Faith & Reason

Student Guide

LabLearner
The Science of Learning

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.

Identify your work:

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 independently. Doing so will enable you to reflect on your personal development and process as a whole.

Your Name:

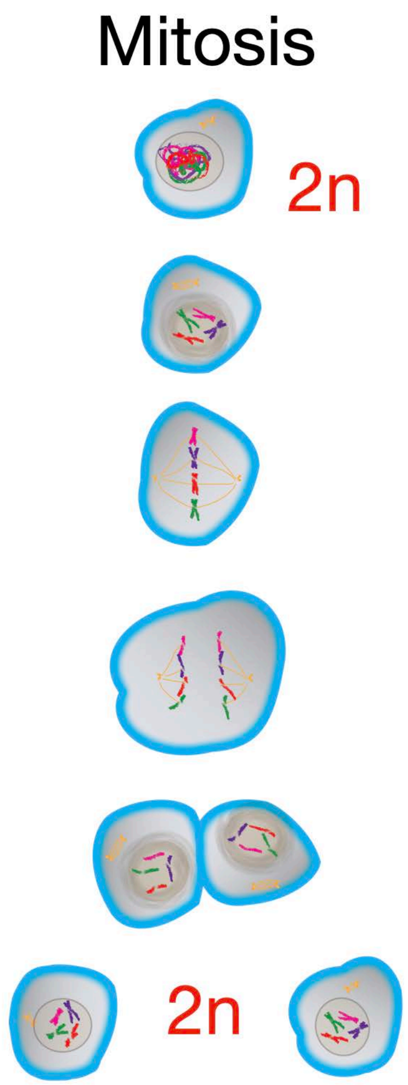
Group or Lab Partner(s):

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 skin 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.

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

1. In your own words, explain what mitosis is. What is the function of mitosis? In a human body, what types of cells divide by mitosis? What type of cells do not use mitosis to divide?

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
- [ ] 10 blocks of a different color
- [ ] 8 blocks of a different color
- [ ] 2 blocks of a different color
- [ ] 4 pieces of string about 40 cm in length
- [ ] 2 pieces of string about 60 cm in
- [ ] length Metric ruler
- [ ] Triple beam balance (or digital scale)
- [ ] Modeling clay

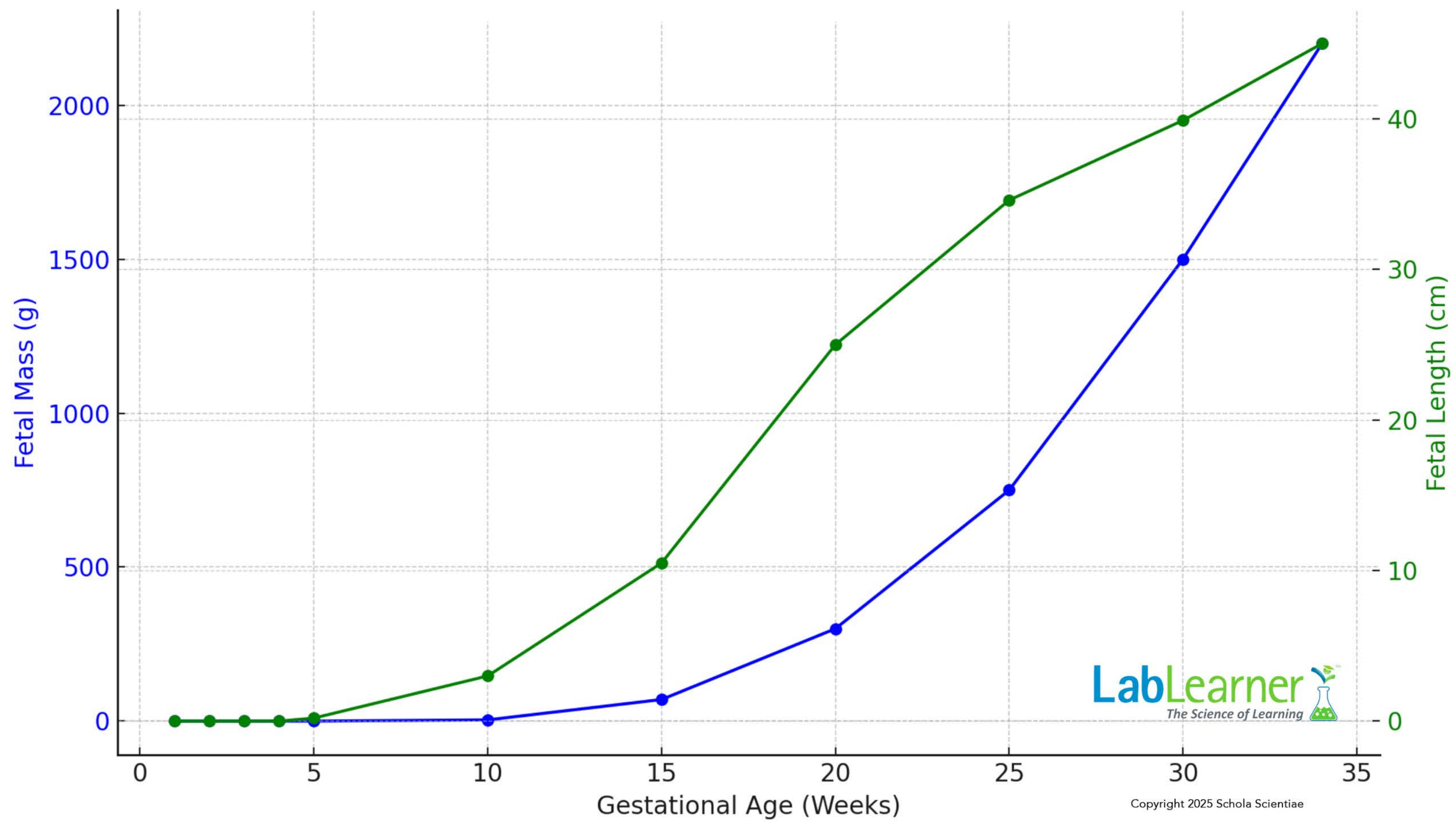
Experiment-Protocol:

