



VGEC: Student Notes

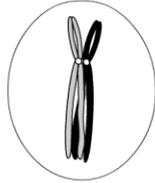
Meiosis Tutorial

A quick summary of meiosis

Meiosis is the process through which a reproductive cell goes in order to produce gametes. In humans, this means that a single *diploid* cell, $2n$ (with two copies of each chromosome) produces four unique *haploid* gametes, n (containing one copy of each chromosome) during two cell divisions. The diagram below shows the process of meiosis in a cell containing just one pair of chromosomes ($2n = 2$).



By the **end of interphase**, chromosomes have replicated and condensed.



By the **end of prophase 1**, *homologous chromosomes* have paired up and *chiasmata* have formed.



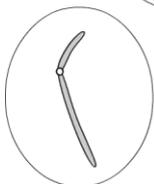
The *bivalent chromosomes* line up at the metaphase plate and during **anaphase 1** the bivalent chromosomes are pulled to opposite ends of the cell.



At the end of **telophase 1**, two separate, haploid cells have been formed, each containing one duplicated chromosome.



The duplicated chromosomes in each cell line up at the metaphase plate. During **anaphase 2**, the *chromatids* are pulled to opposite ends of each cell.



When meiosis is complete, four unique, haploid gametes have been produced.

Notes

- *Homologous chromosomes* are chromosomes that contain the same genes in the same order along their length. You inherit one from your mother and one from your father.
- *Chiasmata* are the crossover points that form between chromatids during meiosis. They result in the exchange of genetic material between maternal and paternal chromosomes.
- *Bivalent chromosomes* are a pair of homologous chromosomes joined by chiasmata.
- *Chromatids* are the two copies of a duplicated chromosome which are attached at the centromere.

Meiosis Card Tutorial

The aim of this tutorial is to help you to understand the differences between mitosis and meiosis, and to understand the basis of genetic variation during gamete production.

You are provided with a set of cards showing yellow maternal chromosomes and blue paternal chromosomes. Each card has a number in the top left-hand corner and a letter and sometimes also Roman numerals in the top right-hand corner.

- 1 Study the cards numbered **1** and **2** in your set and answer the following questions:
 - (a) Which phase(s) of Meiosis do they represent?
 - (b) Which of these cards could represent a stage of *either* meiosis *or* mitosis?
 - (c) Which of these cards shows processes that happen *only* in meiosis? Using the appropriate terminology, describe what is happening in the card(s) that are relevant *only* to meiosis.
 - (d) Place cards **1** and **2** on the table in front of you in order, with card number **2** below card number **1**.
- 2 The rest of the cards are divided into **A** cards and **B** cards by the appropriate letter on the top right hand side of the card. Place the two piles next to each other on the table.
 - (a) Toss a coin. If you get *heads*, choose the **A** set of cards, if you get *tails*, choose the **B** set of cards. The set of cards that are *not* chosen will not be needed until you reach question 4. Look carefully at the differences between the top card of the **A** pile, and the top card of the **B** pile. By choosing one of the sets of cards, which process that occurs during meiosis have you simulated?
 - (b) Take cards **3**, **4** and **5** from whichever set of cards you now have and lay them below cards **1** and **2** from question 1. Assign a phase(s) to each card.
 - (c) Each cell on Card **5** now contains *ONE* of each of the homologous pairs of chromosomes. Are the cells still diploid, or are they now haploid? Why?
- 3 You can see that card **5** depicts two separate cells, **i** and **ii**. These are the two cells that are present after the end of the *first* division of meiosis. The rest of the set of cards you have been using is further divided, into cell **i** and cell **ii** (both called cards **6**, **7** and **8**), shown in the top right-hand corner of each card. These cards represent what happens next to each of these cells.
 - (a) First you will decide how cell **i** will progress. You will notice that the **i** cards, each numbered **6**, **7** and **8** are printed on both sides of each card. One side is **blue**, the other side is **orange**.
 - (b) Toss your coin again. For cell **i**, if you get *heads*, place your cards **blue side up**, if you get *tails*, place your cards **orange side up**. By choosing one side of this set of cards, what, specifically, is being randomly arranged at this point in meiosis?
 - (c) Place the cards you chose in b. either **blue** or **orange** side up below card **5** on the table in order, (cards **6**, **7**, and **8**). Place the cards to the *left* of the main column (to leave room for the cell **ii** cards). Which phase(s) of meiosis do the cards **6** to **8** represent?
 - (d) Repeat steps a. and b. to decide how cell **ii** will progress.

(e) Place the cell **ii** cards below card 5 on the table in order, (cards **6, 7, and 8**), but to the *right* of the main column.

4 At the bottom of your cards arranged on the table, you should have two of card **8** (one from cell **i** and the other from cell **ii**). Each card has two cells on it numbered **1** and **2** on one card (from cell **i**), and **3** and **4** on the other card (from cell **ii**). Write down the cards that you end up with (For example, **Ai blue** and **Aii orange**).

(a) If the two gametes on each of these cards were produced in the testes of a male, what would they be called?

What if they were produced in the ovaries of a female?

(b) Record the results of your meiosis in the class results table at the end of these questions, and add your results to the displayed class results. Finally, record the results of the rest of your class in your table.

(c) Look at the class results. Are there any missing or duplicated results? Thinking about the process of gamete production, is this expected? Why or why not?

(d) Fill in any missing combinations in the table in a different colour.

(e) This meiosis simulation used a cell with only two homologous pairs of chromosomes. Each chromosome had just one crossover involving only two of the four sister chromatids in each bivalent pair of homologous chromosomes.

How many *different* possible gametes could be produced from the original cell? (HINT: *Remember that there are **two** different gametes on each Card 8 – take a look at **all** the Card 8s you have, from both the A and B cards. You can also take a look at the gamete pictures displayed around the table.*)

5 Now let's take a look at the variation that can be produced in meiosis simply by having a higher number of chromosomes, **without** taking crossover into account. We'll start by looking at a cell with just two homologous pairs of chromosomes per cell (as in this exercise).

(a) How many different gametes would be produced?

(b) How many different gametes would be produced if the cell had three chromosomes?

(c) Using the pattern you can see emerging, how many different gametes are possible in humans, even without crossing over?

(d) Based on your result from (c), do you think it is very likely two identical gametes could independently be produced by chance in a human, even if crossover was *NOT* taken into account? Why?