FUTURELAB+

BIOMED

Crowdsourcing Innovations in Biotechnology

Mitosis and Meiosis

Developed in partnership with:

Discovery Education and Ignited

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This document is separated into two sections, For Teachers [T] *and* Student Resources [S]*, which can be printed independently.*

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Follow the tips below in the Range field of your Print panel to print single pages or page ranges:

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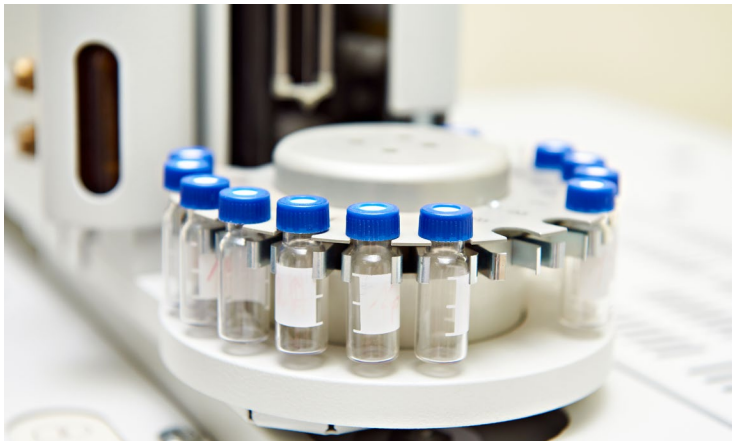


Cover Image
The image shows a cell that has been divided by mitosis.

BIOMED / CROWDSOURCING INNOVATIONS IN BIOTECHNOLOGY

Mitosis and Meiosis

ACTIVITY DURATION

3 class sessions
(45 minutes each)

DRIVING QUESTION

What do scientists look for when using biomarkers to identify diseases?

ESSENTIAL QUESTIONS

How do cells grow and reproduce?

What are the similarities between mitosis and meiosis?

OBJECTIVES

Students will be able to:

Distinguish between mitosis and meiosis.

Develop a claim with supporting evidence including the different types of cellular biomarkers.

Describe the significance of cell cycle regulation in regard to cancer.

OVERVIEW

Cells need to divide for organisms to grow and repair damaged cells. Cell division occurs as a part of the cell cycle. Similar to how we have routines from day to night, cells have routines of their own. Mitosis and meiosis are two kinds of cell division that are essential to most forms of life on Earth. Biomarkers are molecules that indicate normal or abnormal processes taking place in your body. Sometimes, cells divide excessively, resulting in diseases like cancer. Cancer biomarkers help detect the presence of cancer in the body. Biomarkers vary from person to person depending on their age, gender, race, ethnicity, or socioeconomic factors.

In this lesson, students will investigate how cells grow and reproduce through the processes of mitosis and meiosis. The text and activities will increase their understanding of the cell components necessary for an organism to function and the identification of cellular biomarkers.

Materials

- ***How a Vitamin D Test Misdiagnosed African-Americans.***
- **Chart Paper**
- **Cell Division Video Capture Sheet**
- **Mitosis Lab**
- **Meiosis Notes Organizer**
- **Mitosis and Meiosis Venn Diagram**
- **Design Journal**

Pedagogical Framing

Instructional materials are designed to meet national education and industry standards to focus on in-demand skills needed across the full product development life cycle—from molecule to medicine—which will also expose students and educators to the breadth of education and career pathways across biotechnology.

Through this collection, educators are equipped with strategies to engage students from diverse racial, ethnic, and cultural groups, providing them with quality, equitable, and liberating educational experiences that validate and affirm student identity.

Units are designed to be problem-based and focus on workforce skill development to empower students with the knowledge and tools to be the change in reducing health disparities in communities.

SOCIAL-EMOTIONAL LEARNING

In this unit, students discuss whether medical testing should consider differences in race. They must make a case for their opinion on the topic and listen respectfully to students with diverse perspectives. To maintain positive relationships in the classroom setting, students must employ the SEL skill of social awareness.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

Equitable practices allow students to safely discuss sensitive topics like health disparities. This lesson employs the "Raise A Righteous Hand" protocol in order to ask students about their prior knowledge about cancer. This strategy invites students to silently raise their hand if they would like to share and allows students who do not have prior knowledge on a subject (or who are personally impacted by the sensitive nature of the topic) to have their space. To explore the importance of diversity in clinical research, students use the "Placemat" cooperative learning strategy. This technique provides time for internal processors to develop their thoughts before sharing with their group. By finding themes in their responses, students strengthen their sense of community.

ADVANCING INCLUSIVE RESEARCH

In this lesson, students read about the real-life example of a routine Vitamin D test that did not take into account the genetic differences of Black patients. This case study illustrates the importance of diversity when designing clinical instruments. It helps students draw connections back to how biomarkers help scientists and medical professionals personalize individual treatment.

COMPUTATIONAL THINKING PRACTICES

DNA is the body's instruction manual for how to combine proteins into cells. As such, DNA is to our bodies as algorithms are to computer programs. This sentence threw me off. Maybe change to: Through CRISPR technology, scientists can decompose a gene sequence. They can identify a genetic mutation and remove or replace it. This is a representation of the computational thinking strategy of decomposition. Students gain experience with decomposition by breaking down the processes of mitosis and meiosis into stages. They also use the computational thinking strategy of abstraction to complete a Venn diagram that identifies the similarities and differences between mitosis and meiosis.

CONNECTION TO THE PRODUCT LIFE CYCLE

Students consider patient biomarker variation and how to develop a new instrument that can account for less protein-bound Vitamin D. This involves the **discovery** and **development** phases of the product life cycle.

