Melon Meiosis

Grades 6-12

Science, Agriscience, English Language Arts

Objectives

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.

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
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 seeds of the autumn crocus (colchicum autumnale), and is used 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
GMO—a genetically modified organism is any organism whose genetic material has been altered using genetic engineering
haploid—having the gametic number of chromosomes typically including one of each pair of homologous chromosomes
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
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

Background

Watermelon, *Citrullus lanatus*, is a member of the cucumber family that originated from the warm cllimates of tropical Africa. They have been popular as summer garden fare since the time of the Egyptians. Their origin was thought to be China until the 1860s when explorer David Livingston found them growing wild in central Africa. Over 1,200 kinds of watermelons are grown commercially, ranging from the 200-pound behemoths to the seedless melons many consumers prefer today.

The system for producing seedless watermelons was developed by Professor H. Kihara, a Japanese scientist at Kyoto University. By treating watermelon seedlings with colchicine, a natural substance produced by the autumn crocus, Kihara doubled the chromosomes in one of his watermelon lines. O.J. Eigsti, a botanist and researcher at Chicago State and Northwestern Universities, is credited with the original discovery that colchicine could cause a plant to double its chromosomes.

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. Some people incorrectly believe seedless watermelon is a genetically modified organism or **GMO**. While the number of chromosomes is manipulated, the DNA within the chromosomes remains unchanged.

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.

Eigsti co-founded the American Seedless Watermelon Corporation in 1954 to promote production of seedless watermelons, but farmers resisted the extra effort and expense. Each of the top seed companies in the US told him the product had no future. In the late 1960's and early 1970's there was one family farm in central Illinois growing seedless melons. In 1985, at the age of 91, Eigsti entered into a partnership with Dr. Glen Price and Bruce Price (State Senator 1992-2004) from Hinton Oklahoma to form American Sunmelon. This partnership helped seedless watermelon evolve from a novelty to a **viable** commercial crop.

Farmers were reluctant to invest time and capital in seedless melons for several reasons. Seed costs are higher. According to Dr. Glen Price, it takes three growing seasons to produce a crop of seedless watermelon seed, as opposed to one growing season for seeded melons. The seed requires a relatively high soil temperature to germinate. In most parts of the US, this means seeds must be planted in a greenhouse and the small plants are then transplanted into the fields.

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.

Today, about 60 percent of all watermelons consumed are seedless. Restaurants and consumers like the crisp flesh and lack of seeds. Most seedless melons are 12 pounds or less, where traditional seeded melons average 30-40 pounds. For consumers, that means a seedless melon is easier to chill and there are fewer “leftovers” to deal with. For restaurants, the lack of seeds means less waste. These factors make consumers and restaurant owners willing to pay more per pound for a seedless melon.

Additional Reading

Balkwill, Frances R., and Mic Rolph, *Have a Nice DNA (Enjoy Your Cells, 4)*, Cold Springs Harbor Laboratory, 2002

Brown, Nancy Marie and Nina V. Fedoroff, *Mendel in the Kitchen: A Scientist’s View of Genetically Modified Foods*, Joseph Henry Press, 2004

Eigsti, O.J. and Pierre Dustin, *Colchicine in Agriculture, Medicine, Biology and Chemistry*, Sagwan Press, 2015

Hutchens, Paul, *The Watermelon Mystery (Sugar Creek Gang Series)*, Moody, 1998.

Kingsbury, Noel, *Hybrid: The History and Science of Plant Breeding*, University of Chicago Press, 2011.

Woodburn, John H., *20th Century Bioscience: Professor O.J. Eigsti and the Seedless Watermelon,* Ivy House Publishing Group, 2000

Websites

https://www.uaex.edu/yard-garden/resource-library/plant-week/seedless-watermelon.aspx

https://ipm.missouri.edu/MEG/2020/7/watermelon-DT/

https://www.whataboutwatermelon.com/index.php/seedless-watermelon/

https://www.agclassroom.org/matrix/lesson/278/

https://ag.purdue.edu/GMOs/Pages/WhatareGMOs.aspx

REV 05/2021

Activity 1: A Melon Without Seeds, (Science, Agriscience) 1-2 50 minute class periods

Students will engage in hands-on activities to simulate mitosis, meiosis and creation of triploid melon seeds.

