

Microscopes and Mutants

In this episode viewers explore the early days of genetics as a science. Gregor Mendel's original work is viewed through the colored lenses of hindsight and through the enhanced lenses of microscopes. Microscopy permits clear imagery of the cellular events of mitosis and meiosis. The episode concludes by examining one of the early ethical issues that emerged along with the science of genetics: eugenics.

Lesson Planner

Day 1: View Segment 1
Homework: A Lesson in Elegance: Mitosis
Day 2: View Segment 2
Activity: Splat!
Day 3: View Segment 3
Activity: Mittens & Gloves
Activity: Sneakers
Day 4: View Segments 4, 5, 6, and 7
Journal notes: reflection

SEGMENT ONE: EARLY MICROSCOPY AND THE CELL THEORY

In the opening segment, Mendel's work is summarized and rudimentary microscopy is introduced. Nineteenth-century discoveries in cells and cell theory are examined, including the discovery of chromosomes.

Key Words

chromosomes
selective

Learning Objectives

Students will:

- Identify German pathologist and statesman Rudolf Virchow as the father of Cell Theory.
- Clearly identify the importance of observation in research, using Mendel and his pea experiments as an illustration.
- Articulate the relationship between technology and science, as evidenced by lens development and differential staining of cellular components.

Pre-Viewing Activity

Recap what is known about Gregor Mendel's discoveries. Reinforce that Mendel determined these theories without the benefit of any technology beyond that of farming to raise his peas. Mendel used observation, statistics, and interviews to determine his findings. In this segment we'll see what the introduction of the microscope and staining with dyes meant to the emerging science of genetics.

National Science Education Standards

Content Standard C

The molecular basis of heredity; mutations, cell differentiation.

Viewing Activities

CUE the tape to the beginning of this episode; then START tape. PLAY ► through the opening music and the summary of Mendel's work. When you see the cells multiply from one to four and hear the narrator say, "Then came the realization that a plant or animal grows through the multiplication of its cells," PAUSE ⏸ the tape.

In order to gauge student knowledge, ask students to name this concept and, if they know, who articulated this theory? (Answer: the Cell Theory of Life, by Rudolf Virchow in 1855)

Resume PLAY ►. When you see the pen-and-ink drawing of cells dividing and hear the narrator say, "They also discovered that the threads split and move apart, just before the cell divides into two," PAUSE ⏸ the tape. Ask students to identify the cellular event described in the video. (Answer: mitosis)

Discussion Point

Without the Internet to keep contemporaries Mendel and Virchow in touch with each other, or at least with each other's work, it was nearly a generation before Mendel's work was recognized by the scientific community. How likely is this to happen today?

Post-Viewing Activity

A Lesson in Elegance: Mitosis

Hand out the lab packet for the activity "A Lesson in Elegance: Mitosis" and assign it for homework. This activity will serve to give students a clear outline of the cell cycle and of mitosis in particular.

SEGMENT TWO: MITOSIS

This episode revolves around two major cellular events: meiosis, which only occurs in sex cells; and mitosis, which happens in all other cells. Through animation, illustration, and microscopy, viewers watch the fundamental process involved in mitosis.

Key Words

allele	metaphase
anther	mitosis
centromere	mitotic spindle
chromotid	organelle
filaments	ovule
fuses	pistil
homolog	prophase
interphase	telephase

Learning Objectives

Students will:

- Demonstrate the ability to use differential staining in a lab environment.
- Identify and explain the cellular event mitosis in the context of the cell cycle.
- Identify at least one example of this cellular event not performing properly.

Pre-Viewing Activity

Review homework, inviting students to share their creative expressions of mitosis.

Viewing Activities

CUE tape to last stopping point; PLAY ► the video through the entire animated and microscopy segment on the cellular event of mitosis. When the narrator says, "When the process is complete, there are two daughter cells in place of the single parent cell," PAUSE ⏸ the tape.

To check for student comprehension, REWIND ◀ the tape to the beginning of this viewing segment and turn down the sound. Have students narrate the video as you go along, identifying key words from the list above. PAUSE ⏸ the tape and REWIND ◀ as necessary to ensure student comprehension.

START the tape again, and PLAY ► until you see the imagery of the different number of chromosomes in different species and hear the narrator say, ". . . and that their number differs from species to species. But within each species it stays the same." STOP ■ the tape.