Have you ever wondered…

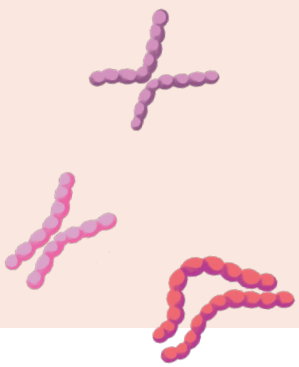
How do scientists or doctors know whether a certain medication or medical intervention is helping a patient?

The use of medications to help alleviate an ailment is not used haphazardly. Doctors monitor patients in order to determine the effectiveness of an intervention. They know whether or not a medicine is working based on evidence of proteins, enzymes, and hormones (*biomarker*) levels returning to normal.

MAKE CONNECTIONS!

How does this connect to the larger unit storyline?

Some diseases or conditions occur during the processes of cells dividing during mitosis or meiosis. By the end of this lesson, students will have identified at least two different biomarkers of a specific disease. Ultimately, this will assist them with designing a wearable device or using available data to prevent and treat diseases.



How does this connect to careers?

Academic researchers use various databases that house peer-reviewed articles, such as PubMed or EBSCO, to locate important information on a certain topic. Information such as data in the form of graphs, tables or even pictures, assist academic researchers with finding evidence to help initiate an experiment or support experimental findings.

Genetic counselors assess individual or family risk of inherited conditions. They need to know how cells grow and reproduce to better understand the conditions. This allows them to provide informed, supportive counseling.

How does this connect to our world?

Wearable devices are utilized for both necessary health and non-necessary health reasons. Watches can collect data on heartbeat, while heart monitors can help a doctor determine whether a patient has an irregular heart rhythm. Scientists are discovering more ways to utilize these devices and the biomarker data that our cells generate. This booming industry requires computer scientists and engineers who can think critically and create devices that can monitor and inform the customer about various health factors. These devices have the potential of saving lives and creating healthier communities.

Day 1

Procedure

LEARNING OUTCOMES

Students will be able to:

Describe the purpose and process of mitosis.

List the steps of a cell's life cycle.

COMPUTATIONAL THINKING IN ACTION

Clinical trials are examples of the computational thinking strategy of collecting data. In the article, students learn how a standard test for Vitamin D deficiency failed to take into account the genetic variances between Black and white patients. This resulted in flawed data collection, which could lead to consequences for patients' health.

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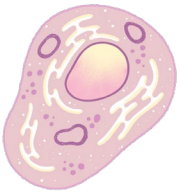
Data are important components in problem-solving. To find the best solutions, it is crucial to design tests that mitigate bias and allow for the collection of the most diverse data possible.



Whole Group (10 minutes)

1 Begin class by having students create an emoji sentence describing what a biomarker is or why it is important in the diagnosis or treatment of patients. Students can use an online free emoji keyboard or write their emoji sentence in their scientific journal. Have students use the Participation Protocol "Whip Around" in order to share their emoji sentence with classmates. Allow students to edit or make adjustments to their emoji sentence, based on peer feedback.

2 Review with students that biomarkers are molecules that indicate normal or abnormal processes taking place in the body. Scientists know that various molecules, such as DNA (genes), proteins, and hormones, can serve as biomarkers. All these molecules indicate something about our health, so biomarkers are used as measurements of health or disease. Biological markers, or biomarkers, vary from person to person depending on their age, gender, race, ethnicity, or socioeconomic factors.

Small Group (35 minutes)

1 Divide students into groups of four to five. Pass out the article, *How a Vitamin D Test Misdiagnosed African-Americans.*

a. Provide each group with a piece of chart paper, and make sure each student has a pen or pencil.

b. Set up a Placemat organizer by asking students to divide the paper into parts based on the number of members in the group, leaving a central square or circle. Also, have each student select a different portion of the organizer as their work area. This is a good SEL skill builder since students have to negotiate space, work together, and synthesize ideas.

c. Students will use the Instructional Strategy: *Placemat*, while reading *How a Vitamin D Test Misdiagnosed African-Americans.* Ask students to consider the question: What are the advantages of medical tests that consider variations in biomarker data? Let students know that one advantage should be short-term, with benefits noticeable in less than five years. The other advantage should be long-term, with benefits noticeable in more than 10 years. Example responses could include short term: increased patient survival rates, early detection of disease, less chance of misdiagnosis, increased number of tests specifically for ethnicities and races. Long term: specific medicines and treatments created based on new tests, decreased number of deaths of a certain traditional ailment, improvement of overall health outcomes, positive

Continues next page >

Day 1

Continued

Procedure

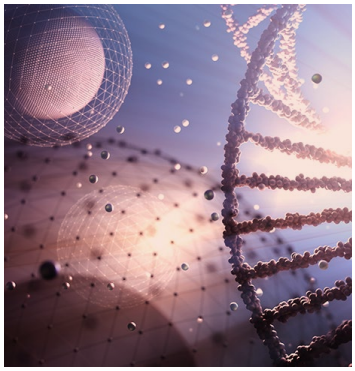
change of attitude towards healthcare for certain ethnicities or races, increased trust between doctors and certain ethnicities or races.

d. After answering the main question, ask students to reflect on the article from a more personal perspective. Have them consider family history and any cultural or personal bias toward medical testing.

e. When students have recorded their own ideas, ask them to share their thoughts in their group and then write the common ideas they all share in the center area of the organizer.

f. After all groups have completed their Placemat, have students do a quick gallery walk to see how their responses differed from other groups.