Oklahoma Academic Standards

Activity 1: A Melon Without Seeds (Science, Agriscience)

6.LS1.2	Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
7.LS1.6	Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
8.LS3.1	Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.
8.LS3.2	Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation
8.LS4.5	Gather and synthesize information about the practices that have changed the way humans influence the inheritance of desired traits in organisms.*
B.LS3.1	Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
B.LS3.2	Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
BS.03.03.01.a	Describe the selective plant breeding process; hybridization.

Materials:

- Activity 1 Reading Page 1 **“Mitosis”**
- Activity 1 Reading Page 2 **“Meiosis”**
- Activity 1 Reading Page 3 **“How We Get Seedless Watermelons”**
- Activity 1 Pattern Page 1 **“Seedless Melon Meiosis”**
- Activity 1 Worksheet 1 **“Seedless Watermelon Meiosis Wheel”**
- Brown beans
- White beans
- Modeling clay
- Wire brads
- Scissors

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 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 In Activity 1 Reading Page 1 **“Mitosis”** to help students model the process of mitosis using the clay circles and four beans (two brown and two white), representing two pairs of chromatids.
   —Repeat as necessary until you are confident students understand this process.
   —Students will clear the circles and model meiosis using Activity 1 Reading Page 2 **“Meiosis”** as a reference. Use 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.)
3. 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.
4. Have students read Activity 1 Reading Page 3 **“How We Get Seedless Watermelons”** and use the information to complete Activity 1 Pattern Page 1 **“Seedless Melon Meiosis”**
   —After students illustrate the blank wheel on the pattern page, they should follow the instructions on Activity 1 Worksheet 1 **“Seedless Watermelon Meiosis Wheel”** to assemble the three wheels.
   —It may be helpful to punch a hole in all three layers of paper before inserting the wire brad so the layers will rotate freely
   —Students should lift the flaps on the wheel they illustrated to line up their illustrations with the written descriptions.
   —Once the two wheels are lined up, the unit can be rotated so the steps are in the correct order on the wheel.
   —Give students time to practice lining up the correct step with the corresponding description and illustration
5. 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.
6. Students will name other fruits and vegetables that are seedless (grapes, oranges and bananas are examples) and research to find out if they are produced by a process similar to that used to produce seedless watermelons.

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.