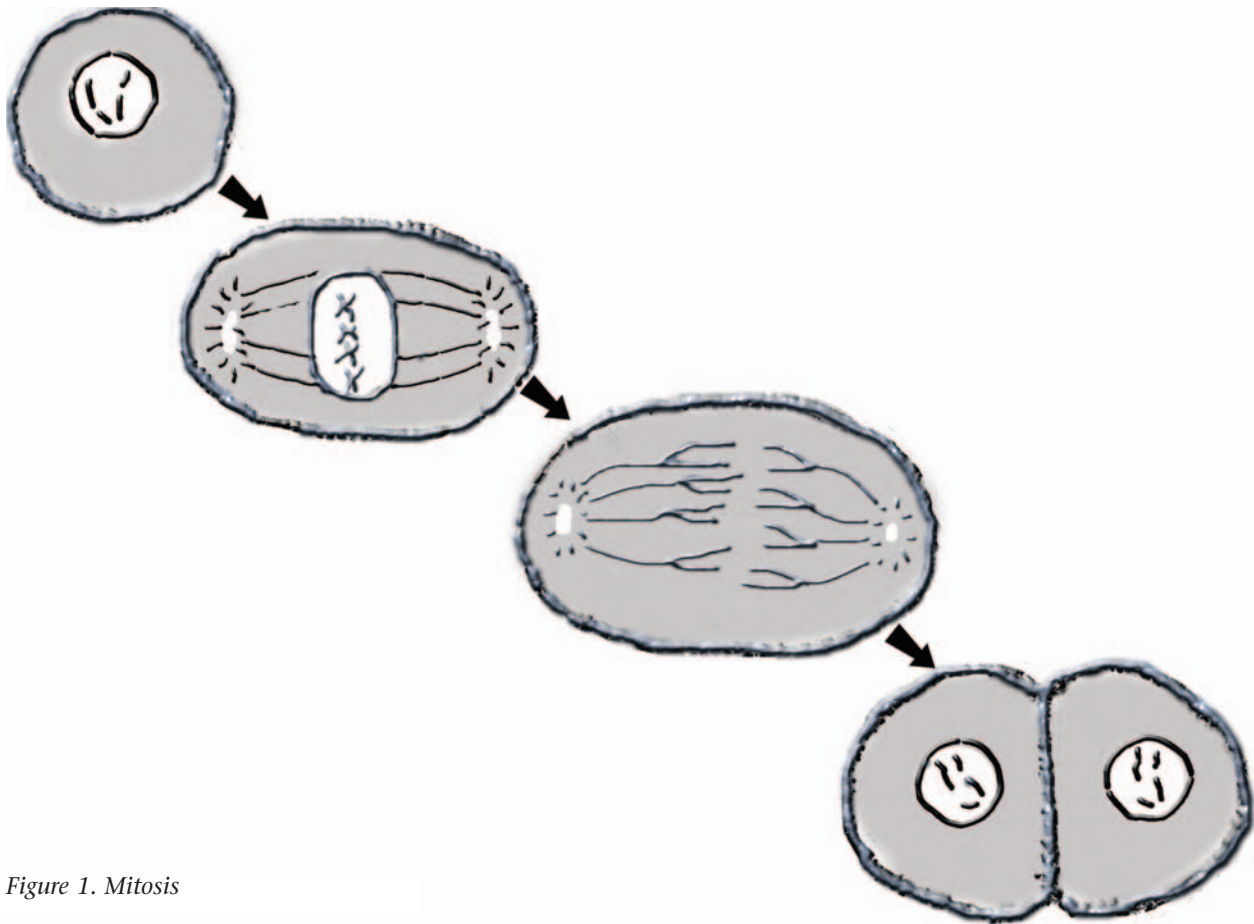


Figure 1. Mitosis

Post-Viewing Activity

Splat!

Conduct the staining and microscopy lab “Splat!” found at the end of this lesson. “Splat!” is an investigation designed to explore what happens when mitosis goes wrong. Cancer cells are used as the medium to foster understanding of the cellular event. Distribute copies of the student lab packet entitled “Splat!” and refer to the teacher lab packet following this lesson.

SEGMENT THREE: MEIOSIS

How do the chromosomes of two parents combine to create the first cell of an offspring? This segment provides a graphic representation of the reduction division, the two-step genetic event called meiosis, how it differs from mitosis, and how the exchange of chromosomes within the germ cells occur during prophase I reproduction.

Key Words

diploid	meiosis
gametes	organism
germ cells	pentadactyl
haploid	polarized
homologous pair	tetrapod
homology	zygote

Learning Objectives

Students will:

- Explain how meiosis differs from mitosis.
- Define and give examples of homology as it relates to cellular biology (and evolution).
- Define and offer metaphors for homologous pairs within the cellular event of meiosis.

Pre-Viewing Activities

Some of the toughest concepts for students to understand are that of homology and the cellular events mitosis and meiosis. Without a solid grasp of homology, other basic and seminal concepts of biology, including segregation,

independent assortment, crossover, heredity, and mitosis and meiosis, may be nearly impossible to understand. This simple pre-viewing activity offers students a physical representation of meiosis and homologous pairs.

Introduce the activity by pointing out that in 1848, scientist Richard Owen first coined the term *homology* to help explain the structural similarities among organisms. It was Owen's contention that certain organisms shared a common plan, or structure. Each species is unique, but constructed based upon similar specifications. Ask students to come up with a metaphor for this concept, or offer this one yourself—the basic similarities between different computers: a laptop and desktop computer use the same operating systems but offer different screens or keyboard options.

Mittens Homology

Materials

- 6–8 pairs of gloves and mittens, all different styles

Have six to eight students come to the front of the room and don a pair of the gloves or mittens and ask them to hold up their hands.

Ask students to define how the gloves/mittens are similar to a pair of chromosomes. Someone may notice that while they are all hand coverings, or perhaps a certain color family, they are all a little bit different. No two pairs are exactly the same. What do they notice? List some similarities and/or differences, such as left and right (which could be metaphors for male and female chromosomes), color, size, etc. Foster a discussion of haploid and diploid, relating to gametes and zygotes.


Summarize what has been observed and check for comprehension.

- 1) Each pair of hand coverings is different from the other pairs.
- 2) Each pair has similarities and similar parts, but is not identical. Make the clear connection


to chromosomes in a diploid cell—don't leave the connection to chance.


