

Course Learning Outcomes for Unit II

Upon completion of this unit, students should be able to:

1. Define the basic concepts of biological sciences.
 - 1.1 Recognize risk factors for cancer.
 - 1.2 Identify what happens during the phases of mitosis and meiosis.
4. Explain Mendel's approach to studying genetics.
 - 4.1 Discuss dominant alleles and recessive alleles.
 - 4.2 Recall that chromosomes come in pairs and carry traits that are inherited by offspring.
 - 4.3 Discuss Mendel's law of independent assortment.
8. Interpret biological data.
 - 8.1 Record flower color genotypes.
 - 8.2 Delineate a Punnett square.

Course/Unit Learning Outcomes	Learning Activity
1.1	Unit Lesson Chapter 6 Unit II Assignment
1.2	Unit Lesson Chapter 6 Chapter 7 Video: <i>Meiosis, Zygotes, and Mutations</i> Unit II Assessment
4.1	Chapter 8 Video: <i>DNA and Inheritance: Heredity</i> Unit II Assignment
4.2	Unit Lesson Chapter 8 Video: <i>DNA and Inheritance: Heredity</i> Video: <i>Mendel, DNA, Genes, and Chromosomes</i> Video: <i>Meiosis, Zygotes, and Mutations</i> Unit II Assignment
4.3	Unit Lesson Chapter 8 Video: <i>DNA and Inheritance: Heredity</i> Unit II Assignment
8.1	Unit Lesson Chapter 8 Video: <i>DNA and Inheritance: Heredity</i> Unit II Assignment
8.2	Unit Lesson Chapter 8 Video: <i>DNA and Inheritance: Heredity</i> Video: <i>Mendel, DNA, Genes, and Chromosomes</i> Unit II Assignment

Required Unit Resources

Chapter 6: Cancer

Chapter 7: Fertility, pp. 124–130

Chapter 8: Does Testing Save Lives?

Cambridge Educational. (2005). [Mendel, DNA, genes, and chromosomes \(Segment 3 of 5\) \[Video file\]](https://libraryresources.columbiasouthern.edu/login?auth=CAS&url=https://fod.infobase.com/PortalPlayer/aylists.aspx?wID=273866&xtid=33836&luid=20017). Retrieved from <https://libraryresources.columbiasouthern.edu/login?auth=CAS&url=https://fod.infobase.com/PortalPlayer/aylists.aspx?wID=273866&xtid=33836&luid=20017>

[A transcript of this video segment is available.](#)

Cambridge Educational. (2005). [Meiosis, zygotes, and mutations \(Segment 4 of 5\) \[Video file\]](https://libraryresources.columbiasouthern.edu/login?auth=CAS&url=https://fod.infobase.com/PortalPlayer/aylists.aspx?wID=273866&xtid=33836&luid=20018). Retrieved from <https://libraryresources.columbiasouthern.edu/login?auth=CAS&url=https://fod.infobase.com/PortalPlayer/aylists.aspx?wID=273866&xtid=33836&luid=20018>

[A transcript of this video segment is available.](#)

Video Education America. (2016). [DNA and inheritance: Heredity \[Video file\]](http://fod.infobase.com/libraryresources.columbiasouthern.edu/p_ViewVideo.aspx?xtid=129089&tScript=0). Retrieved from http://fod.infobase.com/libraryresources.columbiasouthern.edu/p_ViewVideo.aspx?xtid=129089&tScript=0

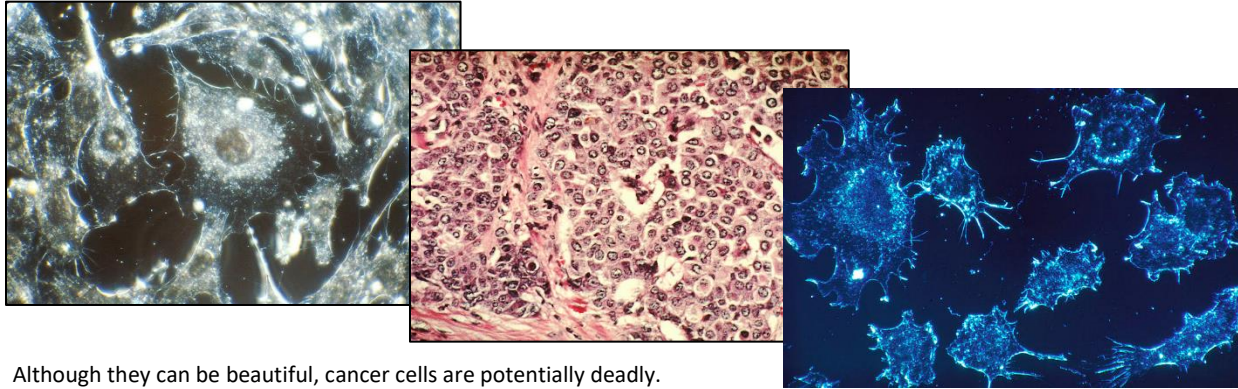
[A transcript of this video is available.](#)

