STUDENT GUIDE

Tips for Success

- ► Login to your account on the Human Prenatal Development Student Portal, then leave the page open so you can access the Introduction & Fun Facts, Concept Slides, and other pages.

- ► A Chromebook/laptop with an Internet connection is required in the lab for each lab group to digitally enter information into this Student Guide. **Alternatively**, the PDF may be photocopied and data can be entered directly on the printed paper version.

You will work with a collaborative team of scientists for Phases 1 and 2. Doing so will increase the reliability of your results. You will complete the Conclusion and Discussion questions on your own. Doing so will enable you to reflect on your personal development and process as a whole.

Your Name:

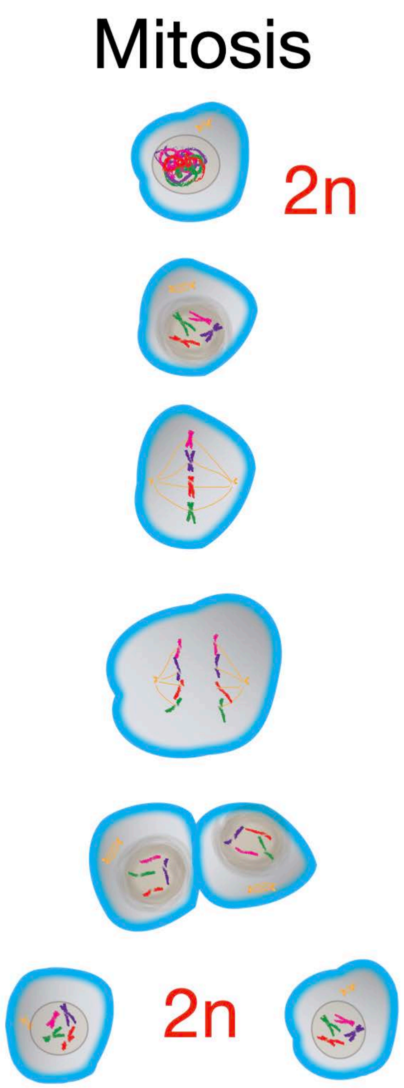
Group or Lab Partners:

Baseline Observation:

Briefly explain what you currently understand about meiosis, gamete (sperm and ova) formation and human chromosomes. Doing so will allow you to evaluate your work over time.

Background Research:

Open the *Introduction* and *Concept Slides* via the *Student Portal*. As you read through the information, think critically, asking questions and evaluating the claims,-not simply accepting what you read. Take note of any information that will help you answer the *Phase 2.2* questions. After reading the research, complete the *Student Guide* through and including *Phase 2.2*, and prepare to share your thoughts during the class presentation of the information.



Mitosis: Cell Division for Growth and Repair

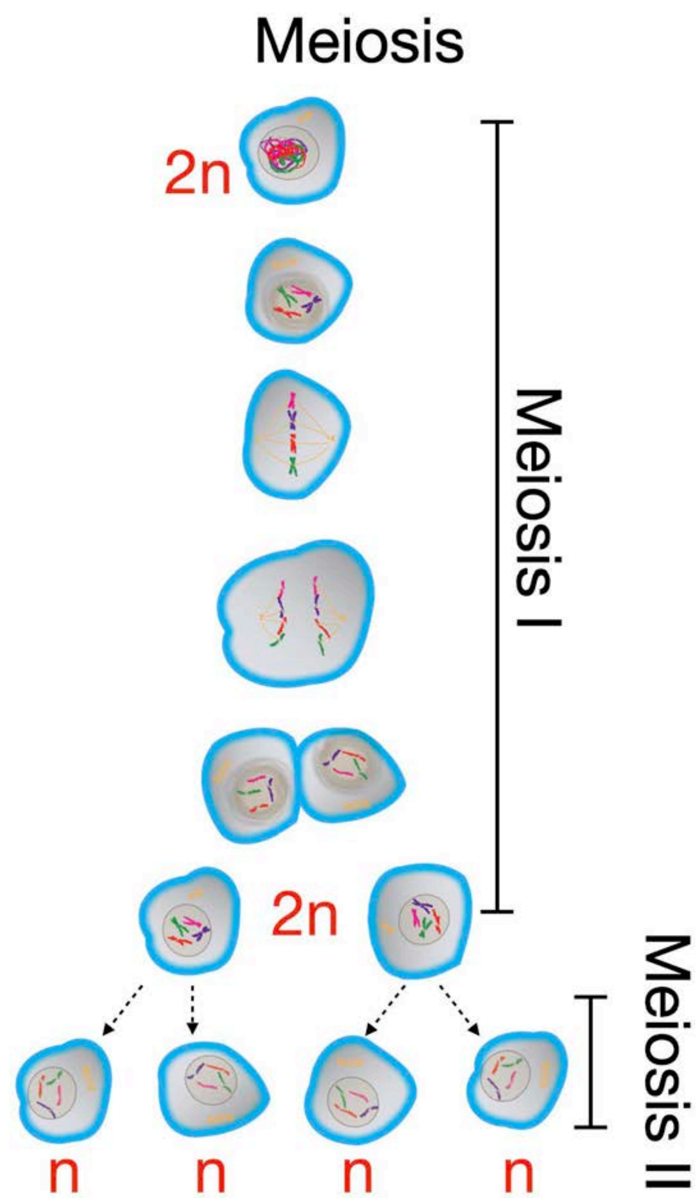
Mitosis is the process that occurs when a cell divides to produce two identical daughter cells (left). It is responsible for the growth of an organism and the repair of tissues. For example, when you get a cut on your skin, mitosis helps to create new cells to replace the damaged ones. Each new cell has the same number of chromosomes (DNA) as the original cell. In humans, this means that each new cell has 46 chromosomes arranged in 23 pairs.

