

Student Name: _____



Biology STAAR Review Practice

Week of 3/30-2020-4/3/2020

Reporting Category 2: Mechanisms of Genetics

Day	Objective/TEKS	Agenda
<p style="text-align: center;">1 and 2</p>	<p>TEKS B.6.A (R): identify components of DNA, identify how information for specifying the traits of an organism is carried in the DNA, and examine scientific explanations for the origin of DNA</p> <p>TEKS B.6B (S) recognize that components that make up the genetic code are common to all organisms</p>	<ol style="list-style-type: none"> 1. Watch these videos: <ol style="list-style-type: none"> a. DNA, Chromosomes, Genes, and Traits: An Intro to Heredity https://youtu.be/8m6hHRIKwxY  b. Evolution The Common Genetic Code https://youtu.be/urthr04mqol  2. Linking Literacy- complete the Before Reading section of the table. 3. Read DNA. While you read, complete the During Reading portion of the table 4. Guided Practice: DNA 5. Math Connections: DNA 6. Science Today reading. 7. Reading in Science: Heredity Relates to Structure 8. STAAR Tune-Up: DNA and Genetic Code 9. Assessment: DNA



Linking Literacy

Name: _____ Date: _____

From DNA to Traits

Before Reading

Answer the following question based on prior knowledge:
How does DNA control the traits of living organisms?

During Reading

While reading, write down evidence that will support the answer to the question.

Reflect

You are probably familiar with the fact that your genetic material determines most of your physical traits. The DNA inherited from each of two parents dictates your body structure, height, eye, and hair color and even the precise shape of your toes. Furthermore, modern science is discovering increasing numbers of your health characteristics that are influenced by genetics.

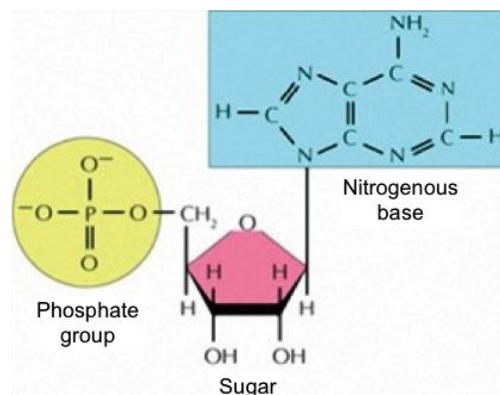
Predispositions to cancer, heart disease, and even drug addiction have links to specific genetic markers. What about personality traits such as calmness, anger, and anxiety? Could these traits be pre-determined by our genetic makeup?

Social and psychological scientists have long debated the question of “nature versus nurture.” How much of what makes us who we are is predetermined by our heredity? How much is influenced by our environment and actions? While scientists increasingly discover genetic links to both physical and behavioral characteristics, most agree that lifestyle choices can have a dramatic impact on many of these traits. Consider the role of diet and exercise in preventing diseases that might normally result from certain genetic patterns.

Inheriting our genetic material may be akin to being dealt a hand of cards. It is up to each individual to make strategic decisions in order to obtain optimal results for health. But what exactly is the genetic material that determines so much about every living organism? What does it look like, how does it work, and where is it found?



Certain phytochemicals found in fruits and vegetables are known to help prevent illnesses such as cancer and heart disease.



The Genetic Blueprint for Life

Deoxyribonucleic acid (DNA) stores all the genetic information required to grow and maintain a living organism. In **eukaryotes**, DNA is housed in the nucleus of each cell. Like other major organic biomolecules, DNA is a **polymer**. It is made up of repeating molecular subunits, called *nucleotides*. A single nucleotide consists of three chemical groups: a sugar, a phosphate, and a nitrogenous base. The sugar found in DNA is called deoxyribose. There are four types of nitrogenous bases: *adenine* (A), *cytosine* (C), *thymine* (T), and *guanine* (G). The particular base within a nucleotide determines the identity of that nucleotide. These components that make up the genetic code are common to all organisms.

