Melon Meiosis

Objective

Students will read about the discovery of colchicine, which made seedless watermelon possible. Students will use modelling clay and beans to model meiosis and mitosis. Students will design imaginary watermelons and write marketing plans for them. Students will examine the meanings of prefixes in scientific words.

Background

O.J. Eigsti was a botanist and plant geneticist from Goshen, Indiana, who discovered that colchicine, a chemical derived from crocus, could cause a plant to double its chromosomes. A Japanese scientist named Kihara used Eigsti's chromosome-doubling process to produce the first seedless watermelon.

The seedless watermelon is a hybrid, a cross between two different kinds of watermelon. Since the purpose of seeds is reproduction, Kihara had to develop a watermelon that could not reproduce.

The normal watermelon is called a diploid because it has two sets of chromosomes per cell (di- means two).

By treating normal watermelon seedlings with Eigsti's discovery, colchicine, Kihara produced watermelons with twice as many chromosomes in each cell. This watermelon, called a tetraploid, had four sets of chromosomes per cell (tetra- means four).

For Kihara, the next step was to cross-breed a tetraploid with a normal diploid as the pollinator. Since cells from each plant contribute half their chromosomes in the reproduction process, the result was a triploid plant. Triploids have three sets of chromosomes per cell (tri- means three).

This triploid seed will germinate and grow into a triploid plant bearing triploid male and female flowers, but the flowers will not produce viable sperm-bearing pollen or eggs because of the odd number of chromosome sets (3). With three sets of chromosomes, one set will not have a matching set to pair up with during meiosis.When flowers of this sterile triploid plant (called the seedless watermelon plant) are pollinated by a normal plant, seedless fruits develop.

When you buy seedless watermelon seeds, you get two kinds of seeds, one for the fertile diploid plant and one for the sterile triploid. The triploid seeds are larger, and both types of seeds are planted in the same vicinity. Male flowers of the diploid plant provide the pollen which pollinates (but does not fertilize) the sterile triploid plant. The act of pollination induces fruit development without fertilization, so the triploid watermelons are seedless.

Procedures

1. Read and discuss background and vocabulary. Ask your students this challenge question: "How is a seedless watermelon like a mule?" (They are both hybrid—a mule is a cross between a horse and a donkey—and

Oklahoma Academic Standards

GRADE 6
Life Science: 1-1,2

GRADE 7
Life Science: 1-4,5; 3-1,2; 4-4,5

GRADE 8
Speaking and Listening: R.1,3; W.1,2

HIGH SCHOOL
Life Science: 1-1; 3-1,4; 4-5

Materials

modeling clay
small beans in two colors
coffee filter
tempera paint
assorted random materials that might be found in a "junk drawer"

Commercial Production of Seedless Watermelon

Most commercial growers do not grow triploid watermelon from seed because it is too expensive. Where the seed of diploid watermelon costs about five cents per seed, the seed of triploid watermelon costs about 30 cents each. Triploid seed is also very sensitive to temperature and overwatering.

Instead of planting seed in the field, growers buy plants from companies that start the seed under very restricted conditions. The seeds are placed in a soilless mix, watered only once, soon after planting, and covered with plastic. They are kept at temperatures between 90 and 100 degrees F. for 2-3 days, until they germinate. At that time they are moved to a greenhouse where they are treated like any other plant.

After 2-3 weeks they are shipped out to the watermelon fields for planting, where they grow vigorously, like any other watermelon. However, they must be planted with regular diploid watermelons for pollination.

Because the seeds in a triploid watermelon are infertile, the melon adapts. The inner, red fruit is often firmer than a seeded watermelon because it does not soften to cushion developing seeds. For this reason, it can also be kept longer on the grocery store shelf.

neither can reproduce.)