Mitosis involves several stages: **prophase,**, **metaphase,**, **anaphase,**,and **telophase**. The goal of mitosis is to make sure that each daughter cell gets a full set of chromosomes. After mitosis, the two new cells are genetically identical to the original cell and each other.

Meiosis: Cell Division for Reproduction

Meiosis is a special type of cell division that occurs only in reproductive cells (gametes). Its purpose is to produce **eggs** in females and **sperm** in males. Unlike mitosis, which produces two identical cells, meiosis results in four *genetically different* cells. These cells have only half the number of chromosomes 24 in humans, so that when they combine during fertilization, the resulting offspring will have a full set of 46 chromosomes.

Meiosis consists of two rounds of division:- **Meiosis I** and **Meiosis II**. During meiosis I, homologous chromosomes (chromosome pairs from each parent) separate, and during meiosis II, the sister chromatids (copies of chromosomes) split apart. This **reduction** in chromosome number is essential for sexual reproduction, allowing genetic diversity through the mixing of parental genes.



Background Research:

Key Differences Between Mitosis and Meiosis:

Purpose: Mitosis is for growth and repair, while meiosis is for reproduction.

Number of Divisions: Mitosis has one division, while meiosis has two.

Resulting Cells: Mitosis produces two identical cells, while meiosis produces four genetically different cells.

Chromosome Number: Mitosis maintains the chromosome number, while meiosis halves it.

Feature	Mitosis	Meiosis
Purpose	Growth, repair, and maintenance of body cells	Production of reproductive cells (eggs and sperm)
Number of Divisions	1	2
Number of Daughter Cells	Two genetically identical cells	4 genetically different cells
Chromosome Number	Maintains the full number of chromosomes (diploid, 46 in humans)	Halves the number of chromosomes (haploid, 23 in humans)
Genetic Variation	No genetic variation, cells are identical	Genetic variation due to crossing over and independent assortment
Occurs In	Somatic (body) cells	Reproductive cells (testes in males, ovaries in females)
Stages	Prophase, Metaphase, Anaphase, Telophase	Meiosis I (Prophase I, Metaphase I, etc.) and Meiosis II (Prophase II, Metaphase II, etc.)
Crossing Over	Does not occur	Occurs during Prophase I, leading to genetic diversity
Function	To create cells for growth and repair	To produce gametes for sexual reproduction

Faith & Reason
From the creators of LabLearner©

Response to Your Research: Answer the question(s) then list **three new facts** you learned from your research.

1. In your own words, explain the differences between mitosis and meiosis. What is the function of each?

2. List and briefly explain three new interesting facts you have learned from your background research.

Experiment-Materials:

- [ ] Chromebook/Laptop (or printed PDF)
- [ ] 14 blocks of one color
- [ ] 14 blocks of a different color
- [ ] 14 blocks of a different color
- [ ] 14 blocks of a different color
- [ ] small balls of clay
- [ ] 4 pieces of twine about 40 cm in length (for spindle fibers)
- [ ] 4 pieces of string about 60 cm in length (for nuclear membranes)
- [ ] metric ruler or meter stick
- [ ] Triple beam balance (or digital scale)
- [ ] Modeling clay
- [ ] Scissors
- [ ] masking tape (for holding down spindle fibers if necessary)

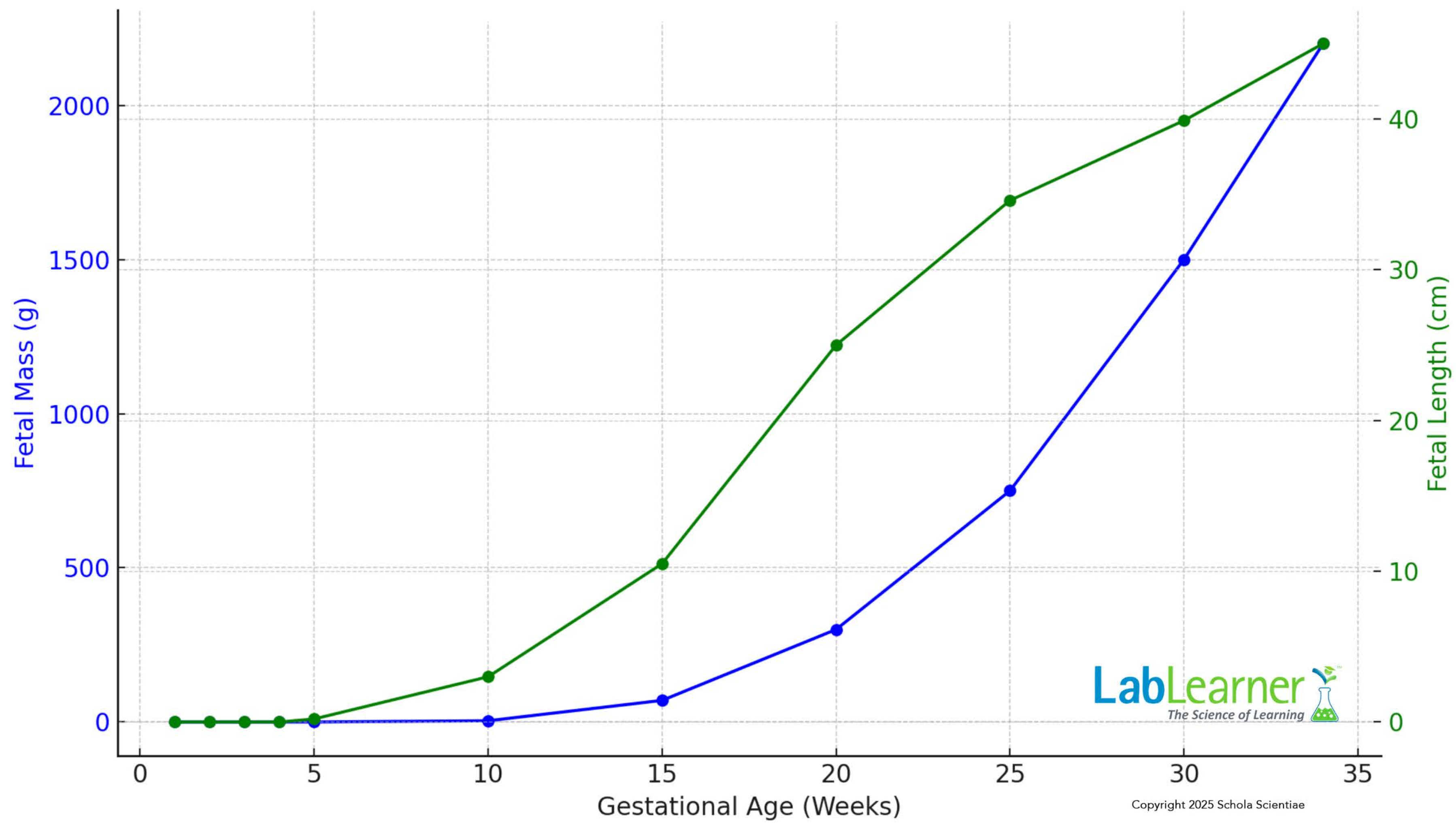
Experiment-Protocol:

This first activity will span the entire *Human Prenatal Development* CELL. Each week in the lab, you will use the data table and graph below that provides developmental milestones to follow fetal mass and length during prenatal development.

This experience will condense the 36-week normal human gestation period into four weeks,,with model measurements taken at approximately weeks 7,,14,,21,, and 28 weeks of development.

Fetal Growth: Mass and Length vs. Gestational Age

Gestational Age (weeks)	Mass (g)	Length (cm)
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0.2
6	0.8	0.8
7	1.6	1.3
8	2.4	1.9
9	3.2	2.4
10	4	3
11	17.2	4.5
12	30.4	6
13	43.6	7.5
14	56.8	9
15	70	10.5
16	116	13.4
17	162	16.3
18	208	19.2
19	254	22.1
20	300	25
21	390	26.9
22	480	28.8
23	570	30.8
24	660	32.7
25	750	34.6
26	900	35.7
27	1050	36.7
28	1200	37.8
29	1350	38.8
30	1500	39.9
31	1675	41.2
32	1850	42.4
33	2025	43.7
34	2200	45



Mass (grams): Based on data from sources like the World Health Organization (WHO), the American College of Obstetricians and Gynecologists (ACOG), and medical texts on fetal development.
Length (cm): Crown-rump length (CRL) in early weeks and crown-heel length in later weeks, commonly sourced from ultrasound or clinical fetal growth studies.

Experiment-Protocol (continued)

Experiment: Development Model at week seven

1. Use a triple beam balance (or digital scale) to weigh out a piece of modeling clay to the mass indicated at week 14 of the **Data Table** on the previous page. Record the mass of your 14-week model: Mass = ____________

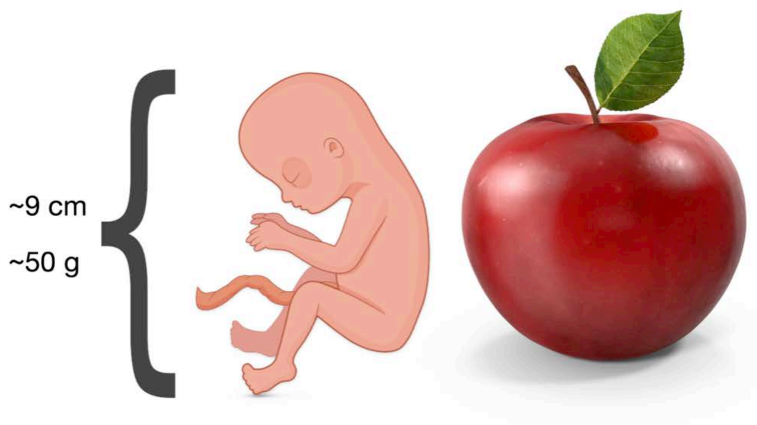
2. Next consult the **Data Table** once again to find the approximate length of the embryo at this age of gestation (14 weeks).

3. Using a metric ruler or meter stick, measure your model and form it to be the approximate length listed in the **Data Table**. Record the length of your 14-week model: Length = ____________

4. Describe the size and shape of your 14-week fetus model (remember that the baby is referred to as an embryo until the 9th week of gestation, thereafter it is referred to as a **fetus**).

5. Depending on your teachers instructions, either keep the 14-week model fetus to compare your model week to week, or return it to the modeling clay container.

14-week Ultrasound



Approximate Size

Experiment-Protocol (continued)

Experiment: Gamete Formation (Modeling Meiosis

In humans,,most cells contain 46 chromosomes,,arranged in 23 pairs — one chromosome in each pair from the mother and one from the father. In humans,,we refer to a full set of 23 chromosome pairs (46 chromosomes total/cell) as **diploid** or sometimes simply **2n**.

However, in **gametes** (**sperm** and **egg** cells) there are only 23 chromosomes *total*. IIn humans,,we refer to a half set of 23 chromosomes/cell as **haploid** or sometimes simply **n**. This is so that when the sperm and egg combine at **fertilization**, the resulting cell has the correct total of 46 chromosomes (**diploid**, **2n**) again.