Unit Lesson

How do humans and other organisms grow, repair themselves, and maintain their health? Why does our skin grow back when damaged while nervous tissue, cardiac tissue, and other tissues do not? How can a starfish regenerate a lost appendage? How do bacteria multiply so quickly? Why do we look different from our siblings when we have the same parents? Why do some people develop cancer and others do not?

These are all questions that can be answered using information about cell reproduction, genetics, and cancer. In this unit, you will learn how cells divide, how information is passed, and how you can reduce your chances of developing cancer. This is an exciting unit because you will develop an understanding of why you have the characteristics that you possess.

Almost 600,000 people die each year in the United States from cancer (National Cancer Institute, n.d.-b). It is the second-highest cause of death in the United States—the first is heart disease. Statistically speaking, a person has about a one-in-four chance of developing some form of cancer within his or her lifetime (National Cancer Institute, n.d.-b). That one-in-four chance may increase or decrease depending upon numerous factors, most of which are derived from lifestyle choices. It is important that you understand more about cancer because the likelihood that you or someone you love will develop cancer is somewhat high. In previous years, cancer was a death sentence; however, through years of research, scientists now understand the disease better and can treat or cure some forms of cancer.

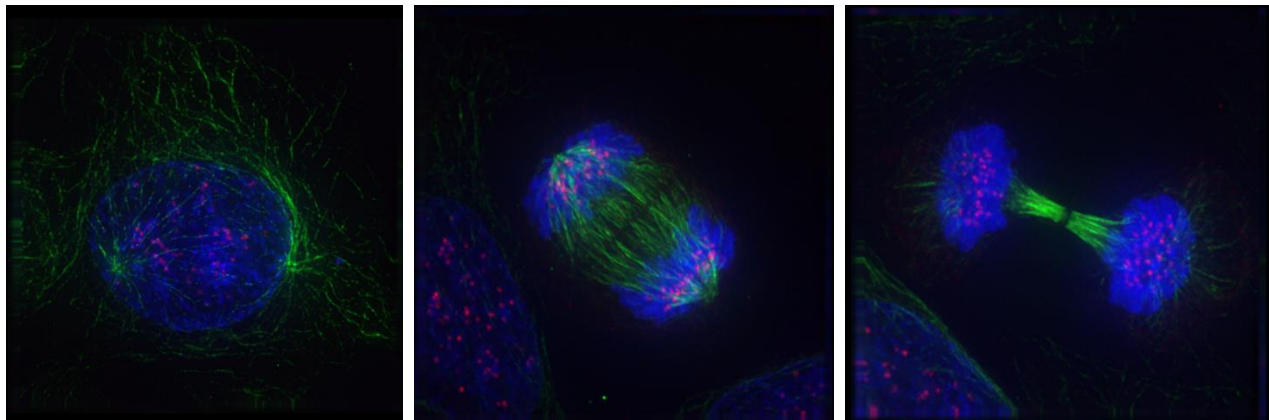


Although they can be beautiful, cancer cells are potentially deadly.
(Fox, 1987a, 1987b, 1987c)

In Chapter 6, “Cancer,” you will learn what cancer is, how cancer affects the human body, why cancer occurs, and what treatment options exist for fighting cancer. You will also learn about different types of cancer and genes or risk factors that increase your possibility of developing cancer. Understanding the risk factors associated with cancer will help decrease your chances of developing cancer in the future.

Simply stated, cancer is *uncontrolled cell division*. In order to understand cancer, you must first understand *controlled cell division*. Most cells in the human body reproduce. This is known as *cellular division* and occurs through one of two processes in the human body: *mitosis* or *meiosis*.