Here is a highly simplified explanation: each healthy chromosome will contain the information needed to write the story of each factor. For example, each allele (one from each parent) will be coding for a specific factor such as blood type, hair structure, eye color. Use blood type for a quick example. Mom is blood type BB; Dad is AO. Their child could receive an A blood type antigen from Dad and a B from Mom, making the child's blood type AB. Or, if they received the O from Dad, BO. So though the alleles themselves were different, their jobs were the same: to code blood type.



Viewing Activities

START  the tape exactly where you left off. The opening image is an animation of a child in the womb. The segment voices the question of how the male and female chromosomes are passed and conjoined from father to mother to create germ cells and, ultimately, new life. Meiosis, a cellular event only occurring in the sex cells, is the answer.

Discussion Points

A potential PAUSE  point in this segment is after the animation that uses a genetic tango to illustrate meiosis. Before you move on, be sure students clearly understand the inherent difference in this cell function producing four haploid cells, not two diploid daughter cells.

PAUSE  after the man and woman have presented flowers to each other, and the narrator has said, "Mitosis, on the other hand, takes place in all other tissues." Ask students to recap what they've learned about the differences between the two cellular events, mitosis and meiosis.

PLAY  through the musical segment reviewing pertinent data learned in these two segments. In order to enhance assimilation of information, hand out the song lyrics found at the end of this lesson for students to follow along. STOP  tape.

Post-Viewing Activity

Either break students into small groups, using one pair of tie-style sneakers per group, or have a single pair of sneakers and conduct a large group discussion. Ask students to liken the elements of the sneakers to chromosomes. Ask if they can figure out a way to use the sneakers to illustrate the “genetic tango” described in the video. (Answer: the crossing over of shoelaces)

SEGMENT FOUR: THE BIRTH OF GENETICS

This segment presents historical evidence that the discoverers of meiosis and mitosis knew nothing of Mendel and his theories, nor did Mendel have any idea where his genetic factors resided within human beings. Additionally, the fundamentals of the first gene mapping discoveries at the turn of the twentieth century are touched upon.

Key Words


microscopist
segregate

Learning Objectives

Students will:

- Articulate Mendel’s Law of Segregation.
- Explain that specific genes are located in certain spots on each chromosome.

Viewing Activities

START tape after the music segment is completed. Students will view how Mendel’s research finally came into the public eye and how three European scientists came together, at roughly the same time, with similar theories to Mendel’s. After the animation of Mendel on stage with the curtain showing “Mendel’s factors = genes,” and the screen fades to black, STOP  tape.

Discussion Point

This segment of the video presents a fundamental issue in any kind of research: that of ethics. Ask if students know what intellectual property is. (Answer: ideas, original research, creative notions, and artistic work) A good

follow-up question is: How, if at all, can it be protected?

SEGMENT FIVE: SEX-LINKED INHERITANCE

At the beginning of the twentieth century the X and Y chromosomes were discovered. This segment discusses their significance in the transmission of genetic material.

Key Words

carrier	hemophilia
correlation	mutant
cross-bred	sex-linked inheritance
dynastic	

Learning Objectives



Students will:

- Explain how some genetic inheritance is gender-based.
- Articulate how sex-linked inheritance was discovered.

Pre-Viewing Activity

Distribute color copies of Queen Victoria’s pedigree found on page 11. Give students a few minutes to look over the handout, analyze what they see, and be able to respond with an explanation. This activity will serve to access prior knowledge.

Viewing Activities

CUE tape to where you ended at the last segment. PLAY  through the explanation of the discovery of the X and Y chromosomes. When you see the vignettes of Stevens and Wilson on the screen and hear the narrator say, “Stevens and Wilson had made the first-ever correlation between an inherited trait and a particular chromosome,” PAUSE  the tape.

Discussion Point

Ask students to recap the information from the last segment, allowing several students to contribute to a list of factoids. Record the facts on the board for students to copy as study materials.

PLAY ► the video to learn about the work of Thomas Hunt Morgan’s lab at Columbia University and of the field of gene mapping.

PAUSE ⏸ the tape where the caricature of Morgan is standing with two crossed paintbrushes, forming the X, symbolizing the X chromosome.

Discussion Point

Ask students if they can name any traits or genes that can be passed by sex-linked inheritance. Direct the discussion to the transmission of hemophilia, a disease only passed through the mother’s X chromosome.

PLAY ► the next segment to see an explanation of sex-linked recessive genes.

STOP ■ the tape when you see the image of Queen Victoria and hear her say, “We are not amused.”

Discussion Point

Should people be tested to learn if they are carriers of genetic diseases? Why or why not?

Post-Viewing Activity

Have students take out Queen Victoria’s pedigree once again. Using the pedigree to follow the X-linked trait will help students understand this concept and reinforce its significance.



Figure 2. Queen Victoria’s family suffered from hemophilia, which is associated with the female or X chromosome.

SEGMENT SIX: GENE MAPPING

In this segment scientists determine where, on each chromosome, the directions for life reside. Studies with fruit flies introduce students to the rudiments of gene mapping. A song at the end of this segment recounts the significance of the research.

Key Words

bands	linkages
bar flies	X-linked
gad flies	

Learning Objective

Students will:

- Explain how gene mapping was discovered.