In this simulation, you will act as a cell undergoing meiosis, the process that creates gametes (egg and sperm cells). You'll use colored LEGO bricks, string,and clay to represent **chromosomes**,,**spindle fibers**, and **centromeres**. You'll trace every step from DNA replication to gamete formation. We will go through the process one step at a time. For simplicity, we will use only 4 chromosomes . So for this cell the diploid number (2n) is 4, and the haploid number (n) is 2.

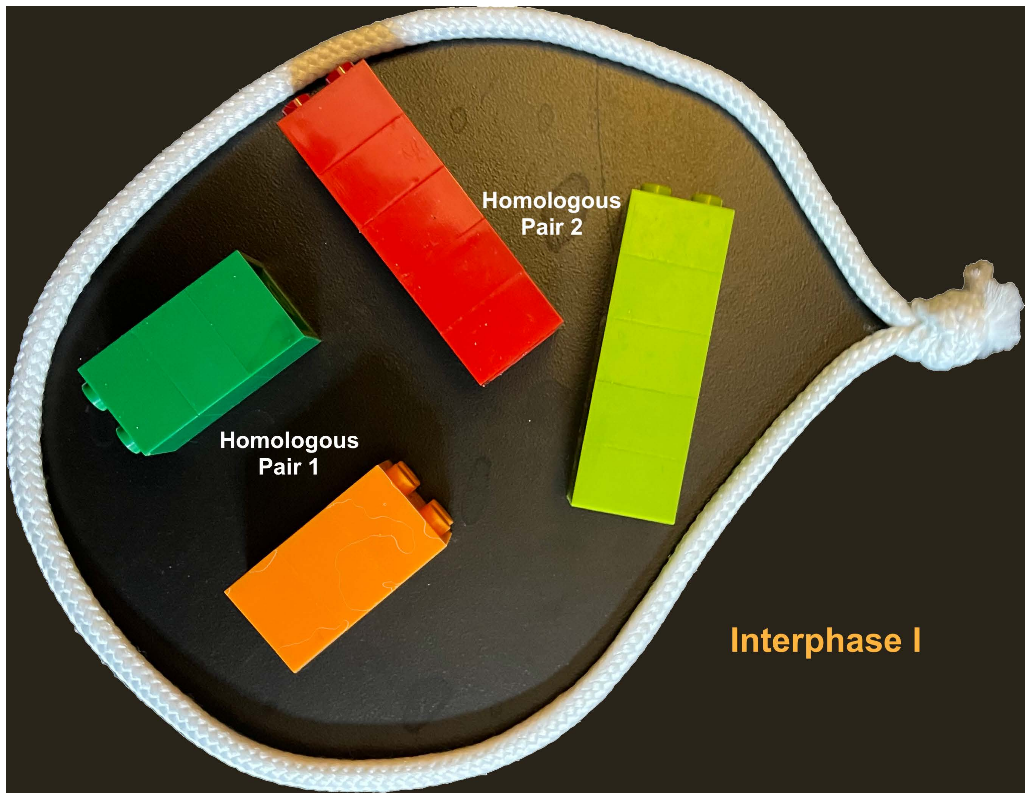
Interphase I – Preparing for Division

☐ 1. Place 4 single chromosomes inside a *string circle* to represent the **nucleus**:

- 3 Dark Green bricks + 3 Orange bricks (1st homologous pair)
- 5 Dark Light bricks + 5 Red bricks (2nd homologous pair)

☐ 2. These chromosomes are **unduplicated** — DNA replication hasn't happened yet.

Q: What's the job of Interphase?



Experiment-Protocol (continued)

Prophase I – Chromosomes Duplicate and Cross Over

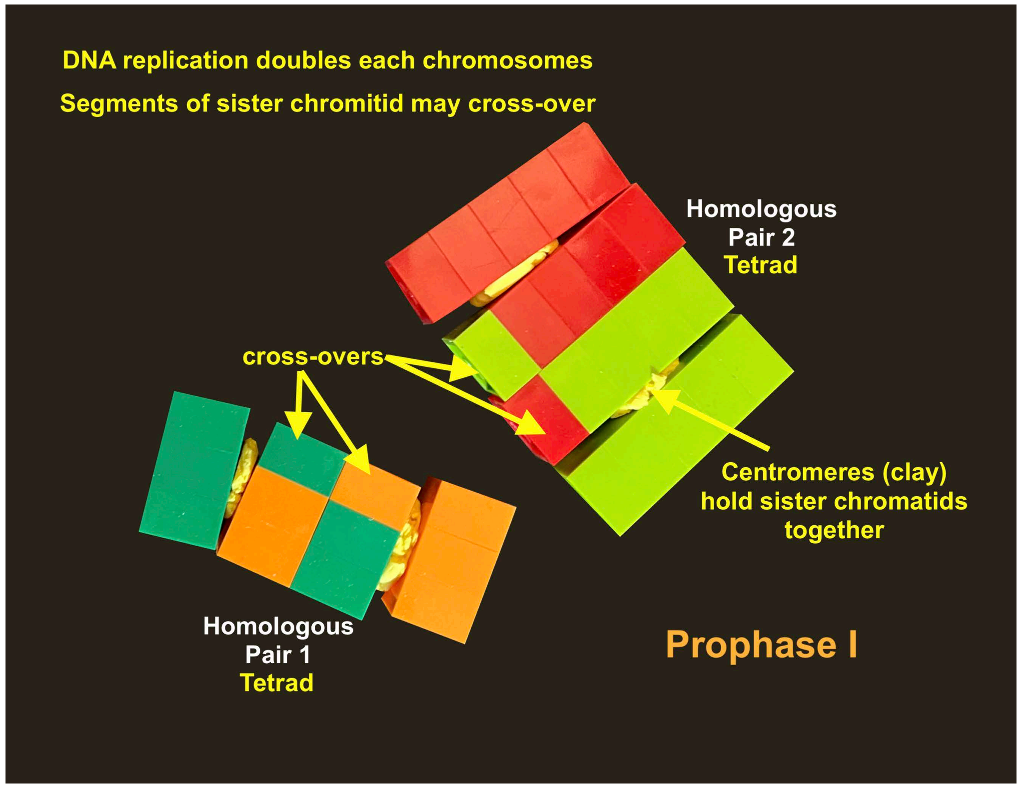
☐ 3. Duplicate each chromosome using identical LEGO bricks and join sister chromatids with a clay centromere.