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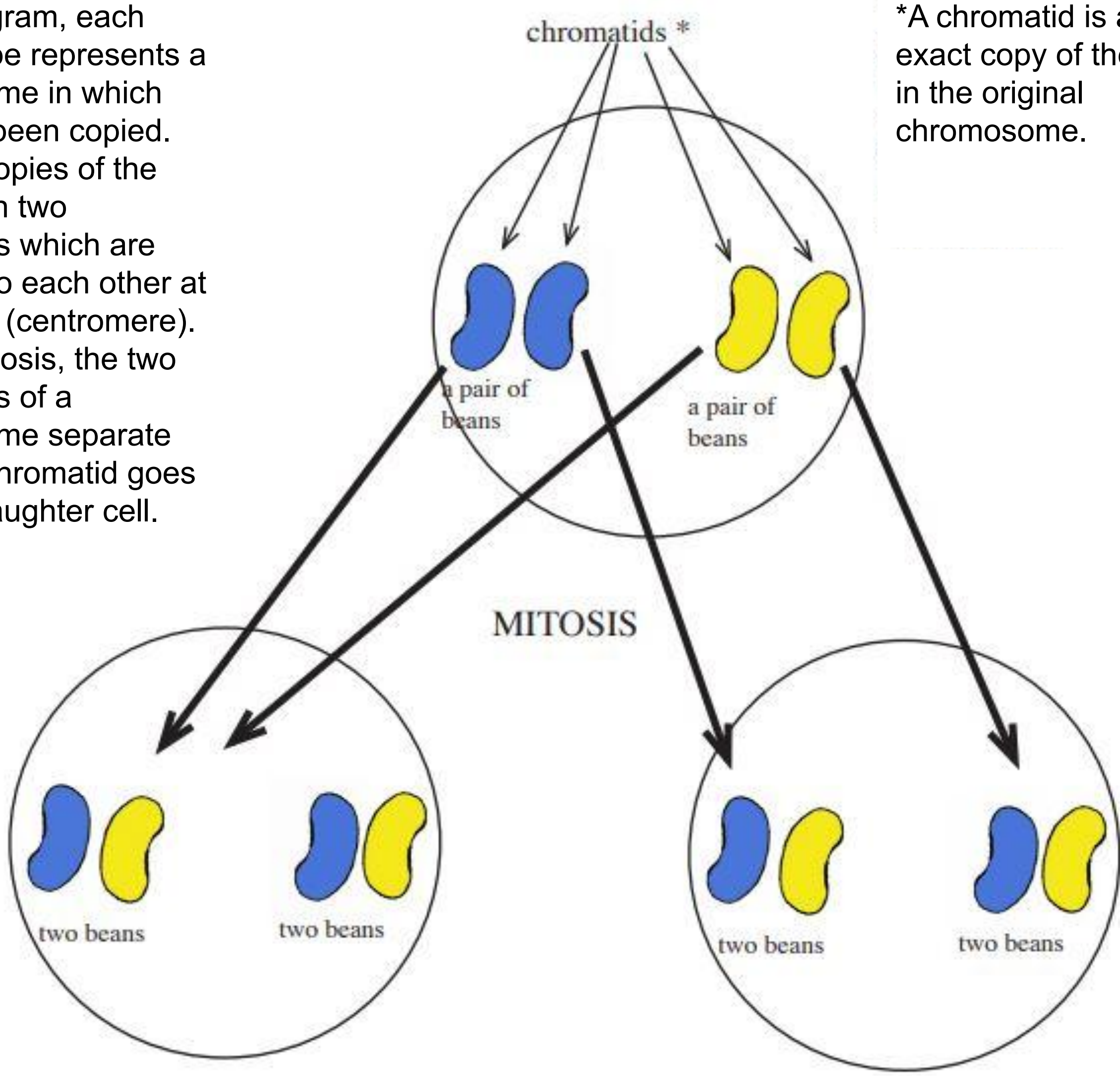
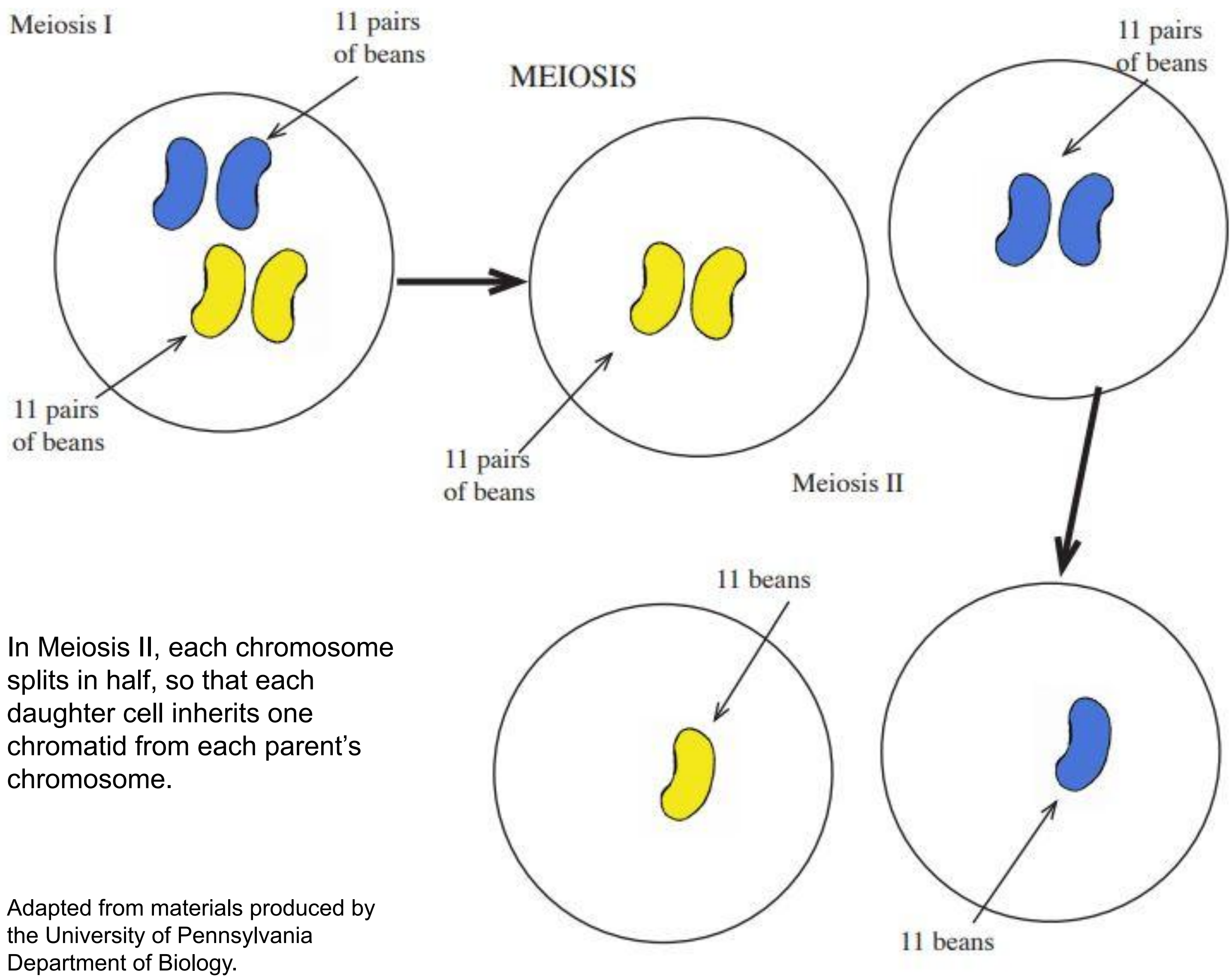