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

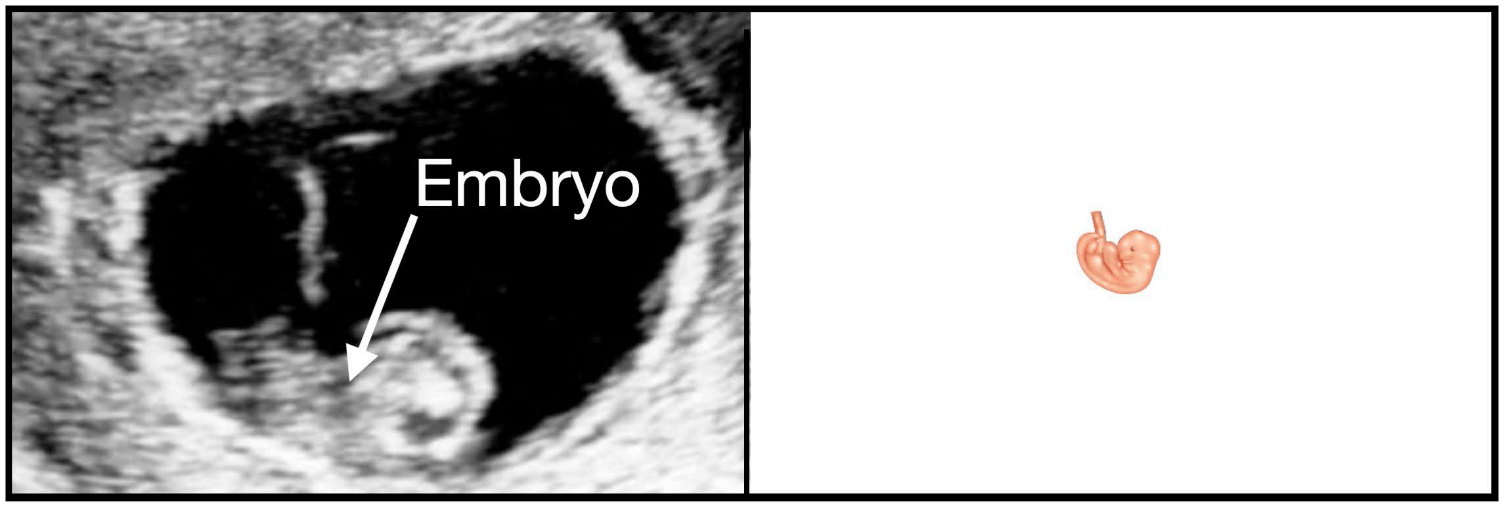
☐ 1. Use a triple beam balance (or digital scale) to weigh out a piece of modeling clay to the mass indicated at week 7 of the **Data Table** on the previous page. Record the mass of your 7-week model: Mass = ☐

☐ 2. Next consult the **Data Table** once again to find the approximate length of the embryo at this age of gestation (7 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 7-week model: Length = ☐

☐ 4. Describe the size and shape of your 7-week embryo 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 7-week model embryo to compare your model week to week, or return it to the modeling clay container.



7-Week Ultrasound Actual Size

Experiment-Protocol (Continued)

Experiment: Human Chromosomes (Modeling Mitosis)

In humans, almost every cell in the body contains 23 pairs of chromosomes, which makes a total of 46 chromosomes. Chromosomes are like instruction manuals that tell your body how to grow and function. You get one chromosome in each pair from your mom and the other from your dad.

The only exception is in sperm and egg cells, called **gametes**, which have just 23 single chromosomes. This way, when they come together during fertilization, the new cell will have 46 chromosomes, with half from each parent!

Below is an illustration of different human chromosomes.