☐ 4. Pair homologous chromosomes side by side to form tetrads (groups of 4 chromatids).

☐ 5. Simulate crossing over:

- Exchange 1 or 2 bricks from one chromatid in each homologous pair with its partner.

Q: Why is crossing over important?

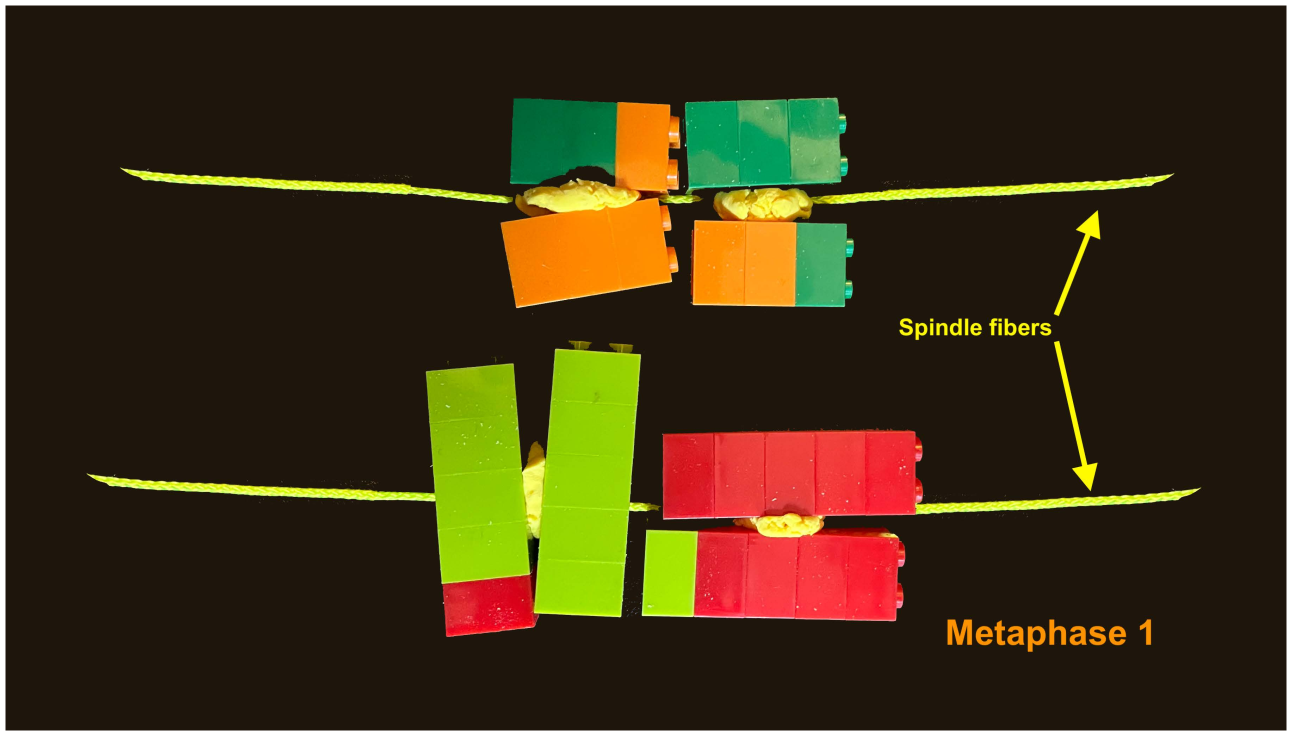


Metaphase I – Chromosome Pairs Line Up

☐ 6. Remove the string circle (nuclear membrane).

☐ 7. Lay out two spindle fibers (string) across your surface.

☐ 8. Align each tetrad in the center of the spindle — side by side.