*A chromatid is an exact copy of the DNA in the original chromosome.

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.)



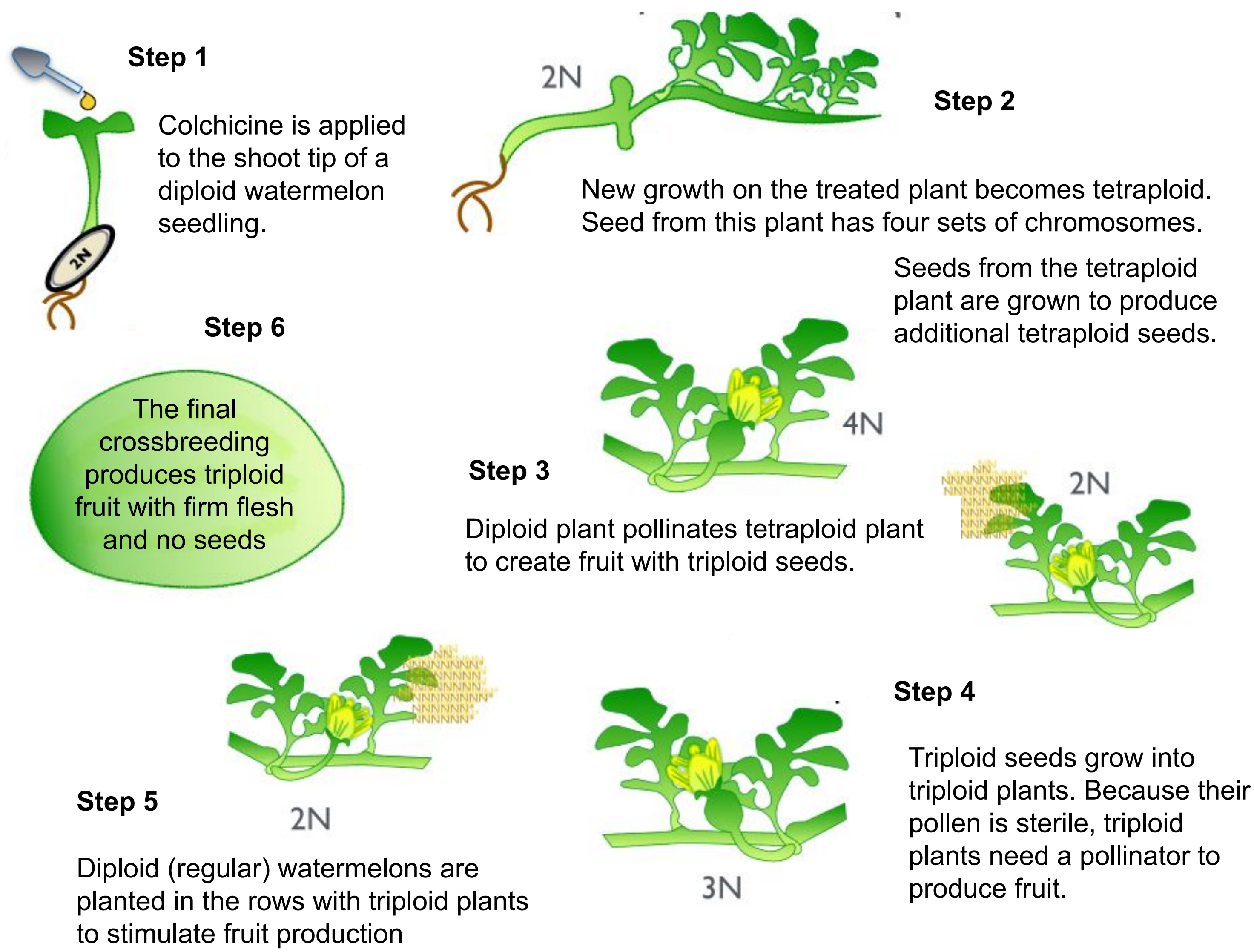
In Meiosis II, each chromosome splits in half, so that each daughter cell inherits one chromatid from each parent's chromosome.