2. Divide students into groups, and provide each group with modeling clay and beans in two colors. Explain that you will be using these materials to model mitosis and meiosis in watermelons.
   —Students will divide the clay into three parts and form the parts into three circles. The circles represent cells.
   —Use the diagram included with this lesson to help students model the process of mitosis using the clay circles and four beans, representing two pairs of chromatids.
   —Repeat as necessary until you are confident students understand this process.
   —Students will clear the circles and model meiosis, this time using the number of beans indicated on the diagram to represent the chromosomes in a normal watermelon. Explain that normal watermelons are called diploid because they have cells with two sets of chromosomes. (Single sets of chromosomes are called haploids. Duplicate pairs of chromosomes are called chromatids.)
   —On completion of the models of meiosis in diploid watermelons, students will model the union of diploid and tetraploid watermelons by setting up the demonstration with the normal number of chromosomes in one cell and double the number (four sets, or 44, instead of two sets, 22). The final result should be three sets of beans, or 33, in the final cell—a triploid. Ask students then to explain why the process would not work with the triploid cell.
3. Students will place tempera paint dots in a pattern of their choice on one half of a round coffee filter. Fold the circle to duplicate the design on the other side. Explain that this demonstrates how our cells' blueprint plan can be repeated. Each cell has chromosome pairs that can divide to form a new set of chromosomes.
4. Provide students with a variety of random materials similar to what could be found in a junk drawer and instruct them to design their own cells using the random materials.
5. Students will name other fruits and vegetables that are seedless and research to find out if they are produced by a process similar to that used to produce seedless watermelons.
6. Divide students into groups of three or four.
   —Each group will design an imaginary watermelon.
   —Students will use their imaginations and give the invented watermelon any trait they would like.
   —Students will develop market plans for their new watermelons and present them to the class, using technology as appropriate.

Vocabulary

adapt—to change so as to fit a new or specific use or situation
botanist—a person who specializes in a branch of biology dealing with plant life
cell—one of the tiny units that are the basic building blocks of living things, that carry on the basic functions of life either alone or in groups, and that include a nucleus and are surrounded by a membrane
chromatid—one of the usually paired and parallel strands of a duplicated chromosome joined by a single centromere
chromosome— any of the rod-shaped or threadlike dNA-containing structures of cellular organisms that are located in the nucleus of eukaryotes, are usually ring-shaped in prokaryotes (as bacteria), and contain all or most of the genes of the organism
colchicine—a poisonous alkaloid c22H25No6 that inhibits mitosis, is extracted from the corms or seeds of the autumn crocus (colchicum autumnale), and is used especially in the treatment of gout and to produce polyploidy in plants
diploid—having two haploid sets of homologous chromosomes
fertile—capable of breeding or reproducing
gamete— a mature sex cell that usually has half of the normal number of chromosomes and is capable of uniting with a gamete of the opposite sex to begin the formation of a new individual
genetics—a branch of biology that deals with the heredity and variation of organisms
haploid—having the gametic number of chromosomes typically including one of each pair of homologous chromosomes
homologous— having the same or allelic genes with genetic loci usually arranged in the same order
hybrid—an offspring of two animals or plants of different races, breeds, varieties, species, or genera
meiosis—the cellular process that results in the number of chromosomes in gamete-producing cells being reduced to one half and that involves a reduction division in which one of each pair of homologous chromosomes passes to each daughter cell and a mitotic division
mitosis—a process that takes place in the nucleus of a dividing cell, involves typically a series of steps consisting of prophase, metaphase, anaphase, and telophase, and results in the formation of two new nuclei each having the same number of chromosomes as the parent nucleus
monoploid—having or being the basic haploid number of chromosomes in a polyploid series of organisms
pollinate—transfer pollen from an anther to the stigma in angiosperms or from the microsporangium to the micropyle in gymnosperms
polyploid—having or being a chromosome number that is a multiple greater than two of the monoploid number
reproduce—to produce (new individuals of the same kind) by a sexual or asexual process
sterile—failing to produce or incapable of producing offspring
tetraploid—having or being a chromosome number four times the monoploid number
triploid—having or being a chromosome number three times the monoploid number
viable—capable of growing or developing