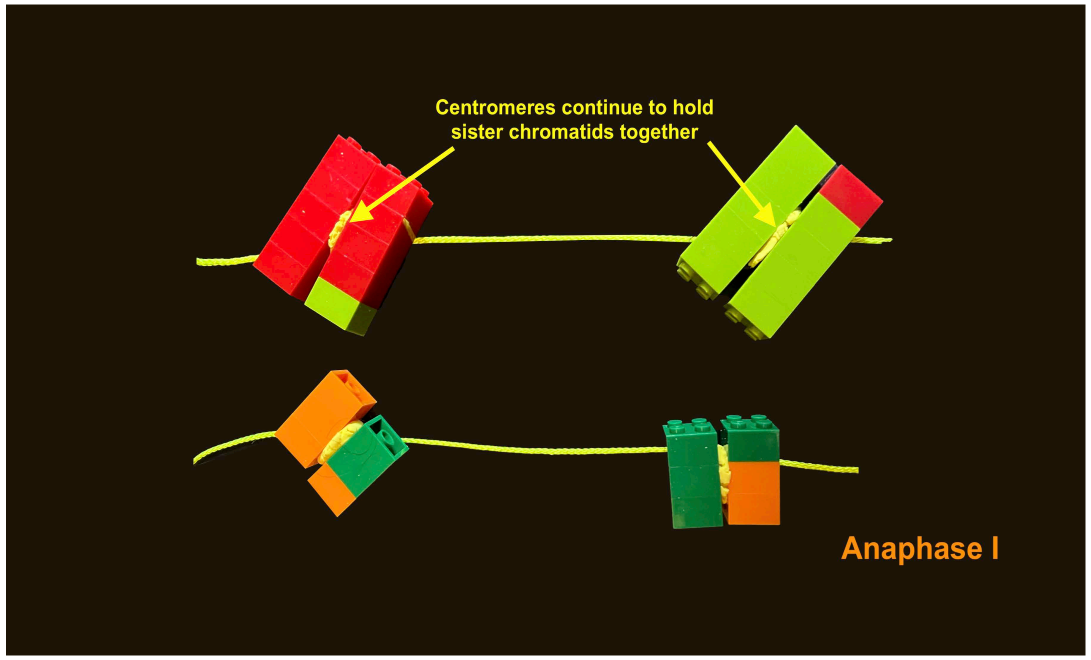


Experiment-Protocol (continued)

Anaphase I – Homologous Chromosomes Separate

☐ 9. Use your hands to pull one duplicated chromosome from each pair to opposite sides. Do not separate the sister chromatids — *centromeres stay intact*.

Q: What stays together in Anaphase I?

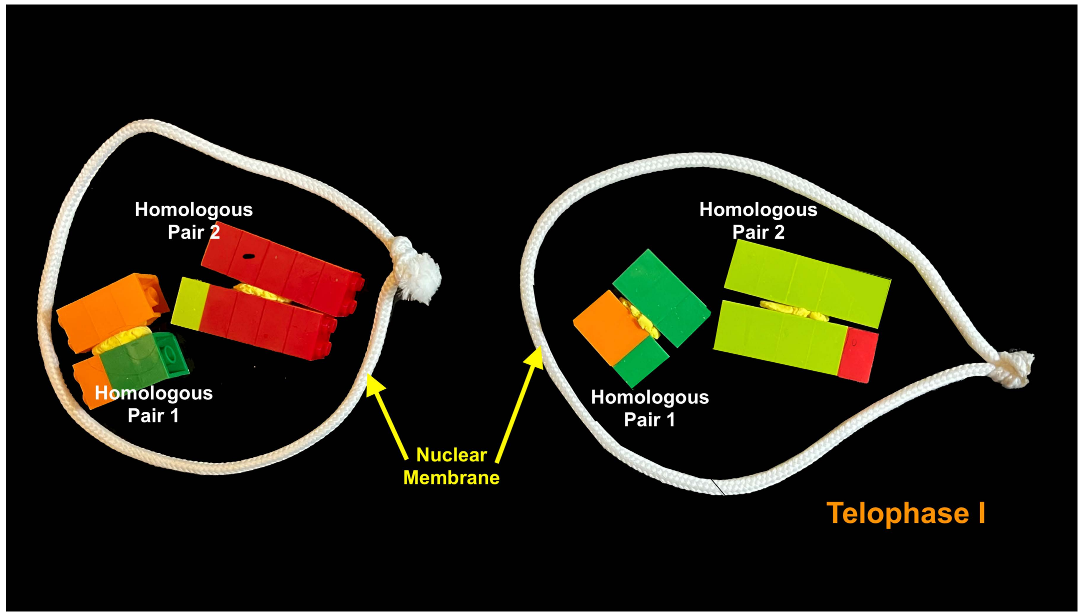


Telophase I – First Division Complete

☐ 10. Remove the spindle fibers.

☐ 11. Use string to form two new nuclei, each with one duplicated chromosome from each original pair.

Q: How many chromosomes are in each new cell?