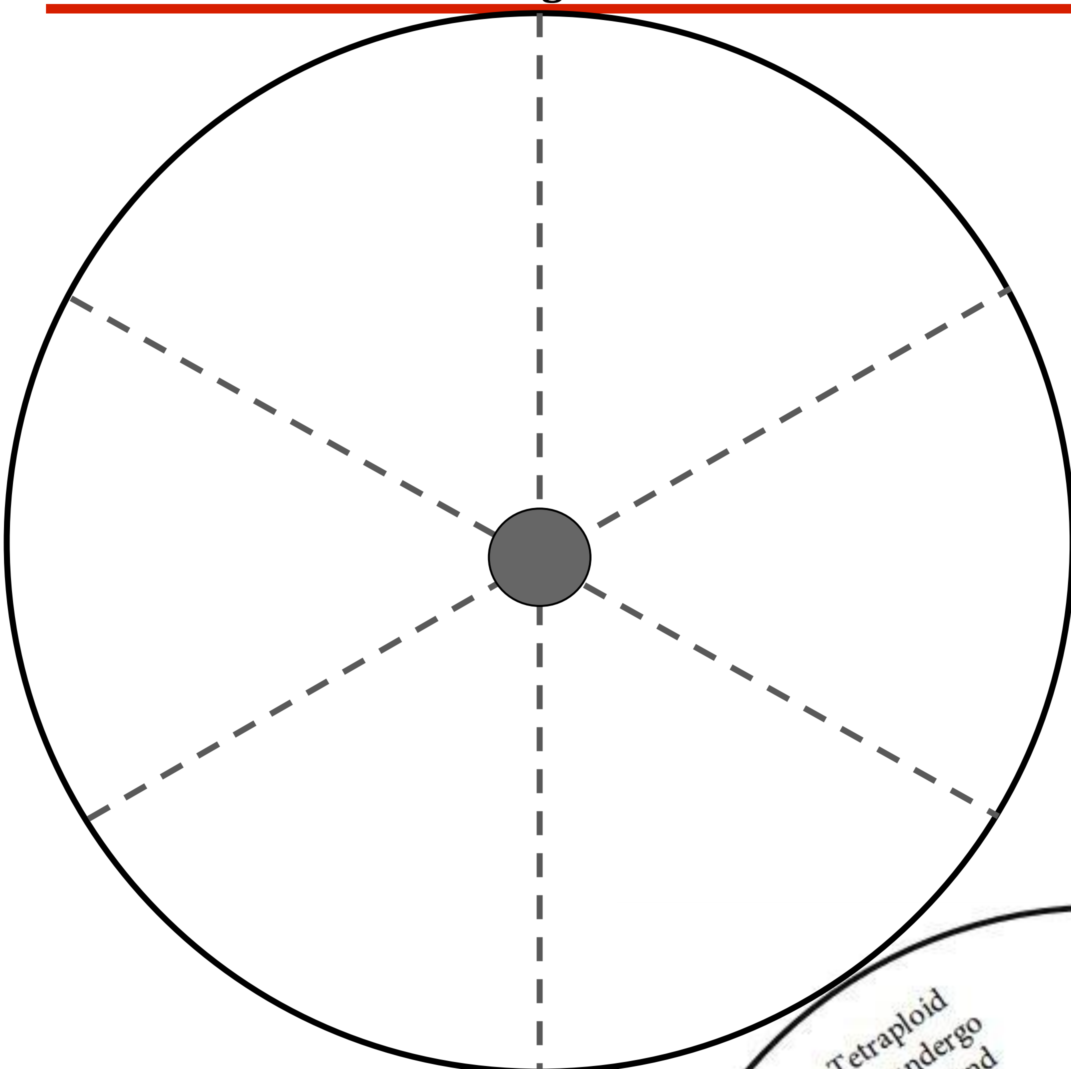
Adapted from materials produced by the University of Pennsylvania Department of Biology.