Teacher Note > *The test that was previously used to evaluate normal levels of Vitamin D was based on a Caucasian standard, resulting in misdiagnosis in African Americans. The test involved a type of Vitamin D that is usually less bound in African Americans compared to Caucasians.*



2 Summarize with students that biomarkers are able to provide a lot of information about our bodies but scientists are continually refining how we use biomarkers to diagnose different ethnicities or races. Remind students that they will be creating a wearable device that will collect data or digital biomarkers to diagnose or treat a patient. They need to consider patient biomarker variation in the creation of their device. Scientists and physicians must consider these implications when they are diagnosing and treating patients.

Teacher Note > *In the next few sessions, students will discover how biomarkers provide information about how bodies are functioning. Biomarkers indicate normal or abnormal processes occurring inside a patient's body. They help determine overall health, underlying conditions, disease, and progression of disease.*

Days 2–3

Procedure

LEARNING OUTCOMES

Students will be able to:

Explain steps of mitosis using root cells as evidence.

Describe the purpose and process of meiosis.

Compare and **contrast** mitosis and meiosis.

Whole Group (15 minutes)

1 Show students the cancer segment (12:15–15:15) of *MIT's Video Lectures*. Before the video, use the CLR Participation Strategy: *Raise a Righteous Hand* to ask students what they know about cancer and how cancer is connected to their prior learning.

Teacher Note > *Answers may include: there are several different types of cancers, some cancers affect certain demographics disportionately, treatment includes radiation and chemotherapy. Be especially mindful of students who may have some personal experience with cancer.*

2 After the video, tell students that today they will discuss a process known as mitosis, which eukaryotic cells normally use to divide. Share that cancer occurs when cells divide excessively. Discuss the levels of organization (cells make up tissues, tissues make up organs, organs make up organ systems, and organ systems make up organisms), and emphasize that cell division is necessary for organisms to grow and repair damaged cells. *Prokaryotic* cells use a process known as *binary fission* to reproduce. Cancer biomarkers indicate a presence of cancer in the body. A biomarker may be a molecule secreted by a tumor or a specific response of the body to the presence of cancer.

3 Introduce the process of mitosis through the *NDSU VCell Production Animation* video. Pause at various portions of the video to describe the steps of mitosis (refer to capture sheet for guidance points).

4 Instruct students to complete *Cell Division Video* capture sheet while watching the video. Remind them to complete the answers to the capture sheet each time the video is paused to ensure the answers are correct. Answers to the capture sheet start 1 minute 30 seconds into the video.

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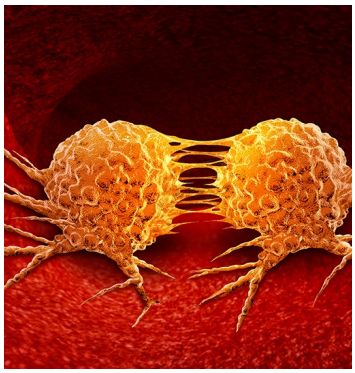
COMPUTATIONAL THINKING IN ACTION

By identifying the stages of mitosis and meiosis, students are using the computational thinking strategy of decomposition. This strategy enhances understanding by breaking complex processes down into smaller, more simple sub-processes.



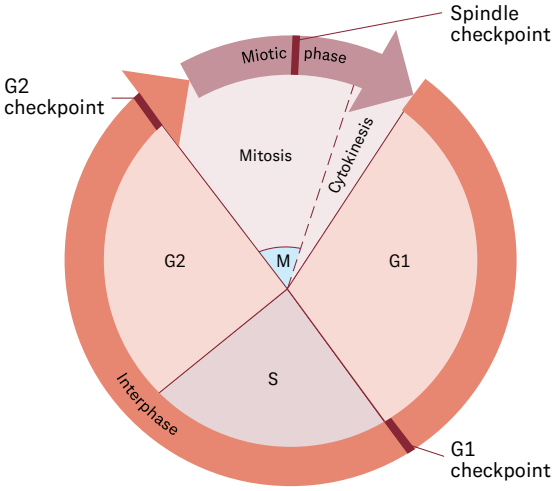
The image shows dividing cancer cell metastasis, (3D illustration).

Days 2–3

Continued

Procedure

5 Conduct a brief discussion with students on cell cycle regulation using the *Cell Cycle Regulation Diagram.* Emphasizing the following points:



a. Cell growth is regulated by various checkpoints throughout a cell's "life".

b. Most of these checkpoints occur during interphase, while one occurs during mitosis.

c. Checkpoints are controlled by different molecules including, **cyclin** and **Cyclin Dependent Kinases (CDKs)**.

d. Molecules such as CDK, cyclin, and other proteins can be used as biomarkers to detect cellular problems, which would relate closely to cancer when discussing cell cycle regulation and mitosis. These molecules are molecules are normal checkpoint regulators that could possibly be used as biomarkers. They are present during normal cell division.

e. A group of these proteins known as tumor suppressor genes, such as p53, can prevent the cell from growing uncontrollably and thus inhibit the formation of tumors.

f. Mutations in these proteins can cause an overgrowth of cells (cancer) or other cellular abnormalities resulting in disease.

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INDUSTRY AND CAREER CONNECTION

Let students know that there are a few steps in the process of mitosis. As a result, the academic researcher soft skill that will be most utilized during the lesson includes having a good attention span. Mention to students that academic researchers are motivated about their particular laboratory research topic. So, another soft skill includes being a motivated learner and having a sense of commitment because additional information will be presented about the connection between mitosis and cancer. The technical skill of maintaining clear records is required while processing different steps in the video. Lastly, when viewing the Cell Cycle Regulation Diagram, students will be practicing the technical skill of analyzing data.