Viewing Activities

START the segment, immediately following the clip on Queen Victoria. The genetic tango will be revisited, offering an explanation of how mutations are transferred within germ cells.

PAUSE ⏸ after the animation of the genetic tango related to mutations, to check student comprehension.

PLAY ► through the entire segment on gene mapping. This is a solid introduction to the history and science of the transfer of genetic material.

Discussion Point

Gene mapping offers tremendous opportunities for manipulation of genetic material. Ask students if they believe this practice will become commonplace? Ask students if they are aware of how much manipulation is happening already in labs around the world?

PLAY ► through the musical segment reviewing pertinent data learned in these two segments. In order to enhance assimilation of information, hand out the song lyrics for students to follow along.

Mitosis and Meiosis

www.biologyinmotion.com/cell_division

Dr. Saul's Biology in Motion Web site offers a cell-division exercise in which students can drag and drop chromosomes to demonstrate knowledge of the difference between mitosis and meiosis.

The Cell Cycle and Mitosis Tutorial

www.biology.arizona.edu/cell_bio/tutorials/cell_cycle/main.html

The Biology Project, from the Department of Biochemistry and Molecular Biophysics of the University of Arizona, sponsors this tutorial in cell biology.

Mitosis and Meiosis Internet Lesson

www.biologycorner.com/worksheets/mitomeo.html

From the Biology Corner, a resource site for biology and science teachers, this Internet lesson allows students to review the steps of mitosis and meiosis and view video simulations of cell division.

The Eugenics Archive

www.eugenicsarchive.org

This Web site is the eugenics site affiliated with the Dolan DNA Learning Center, Cold Spring Harbor Laboratory on Long Island, NY, where much of the repository of data on eugenics is stored. The site is comprehensive, offering historical data, images, and anecdotal history of this period of human scientific development.

Cross-Curricular Activity

Global Studies

Using the Web page Hemophilia: The Royal Disease, at www.sciencecases.org/hemo/hemo.asp, have students read and complete the provided Case Study, an effective tool for explaining sex-linked inheritance. (Note: A copy of the PDF as shown on the Web site is made available FOR TEACHER REFERENCE ONLY.)

This site is sponsored by the National Center for Case Study Teaching in Science.

MICROSCOPE SONG

If it's the secrets of life that you seek, then
Through a microscope you must peek.

Mendel did wonders just using his eye, but
To really see, you must magnify.

You can't help but notice we're nothing but
cells,
But where in the cell, does heredity dwell?

The nucleus, that's where it hides.

You don't see much, until it divides,
Then chromosomes enter new phases,
Split into two. And that is the basis, of
Sexual transmission which always engrosses
Our feverish minds, but it's only meiosis
Reducing the chromosomes fifty percent,
So when egg and sperm meet at that blessed
event,
Their chromosomes form one full set
Just two of each kind, that's the best bet.

And that new cell begins to grow,
Multiplies into an embryo.



The explanation of this growth is
It's due to a process we know as mitosis.

And that's what our microscopes helped us
determine,
In Germany, where all the germ cells are
German.

FRUIT FLIES SONG

Bizzzzzz, bizzzzzzzz

We are the fruit flies that Morgan kept in jars.
He won the Nobel Prize but we're the real stars.

Check out the chromosomes in our saliva
glands.
They're awfully hunky and they have such
gorgeous bands.

Oh he'd be nowhere without our quick birth
rate,
Or the way we strut our stuff when we mutate.

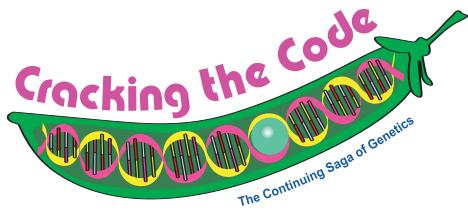
Then the color of our eyes becomes distinct.
That's how we showed him that a trait can be
X-linked.

We know we're just insects, we can't match
their intellects,
But we're superior to them at sex.



We're fruit flies, not bar flies, not gad flies,
please realize.
We're the ones that helped them get so wise.

Bizzzzzz, bizzzzzzzz



Microscopes and Mutants

A LESSON IN ELEGANCE: MITOSIS

Nucleated cells must prepare for the big event, mitosis. Part of that preparation involves duplication of DNA, the master genetic code molecule. Still more preparation includes the assembling of other cellular materials involved with mitosis. Replication of chromosomes can only occur if the DNA is first duplicated. New cells will require other materials such as organelles, the proper enzymes for metabolic pathways to function, and a host of other baggage. There must be choreography of events, checkpoints, craftsmen to handle the complexity of these events, and time. Just who are these craftsmen—and what are the events that are occurring? To answer these questions we turn to something called the cell cycle (see Figure 1 below).

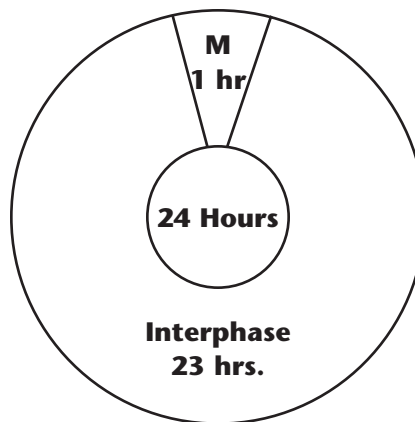


Figure 1. This plant cell cycle has duration of 24 hours. Twenty-three of those hours are spent ensuring that each new daughter cell will have a complete set of chromosomes and cytoplasmic essentials. The stages of mitosis and cytoplasmic splitting take up the other hour. Cells vary greatly in total cell cycle duration and in the total time spent in each segment of the M (mitosis) phase. DNA synthesis occurs during interphase, as does the manufacturing of organelles and essential proteins.