The sweet, juicy watermelon we enjoy each summer depends on a lot of science. Mitosis and meiosis are processes that reproduce cells. Mitosis creates exact genetic copies of a cell. Each cell has an identical copy of the DNA with a full set of chromosomes. Watermelons have 22 chromosomes. Mitosis helps watermelon grow from small to large.

Meiosis only takes place in the plant's reproductive parts. When a reproductive cell divides, instead of making an exact copy, it produces cells with only half the total number of chromosomes. In the case of a watermelon, the male sperm (pollen) and the female ovule each have 11 chromosomes. When fertilization takes place, a single cell is forms with a complete set of 22 chromosomes. After fertilization, mitosis takes over and duplicates each cell so the watermelon can grow to its full size.

Have you ever eaten a seedless watermelon? Today more than half of the watermelons sold in the US are seedless. How can you grow a watermelon without seeds? A new "crop" of watermelon seeds must be produced each year with the help of a chemical called colchicine, which is found in crocus plants. When applied to a watermelon seedling, colchicine results in a plant with twice as many chromosomes in each cell. Instead of two sets of chromosomes (diploid), the treated plant has four sets of chromosomes (tetraploid).





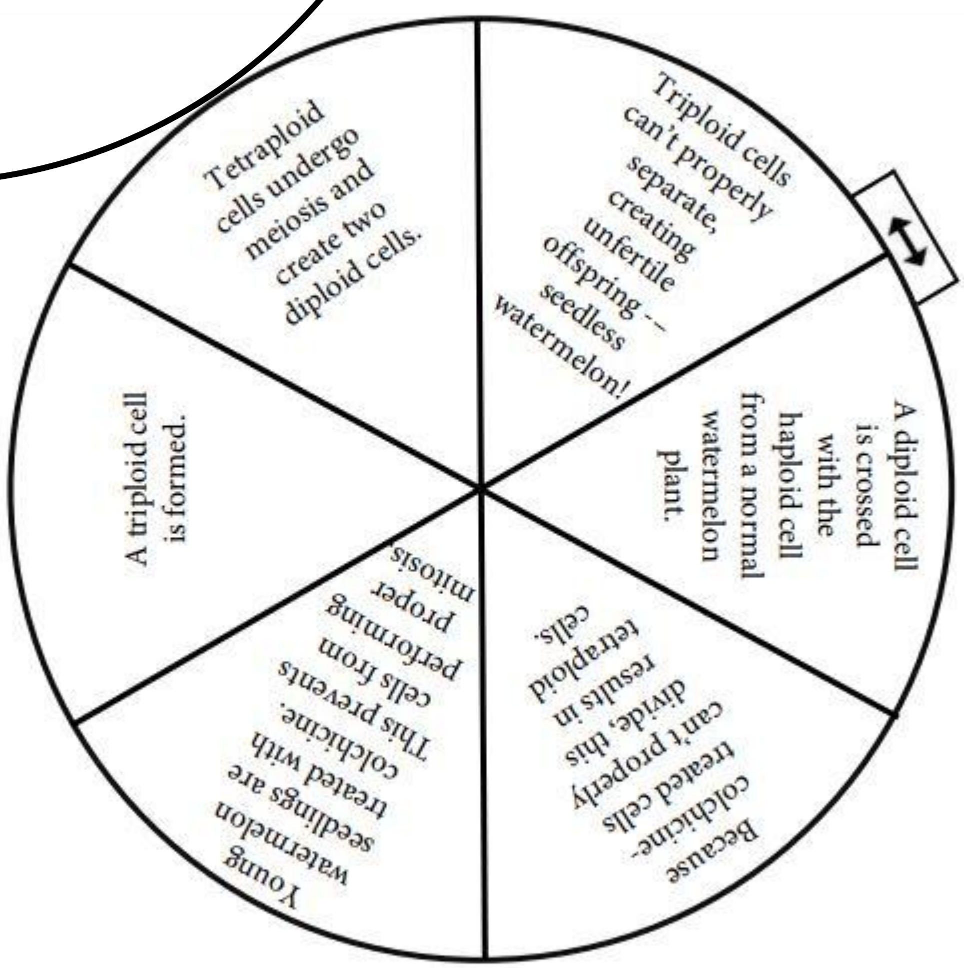
Using Activity 1 Reading Page 3 **"How We Get Seedless Watermelons"**, draw and color pictures of each step in seedless watermelon meiosis in each section of the circle to the left.