Days 2–3

Continued

Procedure

Individual Work (5 minutes)

1 Conclude class by reminding students that, for their final project, they will be selecting a specific disease to research. Allow students to add to their list and make note of the diseases they are considering for their final project. Provide a list that students can choose from.
For example:

Alzheimers	*Liver disease*	*Cystic fibrosis*	*Salmonella poisoning*
Black spot	*Breast cancer*	*Tuberculosis*	*Rheumatoid arthritis*
Diabetes	*Lyme disease*	*Aster yellow*	*Cardiovascular disease*
HIV	*Lung cancer*	*Kidney disease*	*Carbon monoxide poisoning*

2 Have students consider a disease that may be prevalent in their community or that has been experienced by someone close to them.

3 *Google Scholar* can be used to research information about the disease, including its cause and effect, and related biomarkers

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

Student voice in the selection process allows for more personal engagement in the research project.

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Days 2–3

Continued

Procedure

Whole Group (20 minutes)

Teacher Note > *Prepare in Advance: Setup microscopes around the classroom with prepared slides of onion root tip. Each pair of students can share one microscope..*

1	Let students know that they will be observing mitosis of an onion root tip. Have students choose a partner to work with or assign partners prior to beginning the lab.
2	Distribute the *Mitosis Lab*. Remind students that Interphase occurs when the cell prepares for mitosis and cell division.
3	Direct students to microscopes to observe slides and identify the cells that are in interphase and any stage of mitosis. Instruct students to count the number of cells in each phase and calculate what percent of time cells spend in each phase.
4	Collect data from all groups and add up numbers to get a class total. Consider using a shared document for students to input and view the classroom data.
5	As a class, calculate the percentage of time spent in each stage. Discuss the significance of collecting class data and comparing results.
6	Ask students what conclusion can be reached about which is the longest stage of the cell cycle? Which is the shortest? What is the significance of the amount of time spent in each stage?

Teacher Note > *Be sure to project class data in order for students to capture small and large data sets. This will provide students with the opportunity to practice comparing data sets for consistency, use models to generate and analyze data, and apply concepts of statistics and probability.*

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COMPUTATIONAL THINKING IN ACTION

Cellular reproduction is a biological representation of what algorithms can do. Algorithms are sets of step-by-step instructions that computer programmers use to tell a computer how to complete a task. DNA is the algorithm our cells use as an instruction manual for how to replicate. Sometimes, as in the case of cancer, the algorithm copies itself incorrectly. In order to find the error in the DNA algorithm, scientists use the computational thinking strategy of decomposition. Scientists can now pinpoint, and even fix, genetic mutations present in our DNA.

Days 2–3

Continued

Procedure

Whole Group (10 minutes)

1 Review the purpose of **mitosis** by using the instructional strategy *Snowball Fight*. Students will answer a question silently, on a "snowball" and then launch it into the air at the teacher's request. Students will pick-up a "snowball" that has landed near them, open it, and read the response. This process will be repeated until all questions are answered.

a. Q: What happens to the chromosome number by the end of mitosis?

A: Chromosome number stays the same; for example, each cell in a human has 46 chromosomes at the beginning of mitosis and will have 46 chromosomes in each cell at the end of mitosis.

b. Q: How many cells are there at the end of mitosis?

A: There are 2 cells at the end of mitosis.

c. Q: Which type of cells (prokaryotic or eukaryotic) use mitosis to divide?

A: Eukaryotic cells use mitosis to divide their cells.

2 Inform students that today, they will learn about a process sexually reproducing organisms use to produce more sex cells, also known as gametes.

3 Q: Ask students to explain the purpose of sex cell division.

A: The purpose is to increase the population through sexual reproduction. This occurs through a process known as fertilization, where the sperm and egg fuse together to create a zygote.

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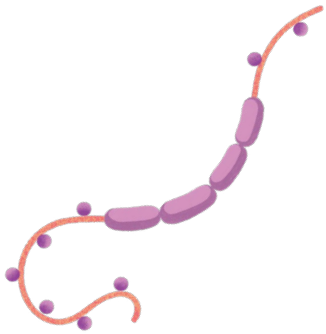
Days 2–3

Continued

Procedure

Small Group (15 minutes):	
1	Divide students into groups of three to four. Allow students to group themselves or group them based on random selection to prevent unconscious bias (modifications could be made as needed for successful learning in small groups, IEP or EL level, etc.). Pass out the *Meiosis Notes Organizer.*
2	Tell students they will be using an *online platform* to investigate the steps in meiosis and to complete the *Meiosis Notes Organizer.* Explain that they may use the transcript of the video OR the slide presentation below the video box to complete their capture sheet, as these are beneficial to learners who need more language support.
3	As students work, walk around answering any questions and gauging for understanding.



Small Group (10 minutes):	
1	Have students complete the *Mitosis and Meiosis Venn Diagram*.
2	Invite students to use their Journal to capture how content learned in this lesson connects to the overarching problem they are investigating. Students should summarize how disruptions in cell division are what biomarkers can help us discover. Disruptions in cell division can tell us about diseases in the body. Have them consider which biomarkers they may want to research for their project.

Teacher Note > *An optional activity or extension for this lesson would be to allow students to create a stop motion animation film showing the stages of mitosis or meiosis. There are various free stop motion animation apps and software that students could use to create their video.*

National Standards

Next Generation Science Standards

LS3.B: Variation of Traits
In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited.

Science and Engineering Practices
Obtaining, Evaluating, and Communicating Information
Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Crosscutting Concepts
Patterns
Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Career and Technical Education (CTE)

A4.4
Explain the basic concepts of cell growth and reproduction, DNA replication, mitosis, meiosis, and protein synthesis.

A5.1
Use the Internet and World Wide Web to collect and share scientific information.

Cell Division Video Capture Sheet

ANSWER KEY **Do not share with students**

Directions
Complete the questions as you view the NDSU VCell Production Animation video.

Most of a cell's life cycle is spent in Interphase.

Interphase is made up of three stages known as: G1, S and G2.