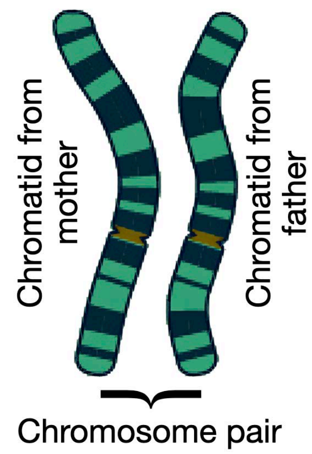
Human Chromosomes

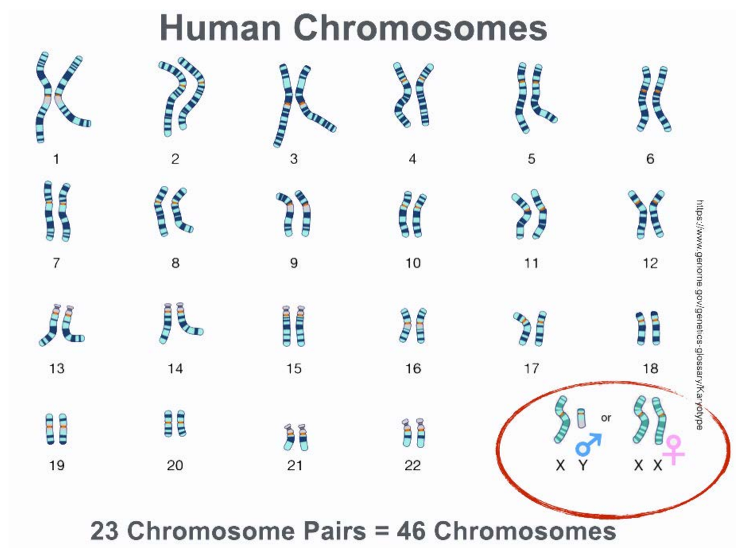
Arranged in pairs ♂

The window at the far left is similar to what you will see when you examine your human chromosome slide at the highest magnification.

The next panel was made by sorting micrographs of the human chromosomes into recognizable pairs and placing them next to each other.

Each pair of chromosomes contains one **chromatid** from the father and one from the mother (see illustration on the right).



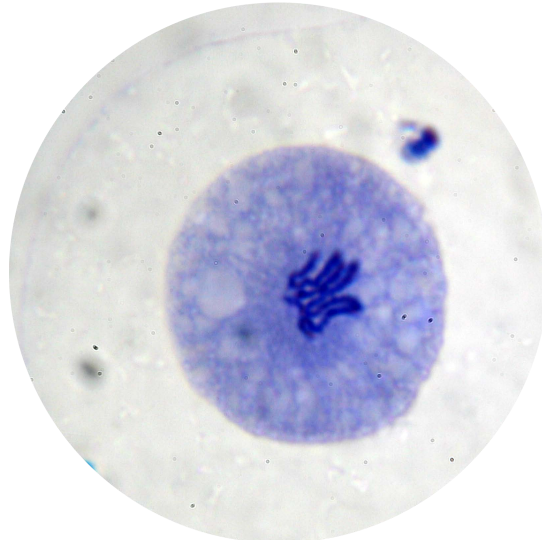


Finally, the image to the right is a cartoon model of the 46 human chromosomes with major bands of genes indicated by the stripes and bands. These characteristic banding patterns are used to identify each chromatid and to organize them into matching chromosome pairs.

As can be seen, while all other chromosome pairs are composed of matching chromatid, the 23rd chromosome pair is entirely different between males and females. While a human female (♀) has two "X" 23rd chromatids, the male (♂) has one "X" chromatid and one "Y" chromatid.

Experiment-Protocol (Continued)

Experiment: Human Chromosomes (Modeling Mitosis, continued)



Prophase

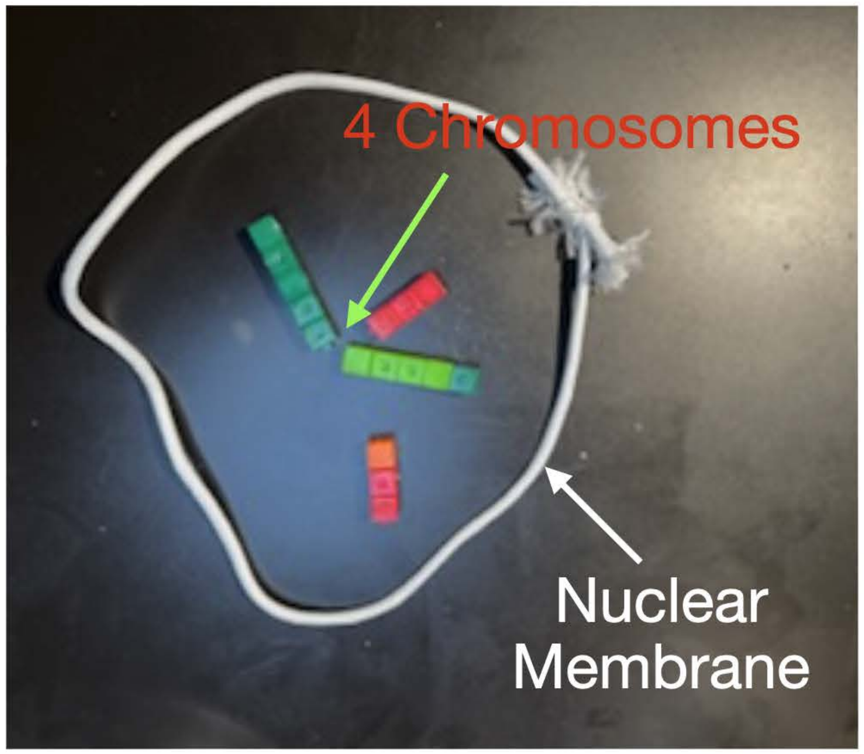
Carefully follow the steps below. By creating this model, step-by-step, you will come to understand the essential cellular process of cell division by **mitosis**. Later, in PostLab, be prepared to discuss the individual steps in mitosis (**prophase**, **metaphase**, **anaphase**, and **telophase**) with your classmates.