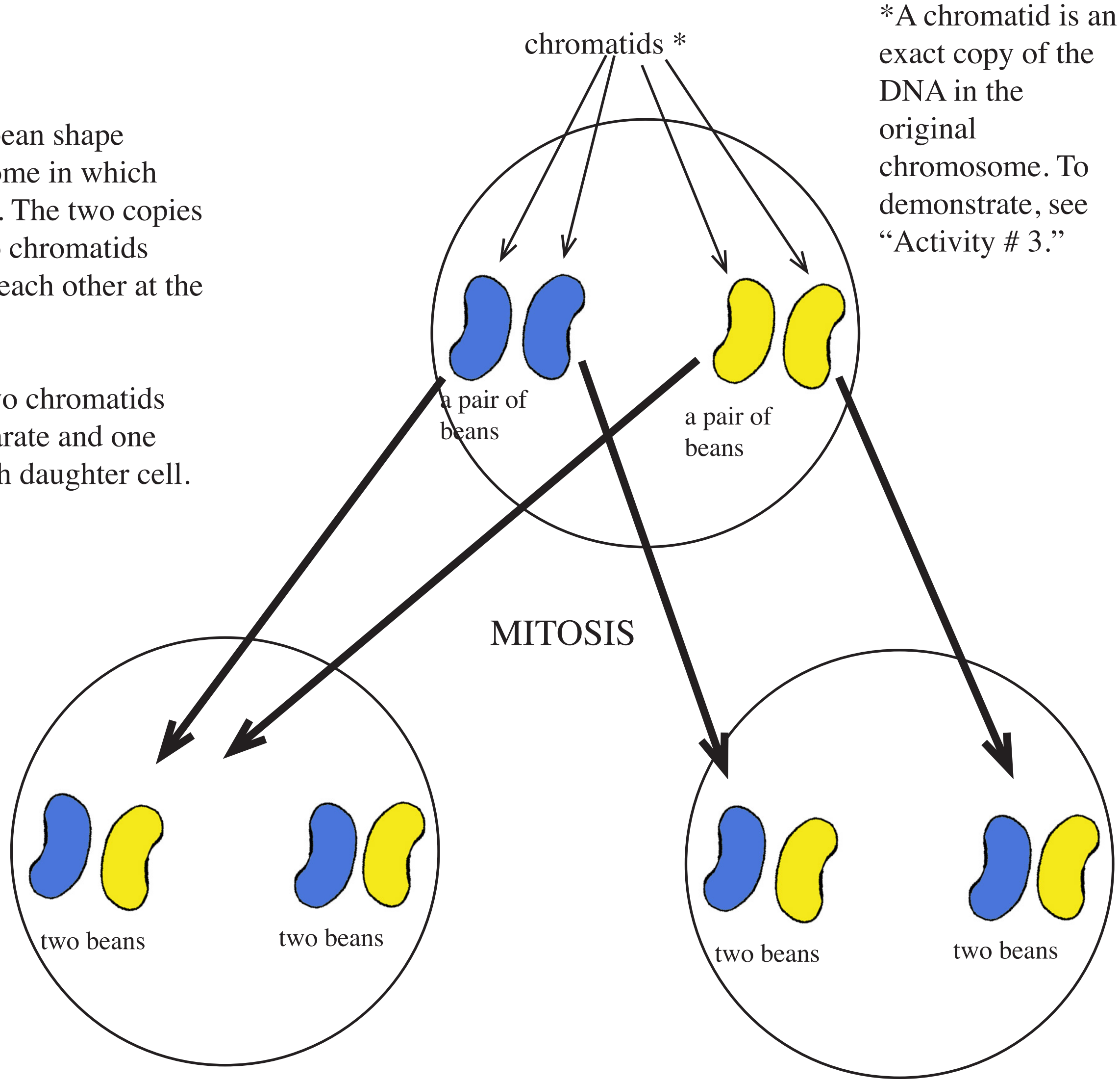
Melon Meiosis

All organisms contain about a trillion cells, but each one began as a single cell. This is accomplished by many repeats of a cycle of cell division in which one cell gives rise to two daughter cells, each of which, in turn, gives rise to two daughter cells, etc.

In a watermelon, the original cell has a complete set of 22 chromosomes (humans have 46) which contain all the DNA with all the genes the watermelon needs to be a watermelon. In each cycle of cell division, the cell first makes a copy of all the DNA in each of the chromosomes and then undergoes a type of cell division called mitosis which carefully separates the two copies of each chromosome to the two separate daughter cells, so each daughter cell ends up with a complete set of 22 chromosomes. Mitosis gives rise to almost all the cells in the body. A different type of cell division—meiosis—gives rise to sperm and eggs. Meiosis reduces the number of chromosomes by half, so in watermelons, each sperm and egg has only 11 chromosomes—one chromosome from each pair of homologous (matching) chromosomes.

In the diagram, each bean shape represents a chromosome in which DNA has been copied. The two copies of the DNA are in two chromatids which are attached to each other at the center (centromere).

During mitosis, the two chromatids of a chromosome separate and one chromatid goes to each daughter cell.



*A chromatid is an exact copy of the DNA in the original chromosome. To demonstrate, see "Activity # 3."

Oklahoma Ag in the Classroom is a program of the Oklahoma Cooperative Extension Service, the Oklahoma Department of Agriculture, Food and Forestry and the Oklahoma State Department of Education.