G1 (Gap) Phase:

TG1 is the first growth state of Interphase. The cell grows to nearly full size and performs many of its specific biochemical functions that aid the organism.

S (Synthesis) Phase:

During this phase, the DNA in the nucleus is replicated.

G2 (Gap 2) Phase:

G2 is the second growth phase of Interphase. The cell grows to its full size, preparing it for mitosis.

1st Stage:

Prophase

What happens?

This is where we first see the classic chromosome structure, which occurs through a condensation process.

Protein strands called microtubules appear from the centrosomes in animals.

Nucleolus disappears.

What it looks like:

Answers will vary.

2nd Stage:

Prometaphase

What happens?

This phase begins when the nuclear membrane breaks down.

Microtubule strands, or spindle fibers, are growing from the centrosomes and attaching to a protein structure called the kinetochore. One kinetochore is attached to the centromere of each sister chromatid.

What it looks like:

Answers will vary.

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Cell Division Video Capture Sheet

ANSWER KEY **Do not share with students**

Continued

3rd Stage:

Metaphase

What happens?

Sister chromatids align along the center of the cell so that both chromatids face towards opposite poles of the cell.

Sister chromatids are ready to be separated.

What it looks like:

Answers will vary.

4th Stage:

Anaphase

What happens?

Separating occurs from a shortening of the microtubules attached to the kinetochores.

Additionally, the poles of the cell move further apart causing increased separation of sister chromatids.

At the end of anaphase, the sister chromatids have moved to the two ends of the cell.

What it looks like:

Answers will vary.

5th Stage:

Telophase

What happens?

The components of the new cells begin to appear, a new nuclear membrane surrounds the chromosomes at the end of each cell, and the chromosomes uncoil and return to an uncondensed state.

Spindle fibers are broken up.

What it looks like:

Answers will vary.

What is cytokinesis?

Cytokinesis is the splitting of the cell after mitosis has finished, forming two new cells.

What it looks like:

Answers will vary.

Meiosis Notes Organizer, Part 1

ANSWER KEY **Do not share with students**

Directions
Use the information found on the site to complete the following questions.

Start here: *Virtual Cell Animation—Meiosis*

1. How would you define meiosis in your own words?

Meiosis is the process in which a single cell divides twice to produce four cells containing half the original amount of genetic information.

2. What type of organisms perform meiosis?

Meiosis occurs in all sexually reproducing organisms.

Proceed to the animation of meiosis video. Click on the + sign in order to view the transcription of the audio. Stop the video once it reaches two minutes.

3. How many copies of each chromosome do diploid organisms have? How can you remember this?

Diploid organisms have two copies of each chromosome. The *di-* prefix in diploid means two.

4. What are haploid cells? How are haploid gametes formed?

Haploid cells are cells that only have one copy of each chromosome and are the gametes that could go on to produce an offspring through sexual reproduction. Haploid gametes are formed through meiosis.

5. How are mitosis and meiosis similar?

Both pass through an Interphase, with G1, S, and G2 stages.

6. What happens to the chromosome number in meiosis?

The chromosomes duplicate.

7. How many divisions are included in meiosis?

Two

Meiosis Notes Organizer, Part 3

ANSWER KEY — **Do not share with students**

Directions
Scroll down to "Review the Animation at your own pace" and complete the following questions.

During prophase I, chromosomes condense.

Crossing over also occurs. Crossing over happens when homologous undergoes synapsis then exchange exchange DNA between non-sister chromatids. This exchange is called recombination or crossing over.

Crossing over ensures genetic variation. After crossing over the homologous chromosomes are no longer entirely maternal or paternal but contain mixtures of both.

By the end of prophase I, the nuclear membrane breaks down and the spindle apparatus is being formed.

Metaphase I

Spindle fibers or microtubules attach to each chromosome.

The chromosomes are then aligned at the equator, or metaphase plate, of the cell.

Anaphase I

The homologous chromosomes are pulled apart to opposite ends of the cell.

Sister chromatids remain attached as a pair.

Telophase I

Microtubules break down, nuclear membrane reforms and chromosomes return to an uncondensed state.

By the end of telophase I the cell then divides into two haploid daughter cells via cytokinesis.

Meiosis II

Similar to mitosis except the results are genetically different.

Prophase II

Chromosomes again condense.

Nuclear membrane breaks down.

Spindle apparatus begin to form in each daughter cell.

Metaphase II

Spindle fibers attach to each sister chromatid.

Chromosomes align at the equator of each cell.

(This process involves random orientation.)

Anaphase II

Sister chromatids are separated and pulled to opposite ends of the cells. Each sister chromatid is now considered a chromosome.

Telophase II

The chromosomes uncoil.

New nuclear membranes form.

The spindle fibers are broken down.

The cells are split once again during cytokinesis.

