

Lab 7: Cell Division – Paper-Based Mitosis & Meiosis

BIOL-8

Name: _____ Date: _____

Learning Objectives & Goals

By the end of this lab, you will be able to:

- **Model mitosis** by physically moving paper chromosomes through each phase
- **Model meiosis I and II** by separating homologous chromosomes and sister chromatids
- **Trace alleles** through both types of cell division to see how they are distributed
- **Compare and contrast** mitosis and meiosis in terms of purpose, process, and outcomes
- **Explain independent assortment** and its effect on genetic variation

Introduction

Cell division is essential for life. **Mitosis** produces new cells for growth and repair, while **meiosis** produces gametes (sex cells) for reproduction. Although both processes involve dividing a cell's chromosomes, they differ in critical ways.



In this lab, you will use **paper chromosomes with labeled alleles** to physically walk through both mitosis and meiosis. By tracing specific alleles, you will see exactly how genetic information is distributed to daughter cells.

Key Terms:

| Term | Definition |
|-------------------------------|---|
| Diploid (2n) | A cell with two complete sets of chromosomes (one from each parent) |
| Haploid (n) | A cell with one set of chromosomes |
| Homologous chromosomes | Matching chromosome pairs (one maternal, one paternal) |
| Sister chromatids | Two identical copies of a chromosome, joined at the centromere |
| Allele | A version of a gene (e.g., A = dominant, a = recessive) |
| Centromere | The region where sister chromatids are joined |

Materials

- Scissors
- Tape or glue stick
- **Chromosome Cutouts** (provided on the last page of this lab — tear out before starting)
- Chromosome Pair 1: Gene A (alleles: **A** and **a**)
- Chromosome Pair 2: Gene B (alleles: **B** and **b**)
- Blank paper for staging chromosome movements (draw circles to represent cells)

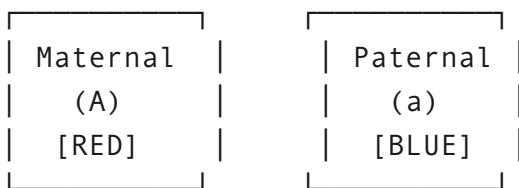
Safety Considerations

- Use scissors carefully
- Keep workspace organized — small pieces can be easily lost

Setting Up Your Cell

We will model a simple organism with **2 pairs of chromosomes** ($2n = 4$):

Chromosome Pair 1 (Gene A):



Chromosome Pair 2 (Gene B):



Genotype of starting cell: AaBb (diploid, $2n = 4$)

Procedure

- 1. Tear out** the last page and cut out the 4 "Starting Cell" chromosomes. Note: RED = maternal, BLUE = paternal.
 2. Draw a large circle on your blank paper to represent the cell.
 3. Place all 4 chromosomes inside the circle — this is your starting **diploid cell ($2n = 4$)**.
 4. **Answer the "Setting Up Your Cell" questions on the Worksheet.**
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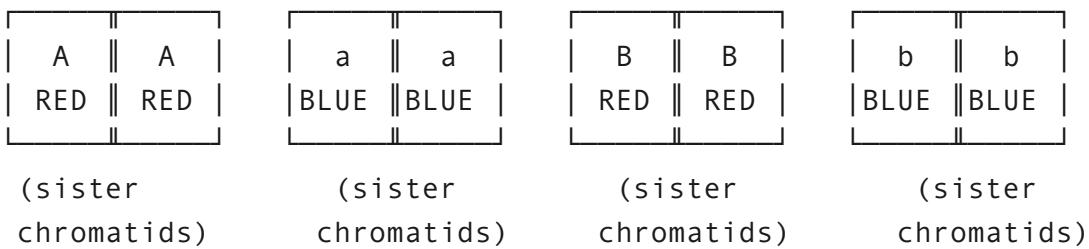
Part 1: Mitosis

Step 1: S Phase (DNA Replication)

Before mitosis begins, DNA is copied during S phase.