Somatic cells (body cells other than cells made for reproduction) that undergo cell division do so by mitosis. When mitosis occurs, a single cell makes an exact copy and divides. The result of mitosis is two genetically identical *daughter cells* (Belk & Maier, 2019). Our cells that undergo mitosis do so in order that we can grow, repair, and maintain our tissues.



Cell going through mitosis stages; from left: prophase, anaphase, and telophase
(van Heesbeen, 2008a, 2008b, 2008c)

Not all body cells divide or reproduce. This means when some types of cells are damaged or lost, they are damaged or lost forever. Cells in the human body that do not reproduce include skeletal muscle cells, neurons, and cardiac muscle cells.

Would we want all cells to produce identical copies? The answer is no, not for reproduction. If every cell was identical, every person would be identical. Every plant would be identical. Virtually every organism would be identical. Diversity is an important key to life on this planet. It enables organisms to mutate and adapt, such as developing and passing on important traits. One example would be a population in which some organisms possess a genetic trait toward greater resistance to disease that could save the organism’s entire species from becoming extinct in the event of a serious disease outbreak. An organism population with diverse genetic variability has more chance of survival than one with more limited genetic variability.

Gametes (sperm and egg cells) do not undergo mitosis. Gametes undergo a process called *meiosis* (Belk & Maier, 2019), which is discussed in Chapter 7. Meiosis is referred to as *reductional division*, in which one cell divides into four cells that each contain half the number of chromosomes compared to the number contained in the original cell before it divided. During meiosis, genetic information crosses over and aligns randomly on the resulting chromosome and, therefore, produces cells that are not genetically identical. This allows for diversity among sperm and eggs.

Cell division does not always happen as it should—sometimes mistakes occur. Think of it this way: If you were to copy information from a note, you might make a mistake and copy down the wrong information. For example, you may copy the word *not* instead of *note*. Mistakes similar to this sometimes occur when cells undergo mitosis or meiosis. When such a mistake occurs during cell division, it is referred to as a *mutation* (Belk & Maier, 2019). Mutation is random and is one of the forces that drive evolution. Mutations can be detrimental because, when a mistake occurs, something may go wrong. However, some mutations do not matter, some can be good, but, as mentioned, some mutations can result in detrimental situations, such as the development of cancer.

Not all cancer results from mutated information in DNA. Some forms of cancer—as well as many other characteristics—are passed to us from our parents. In Chapter 8, “Does Testing Save Lives?” you will learn about the basic concepts of the inheritance of traits and how genes interact with the environment. You will also learn to compute possible offspring outcomes using Punnett squares.

Our knowledge about genes and genetic information began when a brilliant Austrian monk, Gregor Mendel, conducted experiments on pea plants. Mendel conducted his work around 1855-1865. He published his findings in 1865, but his work was not appreciated—perhaps not understood?—until after the turn of the century. Mendel died in 1884, and unfortunately, the abbot who succeeded him burned all of Mendel’s papers; this was a great loss to science. However, Mendel’s work was rediscovered by scientists in the early 1900s (Belk & Maier, 2019).

Mendel figured out that the “factors” he was studying came in pairs. Since then, Francis Watson and James Crick have been credited with the discovery of the structure of DNA with the help of Rosalind Franklin, who used X-ray crystallography to capture images of DNA (Science History Institute, n.d.). Our knowledge of genetics continues to increase. For example, we now know that chromosomes do indeed come in pairs, something Mendel only suspected.

One aspect that determines the success of a scientific study is using the right subject. Mendel did just that. He studied pea plants, which reproduce sexually. Mendel was able to control the plants’ reproduction by removing the flowers’ reproductive organs and fertilizing the plants manually. What patience he must have had! It is estimated that over the course of his studies, Mendel raised about 30,000 plants (Biography, 2014).

Mendel observed that pea plants had some traits that were “either-or,” with only two alternatives. His plant’s flowers were either purple or white, the seeds were either round or wrinkled, the seeds’ color was either yellow or green, and so on. Mendel believed that heredity was carried from parents to offspring by “factors.” He observed that traits, such as color, were either one or the other, never something in between. What does this tell you about the “factors”?