eukaryote: an organism with a membrane-bound nucleus and organelles

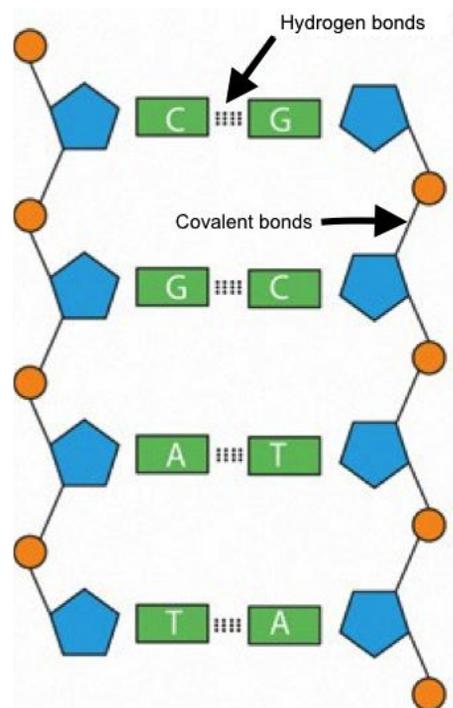
polymer: a large molecule formed by the bonding of smaller molecular units

Reflect

Many nucleotides string together through bonds between the phosphate group of one and the sugar of the next. These bonds are called strong covalent bonds. This nucleic acid structure, including the four nitrogenous bases, sugar, and phosphate, is identical in the DNA of all living organisms.

Two individual nucleotide strands are joined by hydrogen bonds between their respective nucleotide bases. In this way, the DNA molecule may be pictured like a ladder. Together, the sugars plus the phosphate groups make up the vertical beams of the ladder, and the nucleotides make up the horizontal rungs. To complete the picture, imagine the ladder twisted into a helical conformation. This yields the double helical structure of DNA.

Because of their unique structures, the nitrogenous bases that join two strands of a DNA molecule bind according to the following rules: adenine binds with thymine, and cytosine binds with guanine. Due to these binding rules, the two strands of DNA are said to be “complementary.” Therefore, if the sequence of one strand is known, the other can be deduced. The bonds between the sugar and phosphate groups of a DNA molecule are strong *covalent* bonds. In contrast, nitrogenous bases are joined by relatively weak *hydrogen* bonds. Covalent bonds are formed through the sharing of electrons. In contrast, a weak association between a hydrogen atom and with the negatively charged area of another atom forms hydrogen bonds. This relatively weak association becomes important when a DNA molecule must be separated in order for each strand to be replicated. DNA replication occurs each time a cell divides.



What Do You Think?

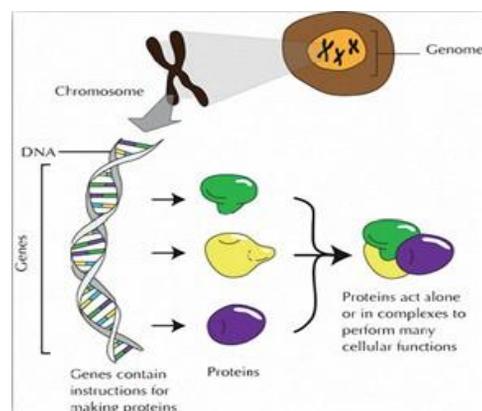
Examine the following nucleotide sequence in a strand of DNA:

CAGTTGATAGCC.

What sequence of nucleotides would be found in the complementary strand?

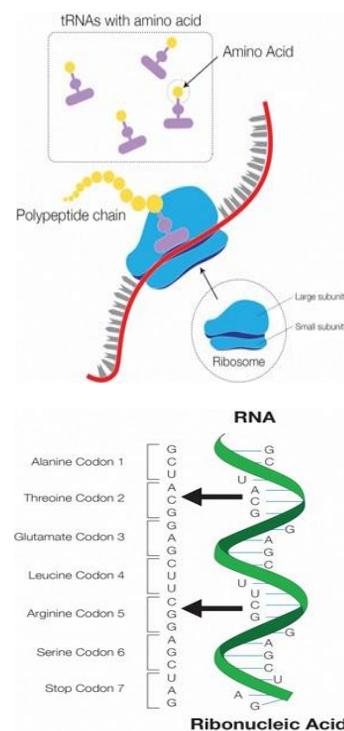
What Do You Think?