Cut out the circle and then cut along each dotted line to form flaps.

Cut out circle to the right.

Stack this circle on top of the wheel on Activity 1 Worksheet 1 **"Seedless Watermelon Meiosis Wheel".**

Stack illustrated wheel (above) on top and use a wire brad to hold all three layers together.

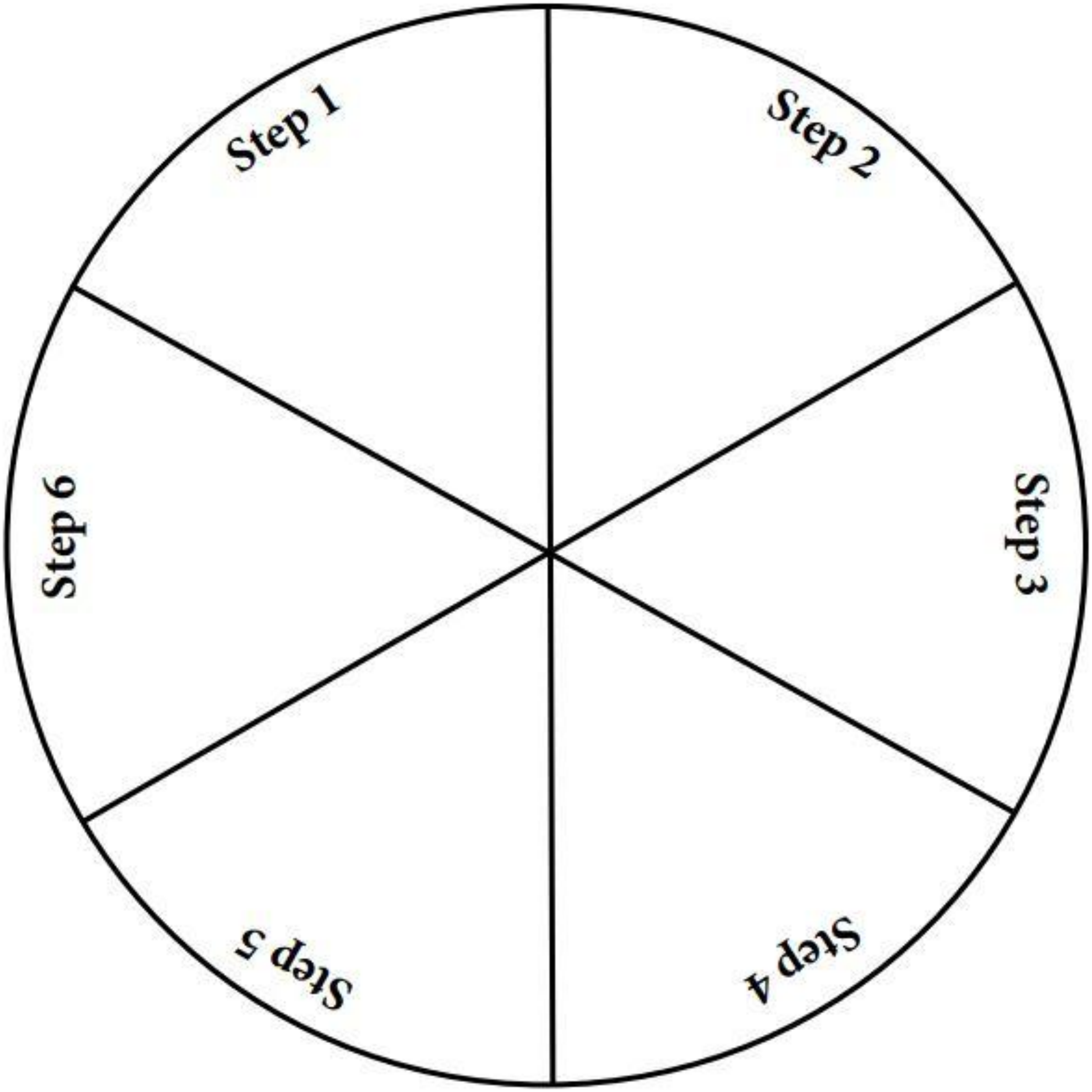


Melon Meiosis

Activity 1 Worksheet 1: Seedless Watermelon Meiosis Wheel

Name: ____ Date: ______________________

Follow instructions on Activity 1 Pattern Page 1 **"Seedless Watermelon Meiosis Wheel"** and attached completed wheels to this page with a wire brad. Punch a hole in the center of all three wheels if needed so the smaller wheels will rotate freely.