A. **Prophase**

☐ 1. Build a model of a body cell with two chromosome pairs in the nucleus. Use the pictures below as a guide. We will use dark green, light green, red, and orange gram cubes in this illustration. You may use different colors but assemble them in the same patterns as shown here.

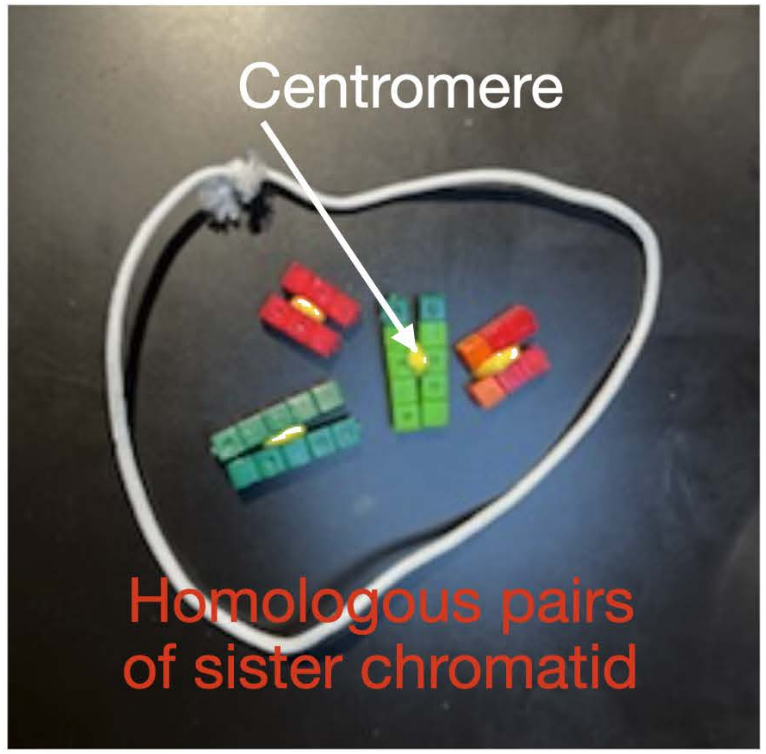
Make your chromosomes as follows (you will need two of each) and a prophase model:

# of each Chromosome	Cubes
2	5 dark green
2	1 dark green 4 light green
2	5 red
2	2 red 1 orange



Cell Nucleus

chromosomes condense in the nucleus



Prophase

DNA replication forms homologous pairs
Homologous pairs held together by centromere

Experiment-Protocol (Continued)

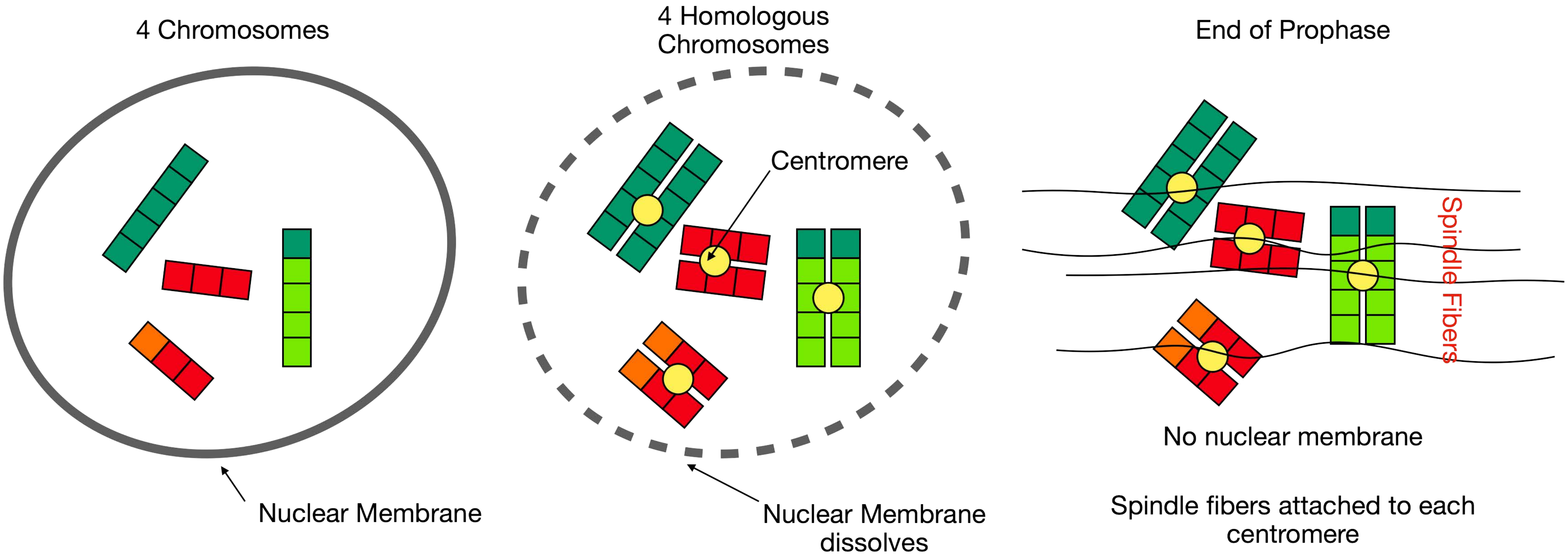
Experiment: Human Chromosomes (Modeling Mitosis, continued)

