terminology. They ask questions like: How many pairs of homologous chromosomes in a daughter cell after division in Meiosis I? Chromatids? , Tetrads?, Strands of DN A? How many chromatids in the parent cell?, Tetrads?, Etc.
Teachers pose the questions. Students are given time to write their answer (which is a number) on a 3x5 card. On queue students place the card with answer on their forehead. If a student does not know the answer they place a "?" in lieu of a number. Students and teachers look at foreheads to see answers. Teachers need a quick informal assessment to determine that students truly understand the terminology before discussing cross-over and the specific phases of meiosis.



Genetic Recombination (cross-over) in Meiosis I, Prophase I.

Prophase I of Meiosis I is probably the most challenging for many students. This is because in Prophase I of Meiosis I, cross-over or genetic exchange and recombination takes place. This cross-over of genetic information between homologous chromosomes is a major contributor to the remarkable