1. Cut out the 4 "**S-Phase Duplicate**" chromosomes from the cutouts page.
2. **Tape** each duplicate to its matching original at the center — these are now **sister chromatids**.
3. You should now have 4 duplicated chromosomes (8 chromatids total).

After S Phase:



Step 2: Prophase

1. Chromosomes condense into X-shaped structures (sister chromatids linked by centromere).
2. Arrange all 4 duplicated chromosomes loosely in the cell.
3. **Note:** In mitosis, homologous chromosomes do NOT pair up.

Step 3: Metaphase

1. **Line up** all 4 duplicated chromosomes single-file along the middle of the cell (the metaphase plate).

Step 4: Anaphase

1. **Separate the sister chromatids** – pull each pair apart at the tape.
2. Move one chromatid from each pair to one side, the other to the opposite side.
3. Each side should now have 4 chromatids (one A, one a, one B, one b).

Step 5: Telophase & Cytokinesis

1. **Draw a line** down the middle to separate the two groups.
 2. Each group becomes a new **daughter cell**.
 3. **Complete the "Part 1: Mitosis" section on the Worksheet.**
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Part 2: Meiosis I — Separating Homologous Chromosomes

Reset Your Cell

Gather your chromosomes back together. If needed, re-tape sister chromatids so you again have 4 duplicated chromosomes inside one diploid cell ($AaBb$, $2n = 4$).

Step 1: Prophase I — Synapsis

This is the critical step that makes meiosis different from mitosis!

1. **Pair up homologous chromosomes** (synapsis):
2. Pair the A chromosome (red) next to the a chromosome (blue)
3. Pair the B chromosome (red) next to the b chromosome (blue)
4. Each pair is called a **tetrad** (4 chromatids in close contact)

Crossing over happens here in real cells — homologous chromosomes can swap segments of DNA, creating new allele combinations. We will skip the physical cutting-and-swapping in this lab, but remember: this is one source of genetic variation in meiosis.

Step 2: Metaphase I — Independent Assortment

1. **Line up the tetrads** (homologous pairs) along the middle of the cell.
2. **IMPORTANT:** The orientation is random. There are two possible arrangements:

Arrangement 1:

| | | |
|--------|--|---------|
| Left | | Right |
| A(red) | | a(blue) |
| B(red) | | b(blue) |

Arrangement 2:

| | | |
|---------|--|---------|
| Left | | Right |
| A(red) | | a(blue) |
| b(blue) | | B(red) |

1. **Choose one arrangement** — this is independent assortment in action!
2. **Answer the Independent Assortment questions on the Worksheet.**

Step 3: Anaphase I

1. **Separate the homologous pairs** — pull each tetrad apart.
2. Move ONE complete (still-duplicated) chromosome from each pair to each side.
3. **Important:** Sister chromatids stay together! Only homologs separate.

Step 4: Telophase I & Cytokinesis I

1. **Divide the cell** into two new cells (draw two new circles).
2. Each cell should have **2 duplicated chromosomes** (sister chromatids still joined).
3. Each cell is now **haploid** ($n = 2$), but chromosomes are still duplicated.
4. **Complete the "Meiosis I Results" table on the Worksheet.**

Part 3: Meiosis II — Separating Sister Chromatids

Perform the following steps for **EACH** of the two cells from Meiosis I:

Step 1: Metaphase II

1. Line up the duplicated chromosomes along the middle of each cell.

Step 2: Anaphase II

1. **Separate the sister chromatids** — pull apart at the tape.
2. Move one chromatid to each side.

Step 3: Telophase II & Cytokinesis II

1. **Divide each cell** into two new cells.

2. You should now have **4 total cells** (gametes), each with **2 single chromosomes**.
 3. Complete the "Part 3: Meiosis II" section on the Worksheet.
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Part 4: Mitosis vs. Meiosis – Side-by-Side Comparison

Review your results and compare the purposes, processes, and outcomes of both types of cell division.