☐ 2. Begin with one of each chromosome inside the nuclear membrane, as shown in the center picture above. This is the situation as a cell enters prophase.

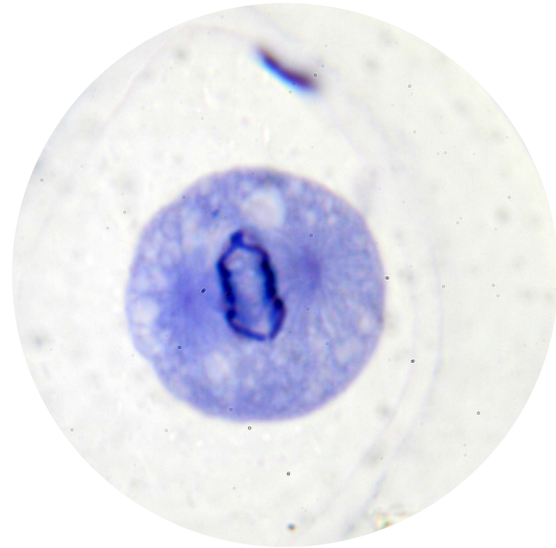
☐ 3. As prophase continues, each chromosome replicates to form a homologous pair of chromosomes held together by a centromere (small ball of clay in our model). The two chromosomes of a homologous pair are referred to as sister chromatids.

Join two identical chromosomes with a small ball of clay, as shown in the right-hand picture above. **At this point, prophase is complete.**

☐ 4. The situation by the end of prophase is shown below. Notice that there are four homologous pairs of chromosomes composed of two sister chromatids held together by the centromere. The nuclear membrane has disappeared, and the pairs of chromosomes are in the cytoplasm. Spindle fibers form from each end of the cell and attach to the centromere of each homologous pair of chromosomes… **metaphase** has started.



Experiment-Protocol (Continued)



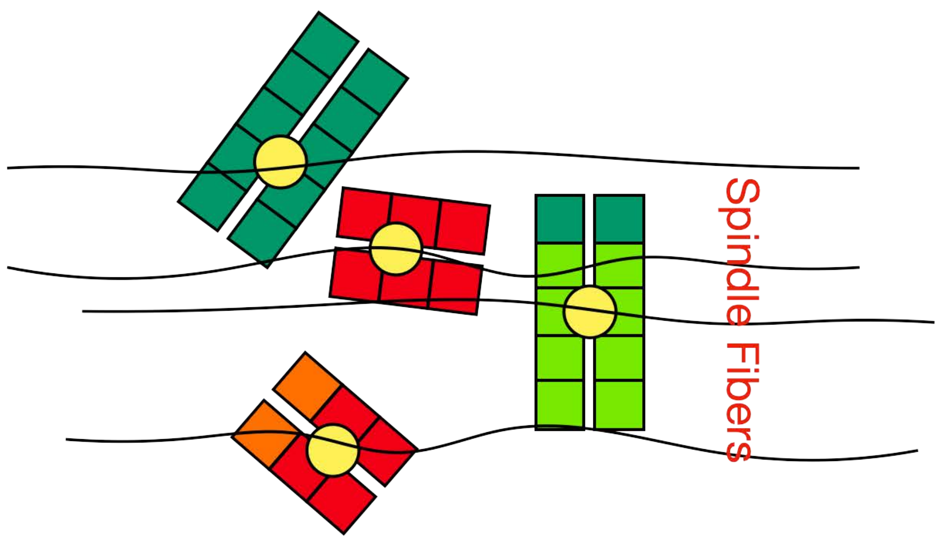
Metaphase

Experiment: Human Chromosomes (Modeling Mitosis, continued)

B. Metaphase
As prophase ends, homologous chromosome pairs form and attach to spindle fibers extending from the cell's opposite ends. During this process, the nuclear membrane dissolves so the chromosomes can attach to the spindle fibers at their centromeres. At metaphase, the chromosome homologous pairs line up near the center in preparation for the next phase of mitosis.

☐ 1. Line the four homologous pairs of chromosomes at the center of the spindle fibers as shown below (note that the fibers attach to the homologous chromosome pairs at the centromeres.