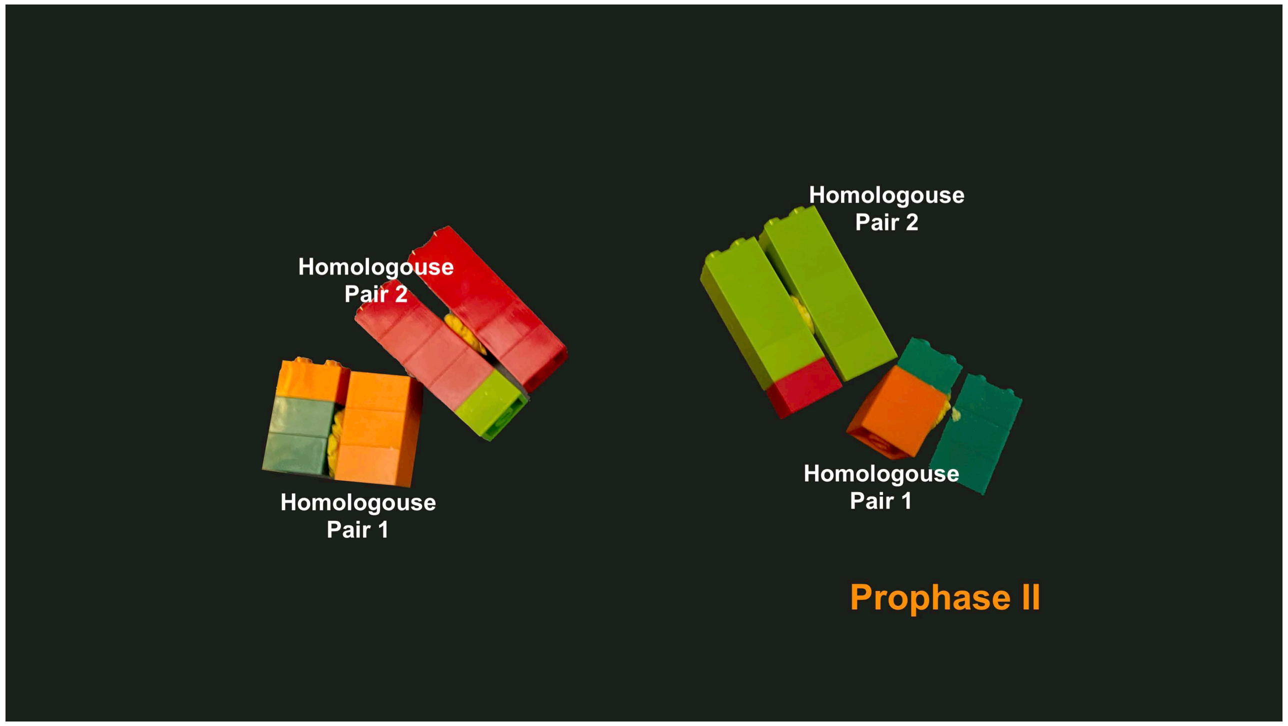


Experiment-Protocol (continued)

Interphase II (if it happens at all)

☐ 12. This phase may be skipped. If it happens, it's brief and has no DNA replication.

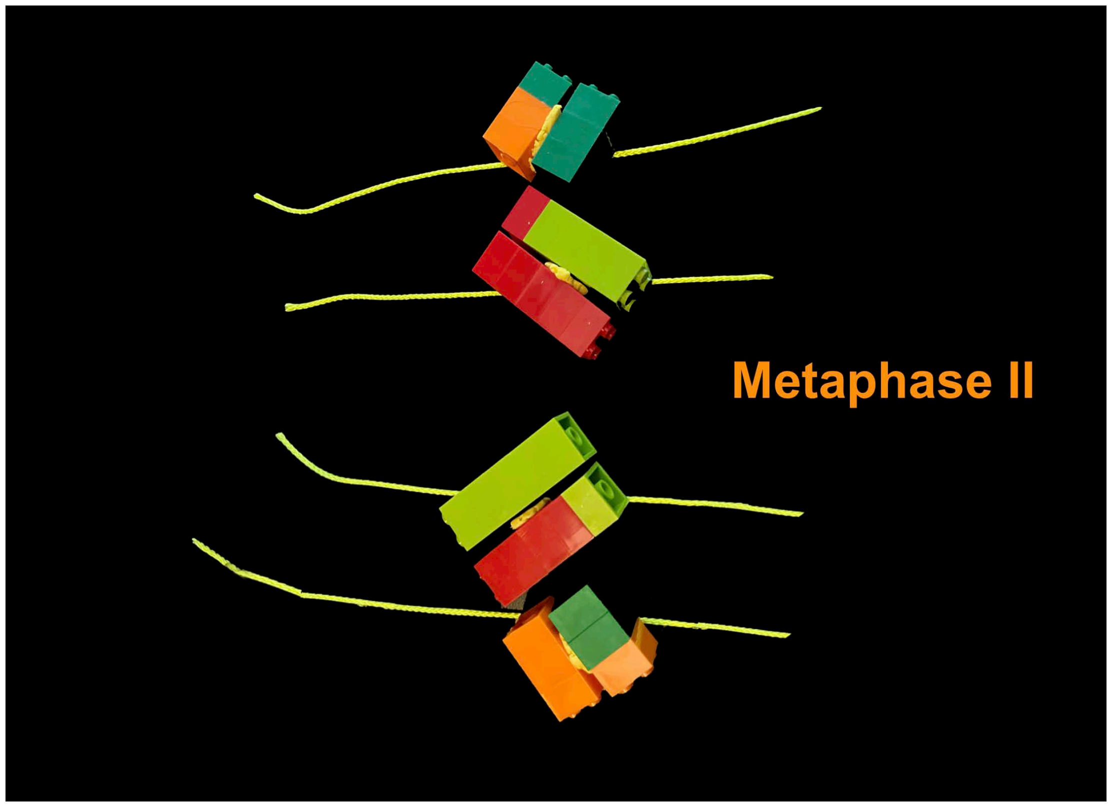
Q: Does DNA replicate again before Meiosis II?



Prophase II – Second Division Begins

☐ 13. Remove the nuclear membranes again.

☐ 14. You now have two cells, each with duplicated chromosomes.