Genes and the Production of Proteins Each cell in an organism contains the entire genome (full complement of DNA) for that organism. If all the DNA within a human cell were laid out in a straight line, it would span approximately two meters! In order to fit inside the tiny cellular nucleus, DNA is folded tightly. Individual strands are wrapped around special proteins called histones. Histone complexes are then repeatedly coiled to form chromatin. During prophase of mitosis and meiosis, each strand of chromatin is super-coiled into tightly compact structures called chromosomes.



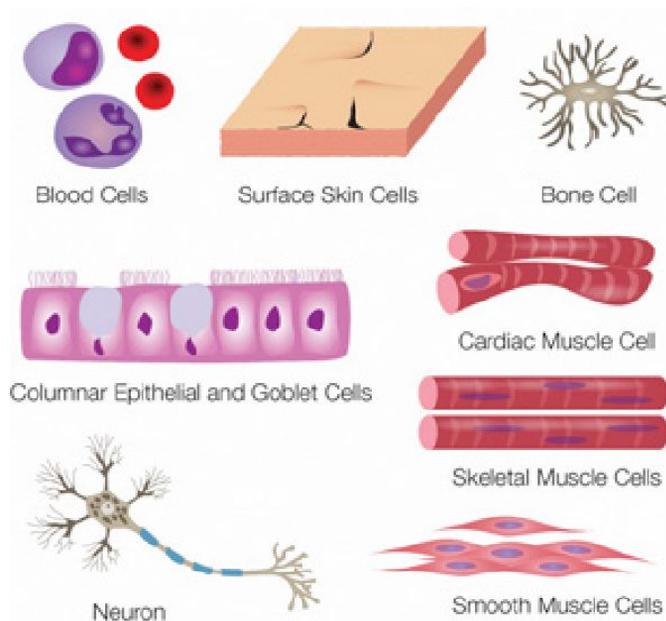
The major question remains: How is it that DNA controls the traits of living organisms? The answer involves a very important cellular component: proteins. Proteins effectively determine virtually everything about a living cell, and thus, an organism. The proteins within a cell determine the cell's structure and its function. Proteins regulate which materials will be transported into and out of cells. They determine the products a cell might make (such as hormones, pigments, or mucus). They also determine whether a cell will be motile, such as sperm cells and certain immune cells, or contain large amounts of contractile muscle fibers, such as muscle cells. Simply put, DNA controls cellular fate by providing the instructions for making each and every protein within a cell. The specific sequence of nucleotide bases within a section of DNA serves as a code that translates into the sequence of amino acids required to build a specific protein. This special section of DNA that includes the sequence necessary to build a protein is called a *gene*. The number and specific nucleotide sequence of all of the genes within an organism's DNA determines the inherited traits of that organism.

The process of reading out the information within a cell's DNA to produce a protein takes place in two stages. First, a specific gene within the DNA is copied to produce a nearly identical molecule of RNA (*ribonucleic acid*). RNA differs from DNA in that it consists of only one strand. RNA also uses the sugar ribose instead of deoxyribose. Additionally, RNA lacks the nucleotide thymine. In place of thymine, RNA uses a nucleotide called *uracil* (U). Once a strand of RNA is synthesized complementary to a gene on the DNA, it leaves the nucleus. In the cytoplasm of the cell, the nucleotide code of the RNA strand is decoded, or "translated," into an amino acid code. Amino acids are brought together one by one with the help of other molecules. These amino acids are assembled in the appropriate sequence to form the final protein.



Look Out!