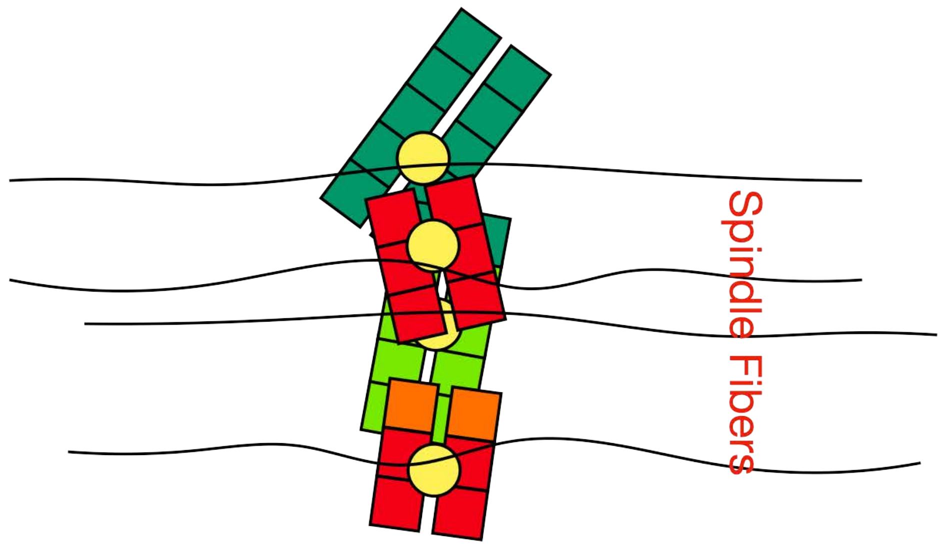
End of Prophase



No nuclear membrane

Spindle fibers attached to each centromere

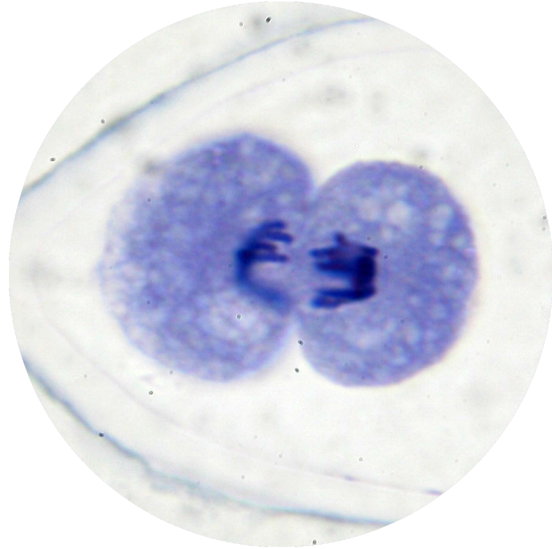
Metaphase



No nuclear membrane

Attached homologous pairs align near the center of the cell

Experiment-Protocol (Continued)



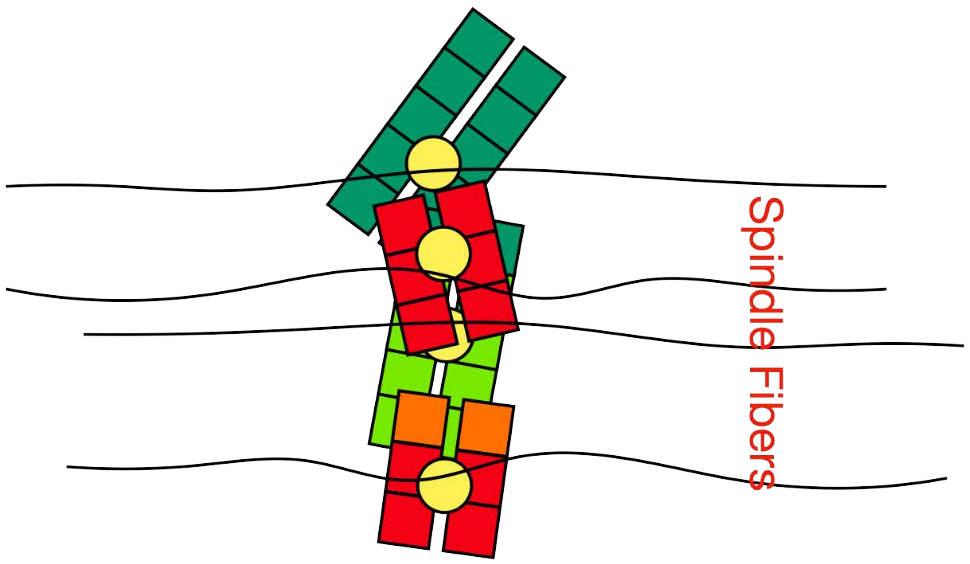
Anaphase

Experiment: Human Chromosomes (Modeling Mitosis, continued)

C. Anaphase
At anaphase, the homologous pairs line up at the middle of the cells begin to separate into sister chromatids, each of which is still associated with the spindle fibers. As anaphase progresses, the sister chromatids are pulled apart and are moved toward opposite ends of the cell.