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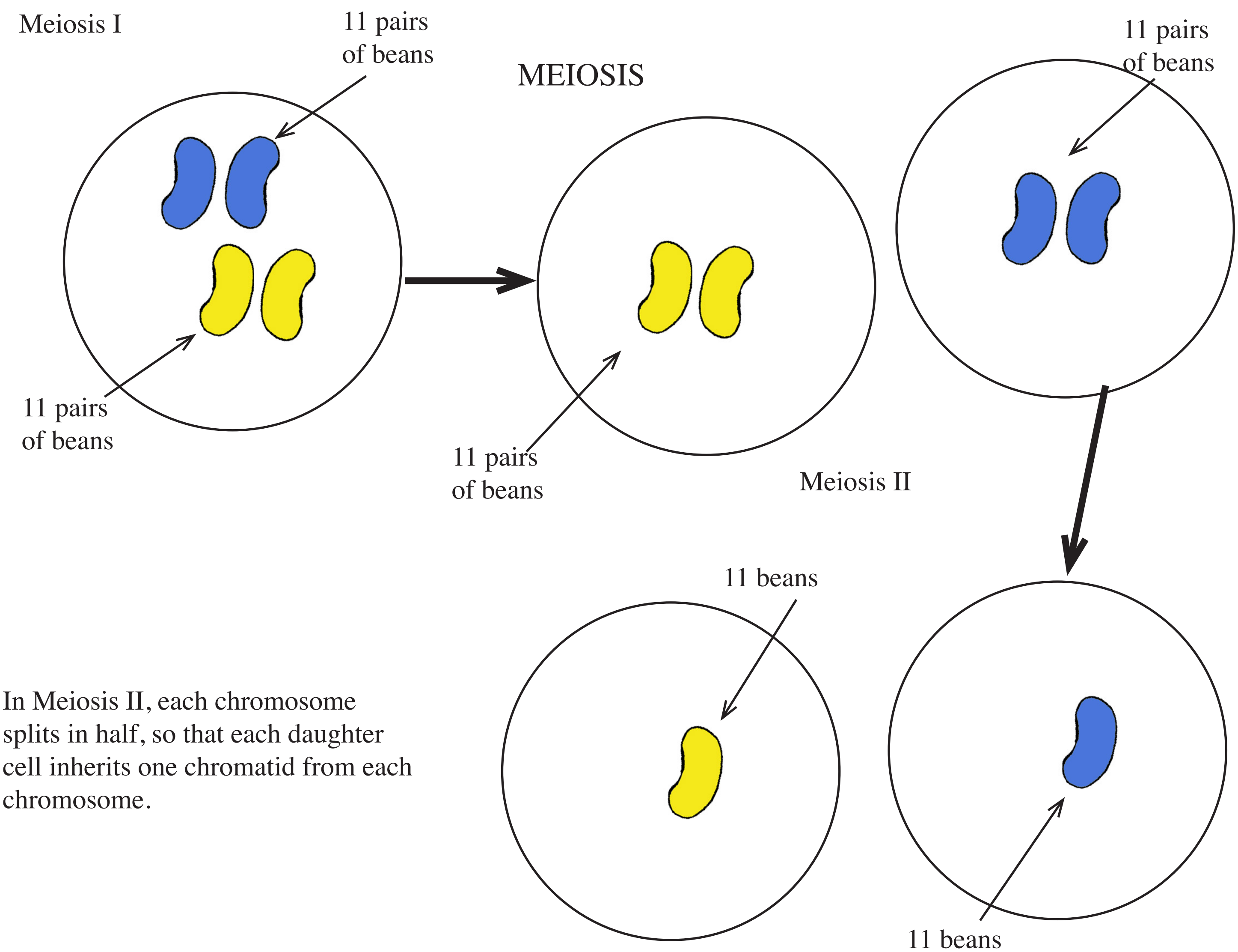
It is important for eggs and sperm to have only half the usual number of chromosomes because during fertilization the sperm and egg unite to form a single cell called the zygote, which contains chromosomes from both the sperm and egg. Thus the zygote has 11 pairs of homologous chromosomes, one in each pair from the sperm and one from the egg. When the zygote undergoes mitosis to begin to form an embryo, each cell will have the normal number of 22 chromosomes.

Meiosis consists of two divisions, meiosis I and meiosis II, which produce four daughter cells. In Meiosis I chromosomes pair with each other and then separate. This produces daughter cells with half as many chromosomes as the parent cell. In the diagram below, notice that the color of the chromosomes in each daughter cell is different. This means the genes in each daughter cell are different. (Each bean shape represents one haploid, or set of chromosomes. In a watermelon, each bean would represent 11 chromosomes.)



In Meiosis II, each chromosome splits in half, so that each daughter cell inherits one chromatid from each chromosome.

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