Complete the "Part 4: Comparison & Conclusions" section on the Worksheet.

Quick Reference

Division Comparison

| Feature | Mitosis | Meiosis I | Meiosis II |
|-----------------|------------------------|------------------------------------|------------------------|
| What lines up | Individual chromosomes | Homologous pairs (tetrads) | Individual chromosomes |
| What separates | Sister chromatids | Homologous chromosomes | Sister chromatids |
| Result | 2 diploid cells | 2 haploid cells (still duplicated) | 4 haploid cells |
| Genetic outcome | Identical | Varied (assortment) | Varied |

Sources of Genetic Variation in Meiosis

| Mechanism | When It Occurs | Effect |
|------------------------|----------------|---|
| Crossing over | Prophase I | New allele combinations on chromosomes |
| Independent assortment | Metaphase I | Random mix of maternal/paternal chromosomes |
| Random fertilization | Conception | Any sperm can fuse with any egg |

Connection to Module 08: This lab directly applies the concepts of mitosis and meiosis from Module 08 (Cell Division). By physically tracing alleles through each stage, you can see how mitosis preserves genetic identity while meiosis creates genetic diversity — the raw material for inheritance (Module 09) and evolution.

Lab adapted for BIOL-8: Human Biology, Spring 2026

Lab 07 Worksheet: Cell Division

(Turn in this worksheet at the end of the lab)

Setting Up Your Cell

Record the genotype of your starting cell:

How many chromosomes are in this cell?

Is this cell diploid or haploid?

Part 1: Mitosis

Mitosis Results — Allele Tracking

| # | Cell | Allele for Gene A | Allele for Gene B | Full Genotype | Diploid or Haploid? | # Chromosomes |
|---|------|-------------------|-------------------|---------------|---------------------|---------------|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |

1. Are the two daughter cells genetically identical to each other and to the parent cell?

2. Did the chromosome number change? How many chromosomes are in each daughter cell?

3. Why is mitosis described as producing "clones" of the parent cell?

Part 2: Meiosis I

Which arrangement did you choose? (1 or 2)

With 2 pairs of chromosomes, how many different arrangements are possible?

With 23 pairs (human), the formula is 2^n . How many possible arrangements?

Meiosis I Results — Allele Tracking

| # | Cell | Chromosome Pair 1 Allele | Chromosome Pair 2 Allele | Ploidy | # Chromosomes (duplicated) |
|---|------|--------------------------|--------------------------|--------|----------------------------|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |

Part 3: Meiosis II

Final Meiosis Results

| # | Cell | Gene A Allele | Gene B Allele | Genotype | Haploid? | # Chromosomes |
|---|------|---------------|---------------|----------|----------|---------------|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |

1. How many cells did you end up with? Are they diploid or haploid?

2. Are any of the four gametes genetically identical to each other? Explain.

3. If you had chosen the other arrangement during Metaphase I, how would the gamete genotypes differ?

Part 4: Comparison & Conclusions

Mitosis vs. Meiosis Comparison

| # | Feature | Mitosis | Meiosis |
|---|---------|---------|---------|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |

In mitosis, the parent cell (AaBb) produced daughter cells with genotype(s):

In meiosis, the parent cell (AaBb) produced gametes with genotype(s):

Which process produced more genetic variety? Explain why:

Summarize the key differences between mitosis and meiosis in your own words:

If a human cell ($2n = 46$) undergoes mitosis, how many chromosomes are in each daughter cell? If it undergoes meiosis, how many are in each gamete?



Chromosome Cutouts – Tear Out This Page

Cut along the dashed lines. **RED = Maternal** | **BLUE = Paternal**

Starting Cell Chromosomes

Use these 4 chromosomes to build your starting diploid cell ($AaBb$, $2n = 4$).



S-Phase Duplicates (Sister Chromatids)

Keep these aside until S-Phase. Tape each duplicate to its matching chromosome above.