☐ 1. Detach the homologous chromosome pairs in your model and a part of each centromere, and move the two homologous chromatids in opposite directions, as shown in the figure below. Once separated, the homologous chromatids are referred to as chromosomes.

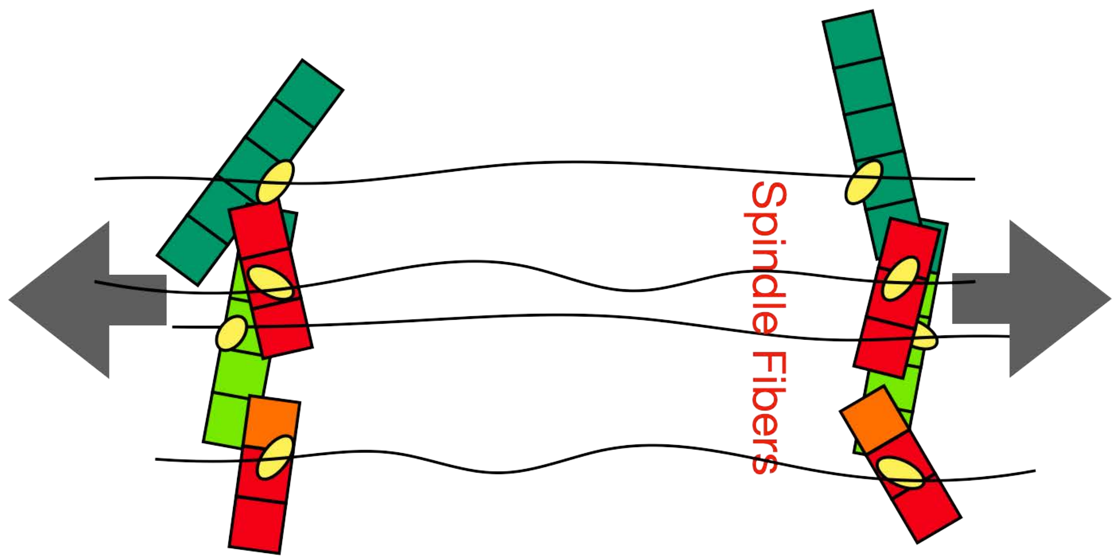
End of Metaphase



No nuclear membrane

Attached homologous pairs align near the center of the cell

Anaphase



No nuclear membrane

Sister chromatids separate and move to opposite ends of the cell and are now, once again, called chromosomes

Experiment-Protocol (Continued)

Telophase

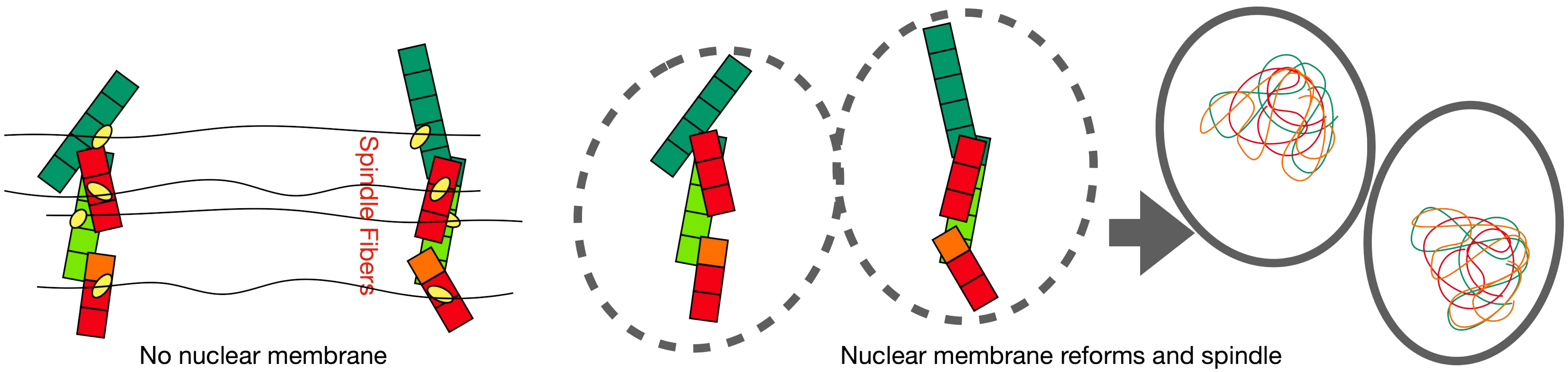
Experiment: Human Chromosomes (Modeling Mitosis, continued)

D. Telophase
At telophase, the chromosomes have moved to opposite areas of the cell. The spindle fibers dissolve along with the centromers. In addition, the nuclear membrane reforms around the chromosome groups at each end of the cell.

☐ 1. Remove the remaining centromeres (clay) and the spindle fibers (strings) once the chromosomes are separated at the end of anaphase.

☐ 2. Finally, add a nuclear membrane (circle of string) around each set of chromosomes.

☐ 3. Confirm that the two new cells formed in the model are genetically identical to the cell you started with.