Seed		Flower	Pod		Stem	
Form	Cotyledons	Color	Form	Color	Place	Size
						
Grey & Round	Yellow	White	Full	Yellow	Axial pods, Flowers along	Long (6-7ft)
						
White & Wrinkled	Green	Violet	Constricted	Green	Terminal pods, Flowers top	Short (<1ft)
1	2	3	4	5	6	7

Mendel’s seven traits

Mendel bred his peas until they either produced all of one trait or the other, such as all yellow seeds or all green seeds. Once he was sure that the plants were either one trait or the other, yellow or green, he crossed them, breeding, for example, yellow-seeded plants with green-seeded plants. He called the purebred plants the P generation (for parental). He discovered that all the offspring looked the same. For example, crossing

yellow-seeded plants with green-seeded plants all resulted in yellow-colored seed plants. One would think that the offspring of the yellow-seeded and green-seeded plants would be half yellow and half green, or a mixture of the colors, but they were not. Mendel called this generation of plants the F1 generation, “F” standing for *filial*, Latin for daughter.

Therefore, if you cross an organism that is purebred for a specific trait with another purebred organism with a different allele for that trait, the first generation is called the F1 generation. All of the offspring in the F1 generation will have the phenotype of the dominant allele, and they will all be heterozygous in their genotype.

In your assignment for this unit, you are asked about crossing F1 organisms with other F1 organisms. This time you will get different results, and the second generation is called the F2 generation. You will determine the phenotypes and the genotypes of the F2 generation.

Why did Mendel not use people or elephants or giant sequoia trees? Is it ethical to pick traits from two people and have them mate to determine the offspring? How much space would it take to study elephants or giant sequoia trees? How much food would it take to feed people and elephants? As mentioned, Mendel chose his subject wisely—not only could he easily manipulate fertilization of his plants, but he could also eat them, and they did not require a tremendous amount of space or resources.

The most important characteristic of Mendel's peas was mentioned earlier—that Mendel was able to manipulate the fertilization of the pea plants (Belk & Maier, 2019). Significant characteristics of the pea plant include these characteristics:

- it can be self-fertilized or cross-fertilized,
- it is easy to grow and cultivate,
- each pea is a different fertilization event,
- it has seven characteristics that have only two phenotypes (dominant/recessive),
- it can be true bred (has a certain phenotype and only produces offspring with the same phenotype),
- it is an annual (life cycle of growing from a seed to producing seeds is one year and then dies),
- it is diploid (contains two sets of chromosomes—one from each parent), and
- it relies on sexual reproduction.

Mendel was also fortunate that each of the seven traits he studied are on separate chromosomes. For example, if flower color and seed shape had been on the same chromosome, he might not have figured out independent assortment, because color and wrinkling would have gone together instead of being independent (Belk & Maier, 2019).

The genetic composition of an individual is known as the person's *genotype*. The genes then result in various physical traits known as *phenotypes*. Variations of genes are called *alleles*. An organism that is produced by sexual reproduction receives one gene from each parent. When an organism receives the same allele from each parent, it is said to be homozygous for that trait. When the organism receives a different allele from each parent, it is heterozygous (Belk & Maier, 2019). So, which trait “wins out” and shows through?

Human and many other organisms' genetics are not simple. Many characteristics and traits are determined by multiple genes and chromosomes. In addition, some alleles demonstrate *incomplete penetrance*, which means that the person who has the allele may not ever develop those features, such as a person with a cancer gene who never develops cancer. Nevertheless, Mendel brilliantly started us in the right direction concerning genetics. He knew about chromosomes many years before science was able to determine such things existed.

Reginald Punnett was a British geneticist who was among the first to understand Mendel's work. He wrote the first book about Mendelian genetics, called *Mendelism*, the first edition of which was published in 1905. Punnett went on to develop the Punnett square to explain how the chromosomes of parents cross and produce offspring.

Dominant genes always mask recessive genes. If an organism receives two dominant traits or one dominant and one recessive, the dominant trait will be displayed. The only time a recessive trait will be displayed is if the two recessive traits are passed on—one from each parent. Punnett squares can be used to determine the probability of outcome when you know the genes of the parent (Belk & Maier, 2019). When using Punnett

squares, the dominant gene is represented by a capital letter and the recessive gene is represented by a lowercase letter.