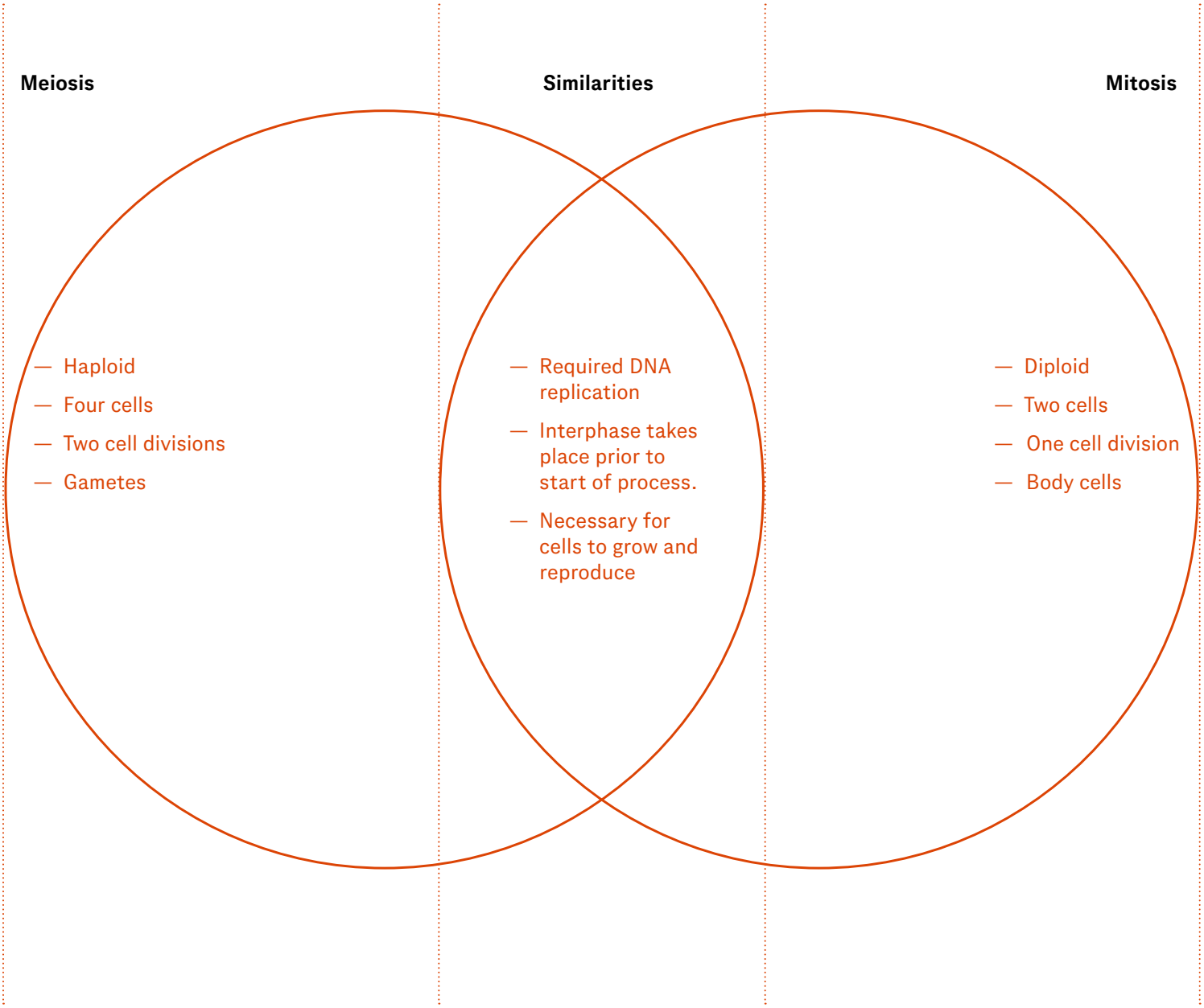
At the end of this stage four new haploid cells or gametes are formed.

Mitosis and Meiosis Venn Diagram

ANSWER KEY — **Do not share with students**

Directions

Compare and contrast meiosis and mitosis using the Venn diagram below. Include at least four differences and three similarities between the two. Be sure to use the following terms: Haploid, Diploid, Gametes, Body Cells.



FUTURELAB+

How A Vitamin D Test Misdiagnosed African-Americans

By: Richard Knox

By the current blood test for vitamin D, most African-Americans are deficient. That can lead to weak bones. So many doctors prescribe supplements to increase patients' levels of vitamin D. But the problem is with the test, not the patients, according to a new study. The vast majority of African-Americans have plenty of the form of vitamin D that counts— the type their cells can readily use. The research resolves a long-standing paradox. "The population in the United States with the best bone health happens to be the African-American population," says Dr. Ravi Thadhani, a professor of medicine at Massachusetts General Hospital and lead author of the study. "But almost 80 percent of these individuals are defined as having vitamin D deficiency. This was perplexing." The origin of this paradox is a fascinating tale of genes interacting with geography. More on that later.

To unravel the mystery, Thadhani and his colleagues looked closely at various forms of vitamin D in the blood of 2,085 Baltimore residents, Black and white. They focused on a form of the vitamin called 25-hydroxyvitamin D (25-hydroxy form), which makes up most of the vitamin circulating in the blood. It is the form that the standard test measures.

The 25-hydroxy form is tightly bound to a protein, and as a result, bone cells, immune cells, and other tissues that need vitamin D cannot take it up. It has to be converted by the kidneys into a form called *1,25-dihydroxyvitamin D*. For Caucasians, blood levels of 25-hydroxyvitamin D are a pretty good proxy for how much of the bioavailable vitamin they have. But not for Blacks.

That is because blacks have only a quarter to a third as much of the binding protein, Thadhani says. So the blood test for the 25-hydroxy form is misleading. His study finds that because of those lower levels of the protein, blacks still have enough of the bioavailable vitamin, which explains why their bones look strong even though the usual blood tests say they shouldn't.

"The conclusion from this study is that just because your total levels are low, it doesn't mean we need to replace vitamin D" using supplements, Thadhani says. The study was published Wednesday in the New England Journal of Medicine.