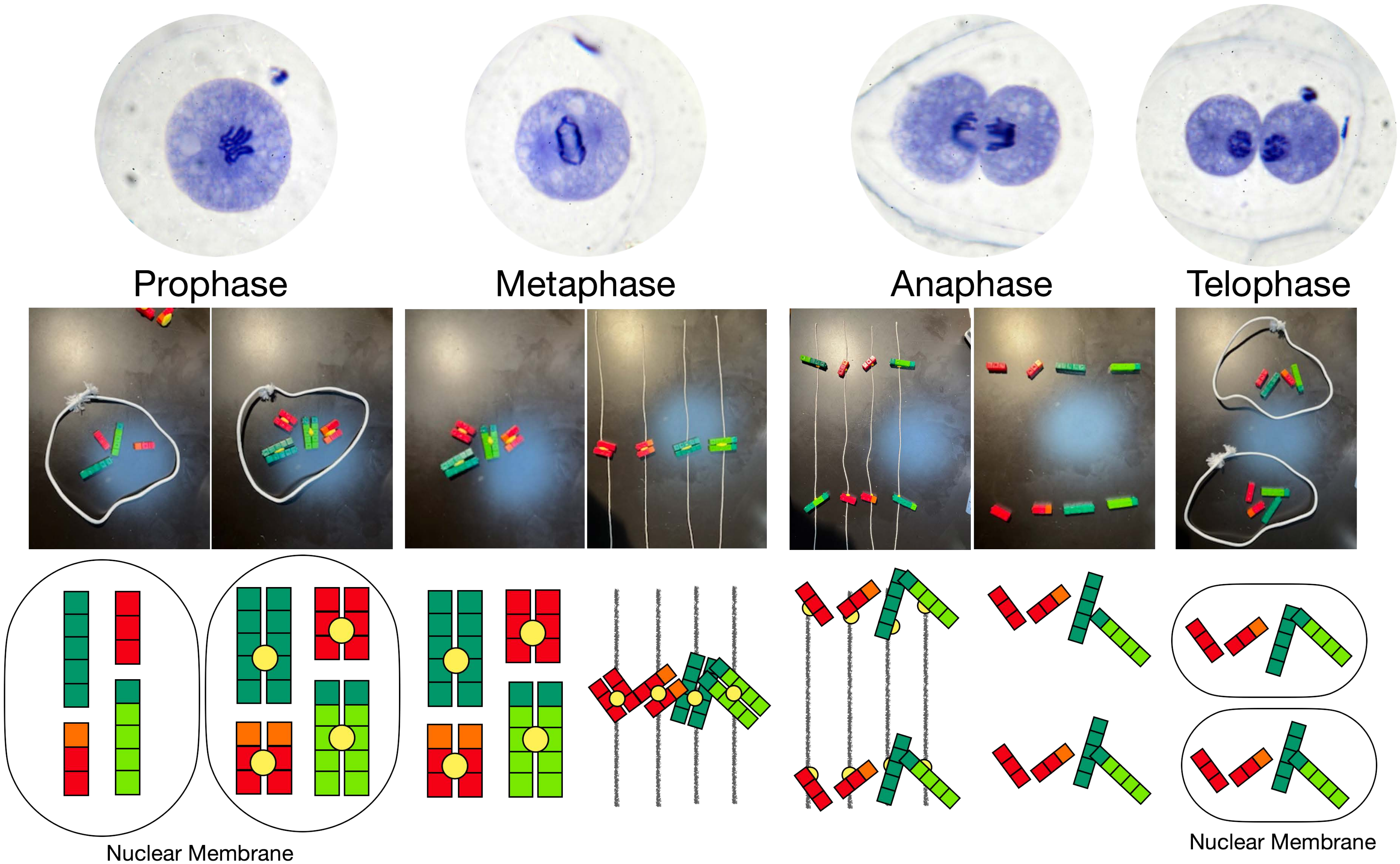


Note: After telophase, cytokinesis completes the process of cell division by physically separating the cytoplasm into two distinct daughter cells. Cytokinesis ensures that each new cell has its own complete set of organelles and cytoplasm, finalizing the mitotic process.

Experiment-Protocol (Continued)

Experiment: Human Chromosomes (Modeling Mitosis, continued)

SUMMARY OF MITOSIS



Conclusion:

1. **Question:** Is it possible to identify a difference between male and female chromosomes through microscopic analysis of human chromosome preparations? Explain what you would look for.

2. **Question:** Think about the first part of the lab activity, where you began modeling the development of a human embryo by creating "7-week-old" example. According to your current background knowledge, do you think that an embryo at this stage would be capable of independent life outside the mother's uterus (womb)? Explain your thinking.

Discussion:

1. **Question:** What are the major differences between asexual and sexual reproduction? In your answer, describe both the advantages and disatvantages of asexual and sexual reproduction. Do humans reproduce asexually or sexually?

2. **Question:** Even though the two chromatids in a chromosome pair are recognizable and can be paired in a karyotype, children generally do not look *exactly* like either their father or mother. Explain why this is so.

3. **Question:** On the other hand, children often do look *similar* to their parents in some respects and also look a bit like their brothers and sisters. Why is this the case?