Suppose we have an imaginary yellow and green deck of cards, and we want to use it to illustrate a Punnett square. Let's do an F2 generation cross. We will use Yy for both parents, with capital Y (yellow) as dominant and lowercase y (green) as recessive.

Even though each parent has two chromosomes concerning the trait in question, each parent (because of mitosis) donates only one chromosome to the offspring. Therefore, only one chromosome is in each parent cell in the row and the column. Therefore, the completed Punnett square for this F2 generation cross involving yellow and green cards (chromosomes) would look like this:

		F1 Parent #1	
		Y	y
F1 Parent #2	Y	YY	Yy
	y	Yy	yy

Please watch this [video](#) explaining Punnett squares and how to complete them.

[A transcript of the video is also available.](#)

Are genes the only aspects that determine the fate of an organism? What about the environment? Does the environment that an organism inhabits affect the organism's fate? What about IQ? Is intelligence passed in a gene? Does it matter if you study and try to become more knowledgeable, or does your ability to learn totally depend on your genetic makeup? If you have certain genes, does that mean that you will always develop the traits associated with those genes? Notice that even cloned cats do not look the same, as was shown in an experiment conducted in 2001 in which the world's first cloned cat had different fur coloring than her genetic mother (Yin, 2011).

Recently, scientists discovered two genes related to breast cancer: BRCA1 and BRCA2. Since breast cancer is the second leading cause of all cancer deaths, this is a significant find; however, only about 5% of breast cancers are related to the BRCA1 gene (National Cancer Institute, n.d.-a). This means that not all people who develop breast cancer have the genes. This also means that a person who has the genes will not necessarily develop breast cancer.

With all this information, it is obvious that there are no guarantees in life. If all cells divided as they were designed to divide (no mutations and no uncontrolled division), would we live forever? If a cell received everything that it needed every day and nothing that it did not need, would it live eternally? Does the science behind cell division hold the future for the fountain of youth? Perhaps cells could live forever, and we could be forever young; however, such is not the case now. Besides, would anyone even want to live forever?

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Learning Activities (Nongraded)

Nongraded Learning Activities are provided to aid students in their course of study. You do not have to submit them. If you have questions, contact your instructor for further guidance and information.

Random Assortment Card Activity

Estimated time to complete: This activity will take approximately 15–20 minutes.

Introduction: We often have a hard time realizing the vast number of possible arrangements of paternal and maternal homologues, even with a relatively small number of chromosomes. This exercise reinforces the concept of independent assortment during meiosis, placing particular emphasis on the large number of possible outcomes.

Material: You will need two decks of playing cards, with backs of two contrasting colors or patterns.

Procedure:

1. A relatively small number of chromosome pairs can produce a huge number of possible configurations at metaphase I of meiosis. The math behind this concept is a simple exponential relationship. Relate this to a peasant who was offered either 1,000 shillings per day for 1 month's work, or 1 shilling on the first day, doubling it to 2 shillings on the second day, doubled again for 4 shillings on the third day, and so on. The peasant, by choosing the second option, demonstrated his wisdom, because he became a very wealthy man long before the end of the month. (Add it up—you will be surprised by the ending amount!)
2. Create a deck of cards representing the chromosome set of an organism having 13 pairs of chromosomes by removing all the cards of one suit from both decks and combining them. There are enough cards in two decks of cards to create four such sets. Each set of 26 cards represents 13 pairs of chromosomes. The maternal and paternal versions of each chromosome are represented by the different pictures, colors, or patterns of the backs of the cards.

3. Shuffle the set of 26 cards, and turn it so that the cards are face up. Deal the cards from the top. You will create two rows of 13 cards, one above the other. There is no need to place the cards in numerical order.
4. Because there are two copies of each card in this set (with the only difference being the picture, color, or pattern on the back of the cards), you will eventually turn up a second card with the same value.
5. When the first such duplicate (homologue) card is reached, start the second row by placing the card above its match in the first row.
6. Continue in this manner, placing the first homologue to turn up in the first row, and the second one in the second row, until the deck is depleted.
7. Once the cards are dealt, turn them over. The random arrangement of the maternal and paternal homologues should be evident.

This activity can be done several times. When completing the steps, it may be useful to write down the results so you can see that the combinations of homologues obtained with each shuffling are strikingly different.