Interphase is the period of time between two successive cell divisions. About 90% of a cell's time frame is spent in interphase. Biochemical activity is very high during this period, and the time is broken up into three distinct chapters. The first is known as the G1 phase, or first gap. This precedes DNA synthesis. The cell is increasing its mass, getting bigger and carrying out normal metabolic functions such as manufacturing lipids, carbohydrates, and proteins. Chapter two is the S (synthesis) phase where DNA is synthesized and each chromosome homolog replicates, so each homolog consists of two sister chromatids (see Figure 2). The cell continues to metabolize, making more proteins and growing. The third phase, G2, or second gap, is after DNA synthesis and just before prophase of mitosis. In this phase, proteins are made and the cell continues to grow in size. Organelles are made during the interphase period of time as well.

Once the chromosomes have replicated and the G2 phase is complete, mitosis begins. Mitosis is the process by which a cell ensures that each daughter cell will have a complete set of chromosomes. There are key stages of mitosis. During **prophase**, the chromosomes become condensed and key proteins begin to bind the hooks (kinetochores in centromere region) that will attach the chromosomes to spindle fibers. The nuclear membrane breaks down, the mitotic spindle is formed, and the chromosomes attach to microtubules in the spindle via their hooks. Once attached, the chromosomes start to align along the metaphase plate (equator) in the center of the spindle. During **metaphase**, all of the chromosomes are attached to microtubules via their hooks and are aligned at the metaphase plate. At the beginning of **anaphase**, the sister chromatids (see Figure 3) separate and are moved toward the poles of the spindle. During **telephase**, the mother cell is physically divided into two daughter cells by a process called cytokinesis or cytoplasmic splitting. A cell is not technically split into two new daughter cells until this event occurs.

Interphase

Cell arranges for division by:

- replicating DNA and making organelles
- increasing cell size

Mitosis

Cell prepares for nuclear division by:

- condensing DNA into movable parcels called chromosomes

Cell prepares chromosomes for division by:

- aligning chromosomes at cell equator
- attaching spindle fibers from each new daughter cell pole to each chromosome at the centromere where the “hook” assists

Chromosomes divide:

- spindle fibers pull chromosomes apart
- one-half of each chromosome (chromatid) moves to a new daughter cell

Cytoplasm divides:

- DNA decondenses and two new nuclei form
- new cell wall (cell plate in plant cells) appears between the two nuclei to form two new daughter cells
- animal cells pinch in the outer cell membrane to form two individual cells

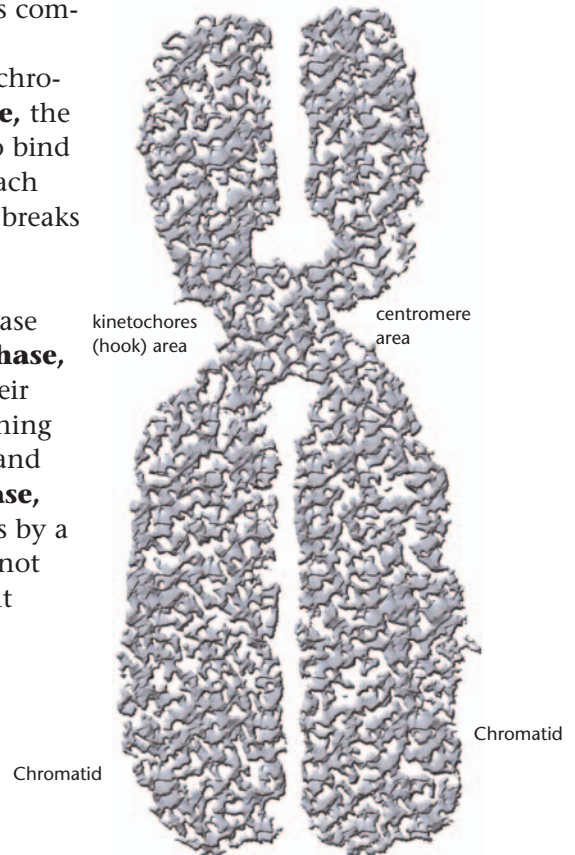


Figure 2. A single replicated chromosome with sister chromatids and centromere highlighted provides visualization of the genetic material that will be passed to daughter cells during mitosis.

Appealing to your Creative Nature . . .

Your task at this point is to create an account from the perspective of a cell or one of its components. In other words, you *are* the cell or component. It is your big moment in life and you're going to divide! Below are a few ideas to help *put you in the mood*.

- Imagine that you are one of the characters of a mitosis screenplay. . . . **or**
- Write a letter to a friend from the perspective of describing:
 1. Who you are.
 2. How and why you got to the mitosis event.
 3. What happened to you (specific biological events) during your time spent in mitosis. . . . **or**
- Create a travel brochure promoting the adventure of mitosis. . . . **or**
- You are a rock group called "Mitosis" and are releasing your first big album. Create some song titles and an album cover depicting the important events in mitosis. . . . **or**
- Produce a TV commercial based on mitosis. . . . **or**
- Choose your own way of sharing what you know.