The reason people of African descent have far less protein-bound vitamin D is probably related to the geographic origins of the human race. Our earliest ancestors lived near the equator in Africa, where sunlight was plentiful and intense year-round. Vitamin D is synthesized in the skin when sunlight strikes it. When sunlight is deficient, the vitamin has to come from dietary sources such as eggs and fish oil. Humans living in sunny climates make plenty of vitamin D on their own. In fact, one reason for the high degree of skin pigmentation in people of African descent is to prevent the synthesis of too much vitamin D, which can be toxic. Early humans did not need to store up reserves of vitamin D, so they did not need as much of the binding protein, whose function is to squirrel the vitamin away in a form where it can be used later. "Everyone who came out of Africa had the ancestral genotype associated with lower vitamin D-binding proteins," Thadhani says. "When humans moved to areas with less sunlight, a different genotype evolved. The farther north they went, the more people needed reserves of vitamin D. So D-binding protein levels went up." And that genetic difference in vitamin D-binding proteins is what researchers have finally figured out.

Dr. Michael Holick, a leading authority on vitamin D at Boston University Medical School, tells *NPR's Health Shots* that the new research is prompting him to resurrect blood samples from earlier studies to figure out whether the ill effects of low vitamin D in African-Americans and Caucasians are related to low levels of the bioavailable form or the protein-bound form. While the effect of vitamin D on bone health is undisputed, Holick says, "there's a lot of controversy about [the vitamin's effect on] hypertension, diabetes, cancer, and infectious diseases."

Meanwhile Holick, who wrote an editorial in the journal accompanying Thadhani's study, intends to keep giving his African-American patients vitamin D supplements when their blood levels of 25-hydroxyvitamin D are low, even though they may not need the pills to maintain strong bones.

"There's no downside to supplementation, so it's not a big deal" Holick says. But Thadhani says doctors should hold off on prescribing vitamin D until they do other tests to determine whether their African-American patients are really vitamin D deficient. Those tests include blood levels of calcium, bone density tests, and parathyroid hormone levels. There is currently no approved test for the bioavailable 1,25-dihydroxyvitamin D, although Thadhani and his colleagues are working on one and have filed for a patent.

He says he used to take vitamin D supplements "until I realized there are genetic differences, then I stopped. I've looked at my bioavailable levels of vitamin D. Now I'm comforted to know that I'm not deficient."

Knox, Richard. "How A Vitamin D Test Misdiagnosed African-Americans." NPR, 20 Nov. 2013.

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Cell Division Video Capture Sheet

Directions
Complete the questions as you view the NDSU VCell Production Animation video.

Most of a cell's life cycle is spent in_____ .

Interphase is made up of three stages known as: G1,

_____ and G2.

G1 (Gap) Phase:

S (Synthesis) Phase:

G2 (Gap 2) Phase:

1st Stage:

What happens?

What it looks like:

2nd Stage:

What happens?

What it looks like:

Continues next page >

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Cell Division Video Capture Sheet

Continued

3rd Stage:

What happens?

What it looks like:

5th Stage:

What happens?

What it looks like:

4th Stage:

What happens?

What it looks like:

What is cytokinesis?

What it looks like:

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Mitosis Lab

In this lab you will use prepared slides of onion root tips to calculate the relative amount of time cells spend in either Interphase (which includes G1, S, and G2) or mitosis. All cells come from preexisting cells. To estimate the relative length of time that a cell spends in the various stages of the cell cycle, you will identify cells in interphase and mitosis. Then you will apply the proportion of cells found in each phase to the percentage of a 24-hour day. In this way, you will infer the percentage of time cells spend in each phase.

Procedure:

1. Observe each cell in one high-power field of view and determine the cell-cycle phase for each cell.
2. Count approximately 100 cells.
   You may need to move the slide to get two fields.
3. Record your data in the table at bottom of the page.
4. Calculate the percentage of cells in each phase and record in the table below.
5. Assume that it takes about 24 hours for onion root tip cells to complete the cell cycle. Calculate the amount of time spent in each phase in minutes.
6. Give your teacher your data to combine into a Class Data set.

Draw and label a pie chart that represents the percentage of cells in each phase of the onion root tip cell cycle:

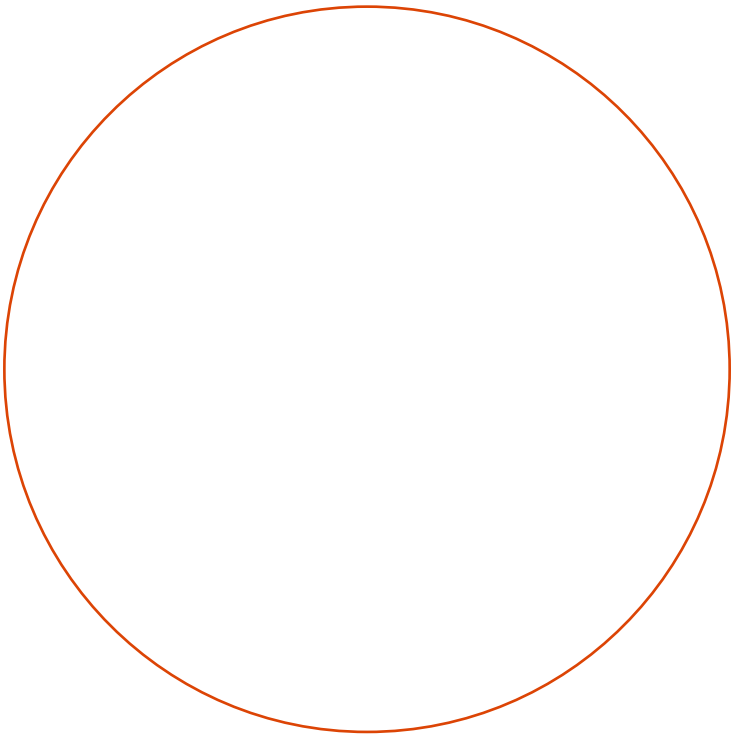

Table for Step 3 data

Phase	Interphase	Mitosis
Number of cells in each phase		
Percent of total cells counted		
Time in each stage		

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Mitosis Lab

Continued

Directions
After completing the pre-readings, the mitosis lab activities, and researching web-based information, answer the following questions.

