SC135 Introductory Biology
Meiosis and Gametogenesis

Introduction:
Most cells in our bodies have nuclei with 46 chromosomes organized in 23 homologous pairs. Because there are two chromosomes of each type, the cells are called diploid. If mothers and fathers each passed 46 chromosomes to their offspring during reproduction, the children in the new generation would have 92 chromosomes apiece. In the following generation, it would be 184. Obviously, this increase does not occur; normal people in each generation have only 46 chromosomes.

To produce a new individual with 46 chromosomes, an egg and sperm each contribute half the total number of chromosomes, or 23. Both sperm and eggs, called gametes, develop from body cells in which the full 46 chromosomes are present. These body cells, located in the testes and ovaries, undergo a special series of cell divisions which reduces the number of chromosomes by half. The special cell divisions, two for each cell, make up a process called meiosis. Cells that have completed meiosis then differentiate to become gametes.

Objectives:
Having completed this laboratory you will be able to:
1) Demonstrate the process of meiosis using models.
2) Recognize and draw a cell in each of the phases of meiosis.
3) Explain the difference between the processes of mitosis and meiosis.
4) Compare and contrast spermatogenesis and oogenesis.

Modeling Meiosis
1) Using your model pieces, reconstruct a diploid parent cell (in the G1 phase) as it appeared in Figure 4 of the previous exercise.
2) What is the genotype of your cell?
3) How many chromosomes does it contain?
4) How many homologous pairs are there?
5) After the G1 phase, what phase does the cell enter?
6) Explain in your own words what happens in the S phase.
7) Model the S phase. How many chromosomes are now in your cell? How many homologous pairs are there?
8) How many chromatids are there?

9) After the S phase, what phase does the cell enter? What happens during this phase?

10) Now you are ready to model the phases of meiosis. List the 4 phases of the first meiotic division here:

11) Using your model, simulate Prophase I and Metaphase I.

12) How many tetrads are modeled? Explain what a tetrad is.

13) Simulate Anaphase I and Telophase I. Draw your result in Figure 5.

14) How much DNA does each daughter cell have compared to the parent cell?

15) Are the two daughter cells identical genetically? Explain how you know this.

16) Record the genotype of each daughter cell below its picture.

17) Rebuild the parent cell you started with by replacing the chromosomes on the template outline.

18) Can you figure out a new way of aligning the chromosomes in Metaphase I so that the daughter cells will have a different combination of alleles from the ones you drew in Figure 5? Do the simulation and record your results in the first half of Figure 6.

19) An important point to be learned from this last step is that the way chromosomes of one homologous pair are distributed to daughter cells in meiosis I does not influence
where members of the second pair end up. They assort independently of one another, so different combinations are possible. This idea is called the Law of Independent Assortment.

20) Now we can move on to the second meiotic division. List the phases of meiosis II.

21) Using your model, simulate each phase of the second meiotic division and draw your result in the second half of Figure 6.

22) How much DNA does each daughter cell have compared to the parent cell (of this division)?

23) How much DNA does each daughter cell have compared to the original parent cell?

24) Are all the daughter cells identical to one another? Explain.

25) Are the daughter cells identical to the parent cell? Explain.

26) How many cells are created from one parent cell during meiosis?

**Spermatogenesis**

27) If the meiotic process that you simulated happened in the testes, it would be called spermatogenesis. Each of the daughter cells would grow a tail. The DNA would be concentrated in the head region.

28) In males, for every meiotic event, how many sperm are produced?

**Oogenesis**

29) Where does meiosis happen in females?

30) The process of meiosis in females is called oogenesis. This differs significantly from spermatogenesis in that the result of each meiotic event is only 1 egg cell (ovum).
31) During the first meiotic division, there is an unequal division of the cytoplasm during cytokinesis. One of the daughter cells receives all the cytoplasm and organelles and the other gets virtually none. Each of these cells gets the appropriate genetic material however. The small cell is called a polar body.

32) The unequal division of cytoplasm happens again in the second meiotic division so that only one cell contains significant cytoplasm and organelles. All the other small polar bodies have only genetic material.

33) The polar bodies disintegrate and are reabsorbed by the female. The result is a single egg. See Figure 7.

34) Give a reason for why unequal division of the cytoplasm is likely to occur.

![Figure 7. Oogenesis](image-url)
Figure 5. The first meiotic division

Figure 6. Meiosis
**Additional questions:**
You should be familiar with all of these questions in preparation for the exam.

1) Contrast the behavior of chromosomes in the following stages of mitosis and meiosis.
   a) prophase I of meiosis vs. prophase of mitosis
   b) anaphase I of meiosis vs. anaphase of mitosis
   c) Anaphase II of meiosis vs. anaphase of mitosis.
   d) Anaphase II of meiosis vs. anaphase I of meiosis.

2) The daughter cells of the first meiotic division have half as much genetic material as the parent cell. The same is true after a mitotic division. There is a big difference, however. What is it?

3) Are the daughter cells following the first meiotic division genetically identical (do they carry the same alleles)? Explain.

4) When does DNA replication occur for meiosis as compared to mitosis?

5) What is the number of chromosomes for human cells in each of the following stages? Indicate if they are composed of sister chromatids or not.
   a) prophase of mitosis
   b) telophase of mitosis after cytokinesis
   c) telophase of meiosis I after cytokinesis
   d) telophase of meiosis II after cytokinesis
6) In your own words, summarize the process of meiosis *without* using the names of the phases.

7) Complete the following table.

<table>
<thead>
<tr>
<th>Stage:</th>
<th>Just before the first division</th>
<th>Just after the first division</th>
<th>After the second division</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of chromosomes in each cell</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of chromatids in each cell</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of homologous pairs in each cell</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the cells haploid or diploid?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Meiosis summary
8) What chromosomes make up a tetrad?

9) What is a polar body?

10) What is an important reason for producing polar bodies in oogenesis rather than more eggs?

11) Name at least two important differences between oogenesis and spermatogenesis.

12) Why is it necessary that sperm and eggs be haploid?

13) Where do spermatogenesis and oogenesis occur in the parent’s body?