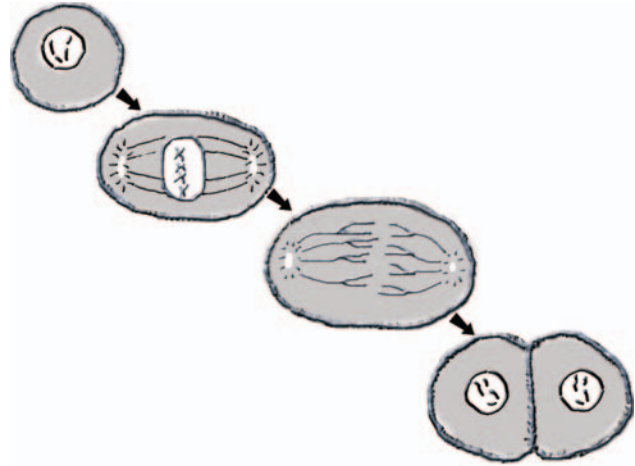


Figure 3. Depicts key events in the process of mitosis. The same chromosome number is retained from generation to generation. Each daughter cell receives an exact copy (clone) of the chromosomes of the parent cell.

Before you make a choice of how to tell your story, visit the following Web sites for visualization of interphase and mitosis.

Links

The Cell Cycle: An Interactive Animation

www.cellsalive.com/cell_cycle.htm

CELLS Alive! Web site © Quill Graphics

Animal Cell Mitosis: An Interactive Animation

www.cellsalive.com/mitosis.htm

CELLS Alive! Web site © Quill Graphics

Tour of the Basics

<http://gslc.genetics.utah.edu/units/basics/tour>

Genetic Science Learning Center Web site of the Eccles Institute of Human Genetics, University of Utah

Reproduction Links

www.lewport.wnyric.org/jwanamaker/links/links_reproduction.htm

(Lew-Port's Biology Place, created and maintained by Mr. James Wanamaker, a biology teacher at Lewiston-Porter High School in Youngstown, NY)

A Lesson in Elegance: Mitosis Rubric for Assessment

	Acceptable	Good	Exceptional
DESIGN 50 points	At least 3 terms are used in a proper context and most of the steps of mitosis are represented in the correct order. 40 pts.	At least 4 terms are used in a proper context and all of the steps of mitosis are represented in the correct order. 45 pts.	All mitosis terms are used in proper context and in proper order with detail to demonstrate student mastery of the process of mitosis. 50 pts.
EXPLANATION 30 points	Plausible with fewer than 3 errors in representing the process of mitosis. 20 pts.	Plausible idea shows some thought went into the assignment. No errors or omissions in representing the process of mitosis. 25 pts.	A plausible explanation that demonstrates the student understands the process of mitosis in detail and can represent the process using analogies in a way that makes it clear and interesting. 30 pts.
STYLE Creativity and writing style. 20 points	Some creativity. 11 pts. Sentences have good structure. 2 pts. 3–5 spelling errors. 1 pt.	More creativity showing student thought about the assignment. 12 pts. Well-organized sentences and paragraphs. 3 pts. 1–2 spelling errors. 2 pts.	Great creativity shows mastery, thoughtfulness, and research into the assignment. 13 pts. Stylish and well-written sentences and paragraphs. 4 pts. No spelling errors. 3 pts.

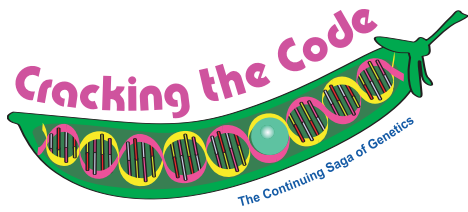
Student name: _____

DESIGN score _____

EXPLANATION score _____

STYLE score _____

TOTAL SCORE: _____



Microscopes and Mutants

SPLAT!

Student Notes

Visualize yourself standing on a chair, your Pasteur pipette armed and ready to unload; your eye is over the target, your adrenalin is coursing. Ready, set, go!

Success! You have achieved your goal. The cells are “splatted” on the awaiting microscope slide. Now it’s time to stain, dry, and view them. You will need **patience** and **perseverance** as you hunt for a chromosomal squash that is worthy of your efforts.

What is this all about, you ask? Sit back and let me tell you a story.

Most of you are at least familiar with the term *mitosis*. It is a nuclear event and involves chromosomes. If mitosis does not follow carefully choreographed steps and a strictly adhered to time frame of start and stop, then cells may experience uncontrolled cellular division, or cancer. If the cells do not respond to signals to stop dividing, then they may change in chromosome number and even kinds of chromosomes. The new cells may even break free from their matrix and grow aggressively in other areas of the organism. Again, we call this cancer. In this laboratory experience, we will study conditions found when mitosis breaks the rules. On to our story . . .

Once upon a time, there was a lady named Henrietta Lacks. She had cancer and died in 1951. The cells that you will be working with in this learning experience are her cells. Henrietta was 31 years old when she died, but given the right environment, her cells live on. Why? A physician at Johns Hopkins University, Dr. George Gey, made a very important discovery.