1. Based on the table and pie chart, what can you infer about the relative amount of time a cell spends in mitosis?

2. What is the significance of using class data instead of individual group data? Did all the groups report consistent data or were there any outliers? What criteria did you use to determine the outlier?

3. Explain the protective significance of chromosomes condensing into tight coils during mitosis.

4. Explain why the nuclear membrane should dissolve during mitosis. What are the consequences for the cell if the nuclear membrane does not dissolve?

5. What is the role of the spindle fibers in mitosis?

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Meiosis Notes Organizer, Part 1

Directions
Use the information found on the site to complete the following questions.

Start here: *Virtual Cell Animation—Meiosis*

1. How would you define meiosis in your own words?

2. What type of organisms perform meiosis?

Proceed to the animation of meiosis video. Click on the + sign in order to view the transcription of the audio. Stop the video once it reaches two minutes.

3. How many copies of each chromosome do diploid organisms have? How can you remember this?

4. What are haploid cells? How are haploid gametes formed?

5. How are mitosis and meiosis similar?

6. What happens to the chromosome number in meiosis?

7. How many divisions are included in meiosis?

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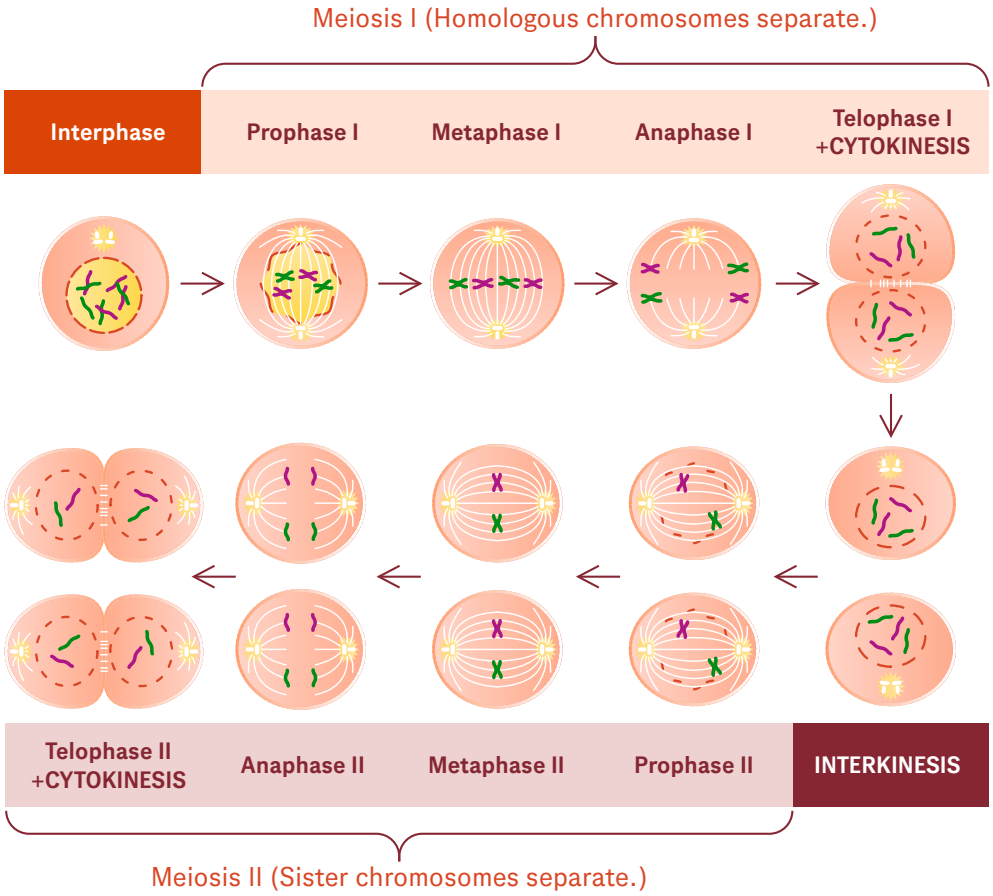
Meiosis Notes Organizer, Part 2

Directions

Write down your observations and critical details as you review the graphic below.



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Meiosis Notes Organizer, Part 3

Directions
Scroll down to "Review the animation at your own pace" and complete the rest of these questions.

During _____ , chromosomes condense.

Crossing over also occurs. Crossing over happens when

homologous _____

exchange _____ .

This exchange is called _____ .

Crossing over ensures genetic variation. After crossing over the homologous chromosomes are no longer entirely maternal or paternal but contain mixtures of both.

By the end of prophase I, the _____

and the _____ are being formed.

Metaphase I

_____ attach to each chromosomes.

The chromosomes are then aligned at the

_____ .

Anaphase I

_____ are pulled apart to

_____ .

_____ remain attached as a pair.

Telophase I

Microtubules _____ , nuclear membrane

reforms and _____ .

By the end of telophase I _____

_____ .

Meiosis II

Similar to mitosis except _____ .

Prophase II

Chromosomes _____ .

Nuclear membrane _____ .

Spindle apparatus _____.

Metaphase II

_____ attach to each sister chromatid.

Chromosomes _____ .

(This process involves random orientation.)

Anaphase II

Sister chromatids _____

_____ . Each sister chromatid is now

considered _____ .

Telophase II

_____ .

_____ .

_____ .

_____ .

At the end of this stage _____

new _____ cells or

_____ are formed.

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Mitosis and Meiosis Venn Diagram

Directions

Compare and contrast meiosis and mitosis using the Venn diagram below. Include at least four differences and three similarities between the two. Be sure to use the following terms: Haploid, Diploid, Gametes, Body Cells.