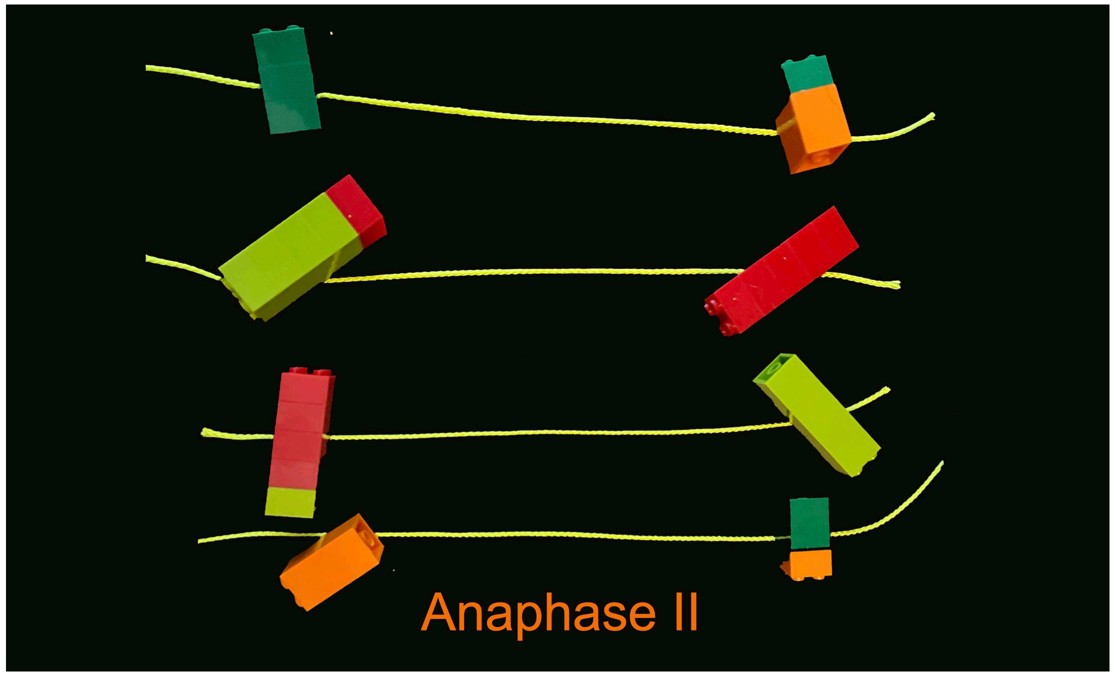
Metaphase II – Chromatids Line Up

☐ 15. Add new spindle fibers across each cell.

☐ 16. Line up each chromosome (still joined chromatids) in the center.

Q: What's different from Metaphase I?

Experiment-Protocol (continued)

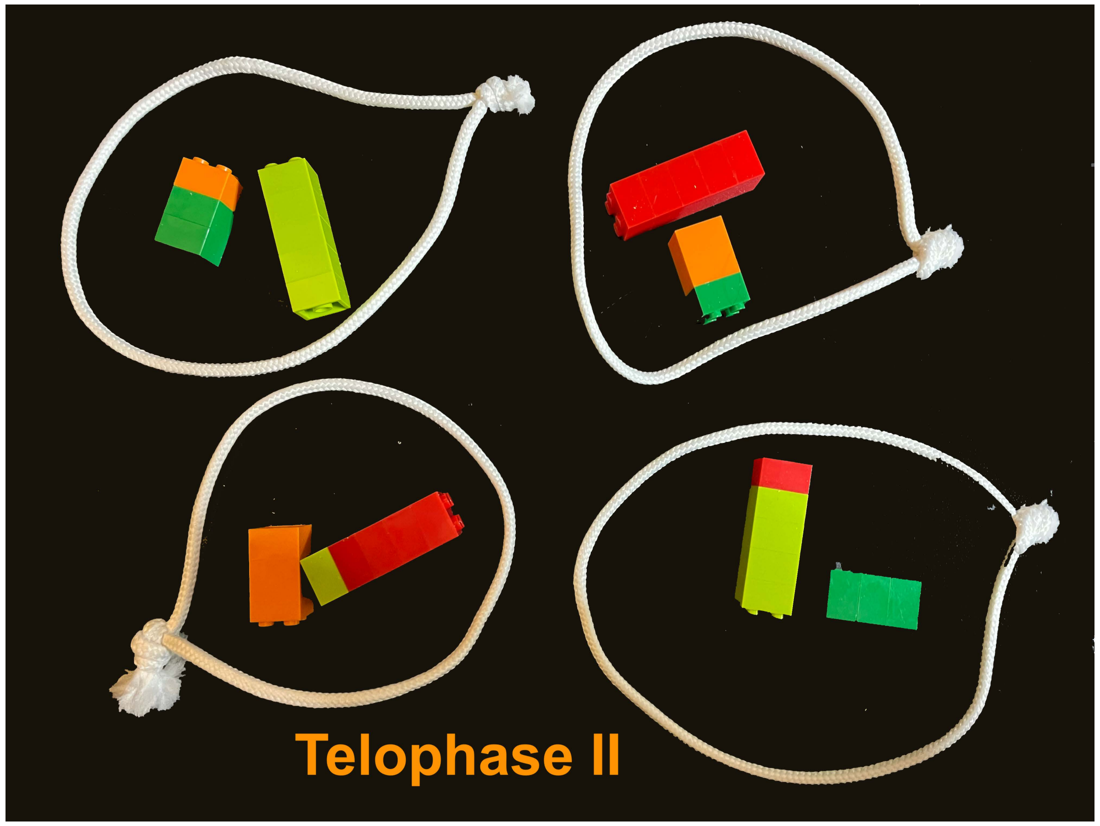


Anaphase II - Chromatids Finally Split

☐ 17. Remove the clay centromeres.

☐ 18. Pull the sister chromatids apart to opposite sides of each cell.

Q: How are these chromatids different from each other?



Telophase II - Meiosis Is Complete

☐ 19. Remove the spindle fibers.

☐ 20. Form a string nuclear membrane around each chromatid group.

☐ 21. You now have four haploid gametes, each with one chromatid from each pair.

Q: Why don't these cells look exactly alike?

Focus Questions:

1. How does a tiny embryo eventually become a fully formed baby ready to live outside the womb?

2. How does meiosis ensure that each new human being begins with the correct number of chromosomes?

3. Why is fertilization such a critical moment for prenatal development?

Focus Questions:

4. How is mitosis different from meiosis, and why is mitosis so important for fetal growth?

5. How does the hands-on activity in this Lab help you understand the main idea of this Investigation?