He and his wife, Margaret, had been searching for a tool for the study of cancer: a line of human cells that would live indefinitely outside the body. If they succeeded, they could observe and test human cells in ways they could never do in humans. Eventually, they could discover the cure for cancer. They were sure of it. After two decades of failure in their laboratory attempts, the Geys turned their attention to cervical cells. Johns Hopkins had kept a tissue sample of Henrietta Lacks’ tumor. Henrietta Lacks’ cells multiplied like nothing anyone had seen. They latched to the sides of test tubes, consumed the medium around them, and within days, the thin film of cells grew thicker and thicker. Using special nutrients and careful techniques, cells can be grown in tissue culture. Normal cells have a finite number of divisions and after around 50 such divisions they no longer divide and eventually die. Cancer cells, however, have no restrictions on the number of divisions and if properly maintained are immortal. George Gey gave the name HeLa cells to the cell line established from Henrietta Lacks’ tumor. He stated, “It is possible that, from a fundamental study such as this, we will be able to learn a way by which cancer can be completely wiped out” (Skloot, 2000).

Packaged in small tubes tucked in plastic foam containers, with careful instructions for feeding and handling, shipments of Henrietta's cells went out to Gey's colleagues around the world . . . to Minnesota, New York, Chile, Russia . . . the list goes on. Researchers welcomed the gifts, allowing HeLa cells to grow. They used the cells to search for a leukemia cure and the cause of cancer, to study viral growth, protein synthesis, genetic control mechanisms, and the unknown effects of drugs and radiation. And though Henrietta never traveled farther than from Virginia to Baltimore, her cells travelled the globe and even multiplied in a space shuttle far above the earth (Skloot, 2000).

Today, you too will join the ranks of thousands of scientists and students who have worked with these special cells. Here is just a short bit of science information you need to start the experience. Normal cells die within a few weeks even under the most ideal laboratory conditions. As stated earlier, Henrietta Lacks' cells (HeLa cells) are able to reproduce themselves and are often referred to as being immortal. Over the past 45 years, research on HeLa cells has provided scientists with an enormous amount of basic knowledge about the physiology and genetics of cells. However, HeLa cells have been responsible for generating a great deal of bogus scientific data as well. It turns out that HeLa cells grow very aggressively in culture and can easily invade other cell cultures during routine lab transfer procedures, when proper precautions are not taken. As a result, numerous research papers have been published on the biology of a variety of cultured cell types which have subsequently been shown to be HeLa cells (Cavanagh, 1997). "Henrietta Lacks' cells were so powerful that if just one cell dropped into another petrie dish or if one was blown across the laboratory they would grow so aggressively that the host was smothered, turning normal cells cancerous" (Schneider, 2000).

Karyotype (chromosome) analysis of HeLa cells from different repositories (labs) around the world shows that different strains of HeLa cells are now very different from each other, probably due to the malignant nature of the cells and differences in culture conditions in different laboratories over the decades since this cell culture was established. Although HeLa cells provided a substantial foundation for today's knowledge of cell physiology, most analysis of cell structure and function in culture is now performed with non-transformed (not malignant) cells (Cavanagh, 1997).

Today *you* will be doing a karyotype. Here are the materials you will need:

- a tube of dead cell suspension (HeLa cells in solution). The solution contains acetic acid (vinegar) and methanol. NOTE: You cannot get cancer from these. They are not contagious, they are all dead. There is absolutely no disease hazard involved in the use of these prepared cells.
- stain #1 and Stain #2 (Be very careful to avoid contact with your skin or clothing.)
- rubber gloves and protective eye gear
- a microscope
- printed instruction packet from your instructor (This includes all background information, questions to be answered, and explanations of procedures.)
- a handheld counter, if available
- mounting medium (permount), optional
- an eyedropper or Pasteur pipette or microliter pippetor
- glass slides and coverslips
- staining jar or beaker (250 mL)
- distilled water
- paper towels

During this laboratory experience be sure to:

- Take notes explaining each step and what you observe in each spread.
- Prepare and use a table to record the number of chromosomes in each spread.
- Use a microscope to locate and count chromosomes; note the power of magnification used.

For assistance in visualizing the material to be successful in this endeavor, review the photos below. To be successful in your learning experience, please read the packet of written instructions provided with the HeLa cell kit prior to and during your tasks.

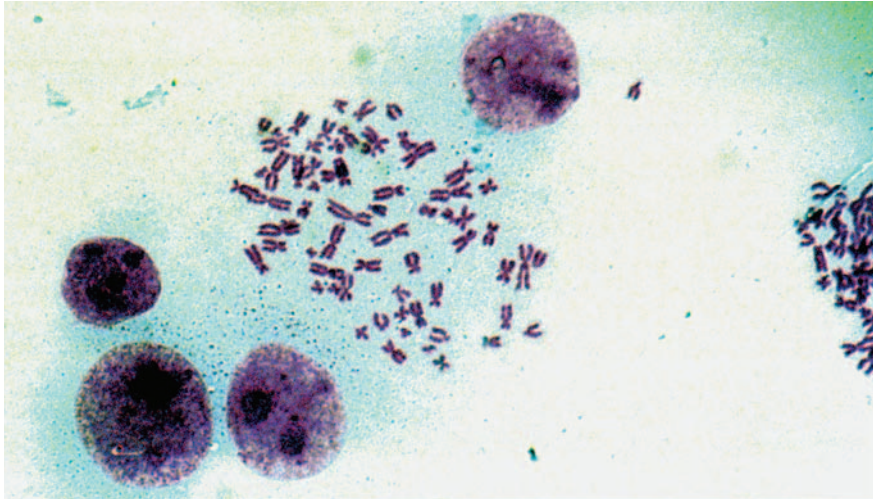


Figure 1. Chromosome spread of cancer cell (HeLa). Sister chromatids and centromere locations are evident. (Permission granted from Mark Nardonne, nardonem@mail.nih.gov)