Rotate the top two wheels until the steps on each wheel line up correctly. Lift flaps to match the pictures with the descriptions. Rotate the two wheels to put the steps in the correct order.

Activity 2: A New Type of Melon, (English Language Arts) 1 50 minute class period

Students will become familiar with plant genetics terms and use them correctly in a sentence. They will design an imaginary watermelon and develop a marketing plan. Students will write stories or plays about watermelon families.

Oklahoma Academic Standards

Activity 2: A New Type of Melon (English Language Arts)

6.4.R.1 7.4.R.1 8.4.R.1 9.4.R.1 10.4.R.1 11.4.R.1 12.4.R.1	Students will increase knowledge of academic, domain-appropriate, grade-level vocabulary to infer meaning of grade-level text.
6.4.R.2 7.4.R.2 8.4.R.1 9.4.R.1 10.4.R.1 11.4.R.1 12.4.R.1	Students will use word parts (e.g., affixes, Greek and Latin roots, stems) to define and determine the meaning of increasingly complex words.

Materials:

- Activity 2 Worksheet 1 **"Vocabulary"**
- Reference books and/or online references

Procedures

1. Discuss vocabulary words and use Activity 2 Worksheet 1 **"Vocabulary"** to evaluate student understanding of the terms.
   —After completing the worksheet, have students write a sentence using each word correctly.
2. "Diploid" means two chromosomes; "triploid" means three and "tetraploid" means four. Discuss the meanings of the prefixes "di-," "tri- ," and "tetra."
   —Students will use dictionaries or online sources to research the roots of the prefixes.
   —Students will look for, list and discuss words in the dictionary with the same prefixes.
3. 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.
4. Students will write stories or plays about the Ploid family— Hap, Dip, Trip, Mono, Polly, and Tetra— incorporating characteristics that reflect the scientific meanings of the words. Of course each story should also include a watermelon.

Melon Meiosis

Activity 2 Worksheet 1: Vocabulary

Name: ____________________ Date: ____________

Write the letter of the correct definition in the blank in front of each vocabulary word.

______ chromatid

______ chromosome

______ colchicine

______ diploid

______ fertile

______ haploid

______ hybrid

______ meiosis

______ mitosis

______ monoploid

______ pollinate

______ polyploid

______ sterile

______ tetraploid

______ triploid

______ chromatid

A. having two haploid sets of homologous chromosomes

B. an offspring of two animals or plants of different races, breeds, varieties, species, or genera

C. having the basic haploid number of chromosomes in a polyploid series of organisms

D. the cellular process that results in the number of chromosomes in gamete-producing cells being reduced to one half in which one of each pair of homologous chromosomes passes to each daughter cell and a mitotic division

E. transfer pollen from an anther to the stigma in angiosperms or from the microsporangium to the micropyle in gymnosperms

F. one of the usually paired and parallel strands of a duplicated chromosome joined by a single centromere

G. having the gametic number of chromosomes typically including one of each pair of homologous chromosomes

H. having a chromosome number four times the monoploid number

I. 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

J. failing to produce or incapable of producing offspring

K. a chromosome number three times the monoploid number

L. a poisonous alkaloid extracted from seeds of the autumn crocus used to treat gout and to produce polyploidy in plants

M. a process that takes place in the nucleus of a dividing cell and results in the formation of two new nuclei each having the same number of chromosomes as the parent nucleus

N. a chromosome number that is a multiple greater than two of the monoploid number

O. capable of breeding or reproducing

Melon Meiosis

Activity 2 Worksheet 1: Vocabulary

ANSWER KEY

Name: ______________________________ Date: ______________

Write the letter of the correct definition in the blank in front of each vocabulary word.

F	chromatid
I	chromosome
L	colchicine
A	diploid
O	fertile
G	haploid
B	hybrid
D	meiosis
M	mitosis
C	monoploid
E	pollinate
N	polyploid
J	sterile
H	tetraploid
K	triploid

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