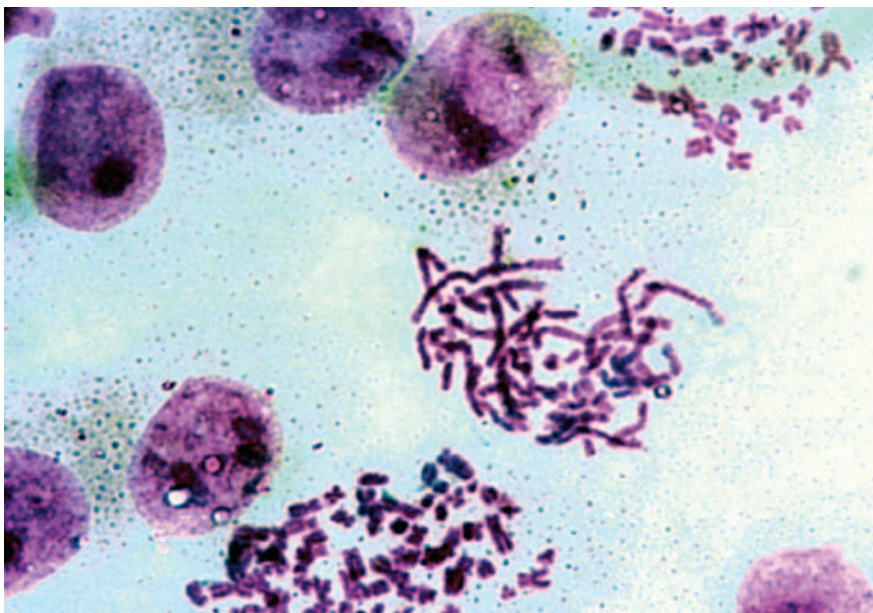


Figure 2. HeLa, a human cancer cell. View shows three degrees of chromosome condensation. Degree of condensation of metaphase chromosomes varies with the amount of time the metaphase cell has been in a substance that halts normal mitosis at the metaphase stage. (Permission granted from Mark Nardonne, nardonem@mail.nih.gov)

Links

Where Can I Find Out More About HeLa Cells?

www.madsci.org/posts/archives/may97/860431113.Cb.r.html

MadSci Network: Cell Biology, T. Cavanagh (1997).

The Body as a Biomedical Resource

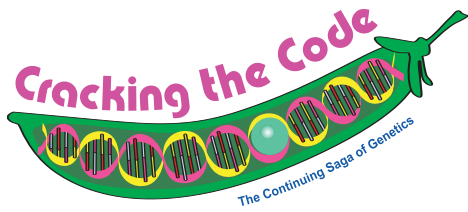
www.vifu.de/new/os/1509_schneider.html

I. Schneider lecture presented at Virtual Independent Women's University's open space (2000).

Henrietta's Dance

www.jhu.edu/~jhumag/0400web/01.html

Johns Hopkins Magazine, R. Skloot (2000).



Microscopes and Mutants

SPLAT!

Teacher Notes

Review the student lab packet. Make copies for each student or group. This learning experience is designed to provide students with a glimpse into biotechnology and why the study of mitosis has value. The learning experience focuses on cells that are not normal but instead are the result of mitosis gone awry: cancer. The materials needed for the activity are, for the most part, easily obtained in a science classroom. The one thing necessary for purchase is the kit of HeLa cells. Students will improve their staining technique and microscope skills, and will also experience real science when looking for and counting chromosomes in a field of view.

Using the CellServ kit allows students to prepare a chromosome spread with human cells. The enthusiasm felt as students “splat” the cells and hunt for their chromosome spreads is definitely picture-worthy—so try to have a digital camera ready for photographing. The manual provided by CellServ gives all the information necessary to make this a memorable learning experience. You might want to encourage your students to be creative in their splatting techniques. (One of your authors has actually stood on a lab bench while “splatting.”) It is also recommended that the long-bore Pasteur pipette be used, as it seems to give more control. However, any dispenser listed under student materials will work well. If you are able to provide handheld counters for your students, it would be very beneficial, but these items are not usually found in a typical classroom. As scientific kits go, the authors recommend this one with four stars ****: CellServ Kit #4 is the one used in this learning experience. For ordering information, see www.cellservkits.com/NewFiles/Kit4.html.

CellServ is sponsored by the Foundation for Advanced Education in the Sciences, Inc., at the National Institutes of Health in Bethesda, Maryland. It provides “preparation of human chromosome spreads suitable for introductory biology, genetics, cytogenetics, cell biology, and oncology courses.” NIH has been affiliated with this project from the beginning. Instructions are straightforward and easily followed by students. The kit includes printed background and procedural information, a glossary of terms, references, and further readings. Class time needed is 40–60 minutes.

The CellServ Kits offer practical student hands-on experience in

- examining a variety of cell types and experimental conditions used in research protocols; and
- making permanent slides.