Complex multicellular organisms contain a huge variety of cell types. Consider the differences between muscle, brain, blood, skin, and bone cells. Each of these cells has a different structure and performs unique jobs. These differences arise from the different proteins expressed in each. However, earlier it was mentioned that all cells contain a copy of the same genome (all of an organism's DNA.) How is it that different cell types contain different types of proteins if all cells contain exactly the same DNA? The answer lies in the control that each cell exerts over which genes are expressed (actively copied to make RNA) and which remain silent. Imagine a group of actors rehearsing a play, with each actor holding a copy of the same script. Each actor reads only his or her own lines, skipping everyone else's. Similarly, each cell within an organism expresses only the specific genes that it needs to perform its functions, skipping other genes. This discretion is made possible with the help of special proteins called "transcription factors." Transcription factors bind to genes within the DNA and either promote or hinder the copying of those genes into RNA.



What Do You Think?

Origin of DNA and Life

Many scientific explanations for the origin of DNA and life have been proposed over the years. Below you will read about some of the explanations in more detail.

The Origin of Life

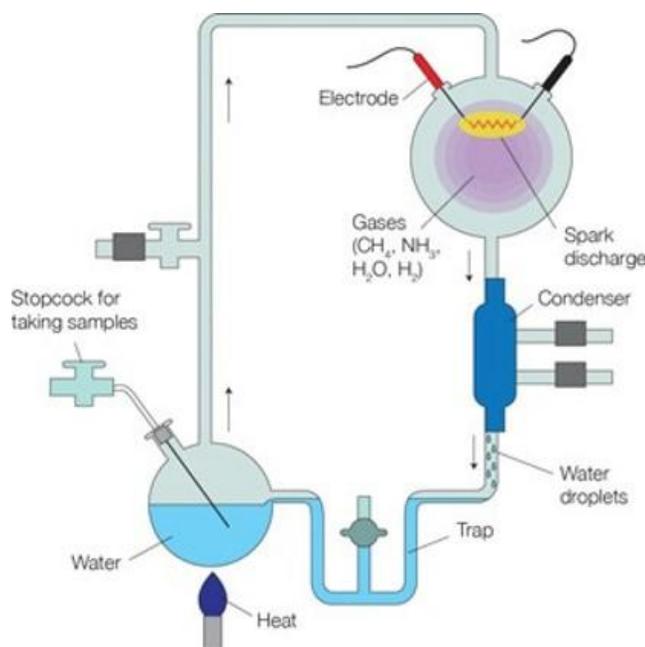
Spontaneous generation (the idea that organisms automatically form from nothing) was the widely accepted theory on how Earth was formed. Louis Pasteur disproved this theory in 1862.

In the 1920s, two scientists, working in different countries, proposed the same hypothesis on the origin of life. Russian biochemist Alexander Oparin and British geneticist J. B. S. Haldane proposed that life began spontaneously from combinations of nonliving matter exposed to energy from lightning, volcano eruptions, or the Sun.

Oparin and Haldane proposed that life began in the oceans, where organic molecules were everywhere, thus resulting in a “primordial soup.” The two scientists suggested that Earth’s early atmosphere lacked oxygen. Instead, it was composed of nitrogen, hydrogen, and other compounds, including water vapor, ammonia, and methane. Life could more easily arise in this environment because electrons from energy sources such as lightning could react with molecules such as nitrogen to form organic compounds. An oxidized atmosphere would have simply absorbed these electrons. Their ideas became known as the Oparin-Haldane hypothesis.

In 1953, Stanley Miller and Harold Urey tested this hypothesis with the Miller-Urey experiment. They built an apparatus to simulate Earth’s early atmosphere, shown in the diagram at right. They applied a continuous electric current to mimic the lightning storms on Earth. Within a week, small amounts of carbon had formed into organic molecules, and some had even formed into small amino acid chains. Amino acids are the building blocks of proteins.

Many scientists are skeptical of this theory, partly because lightning storms probably did not occur often enough to generate the quantities of organic molecules necessary for the origin of life. So, while amino acids and other organic compounds may have been formed, they would not have been formed in the amounts produced by the Miller-Urey experiment.



Look Out!

Iron-Sulfur World Theory

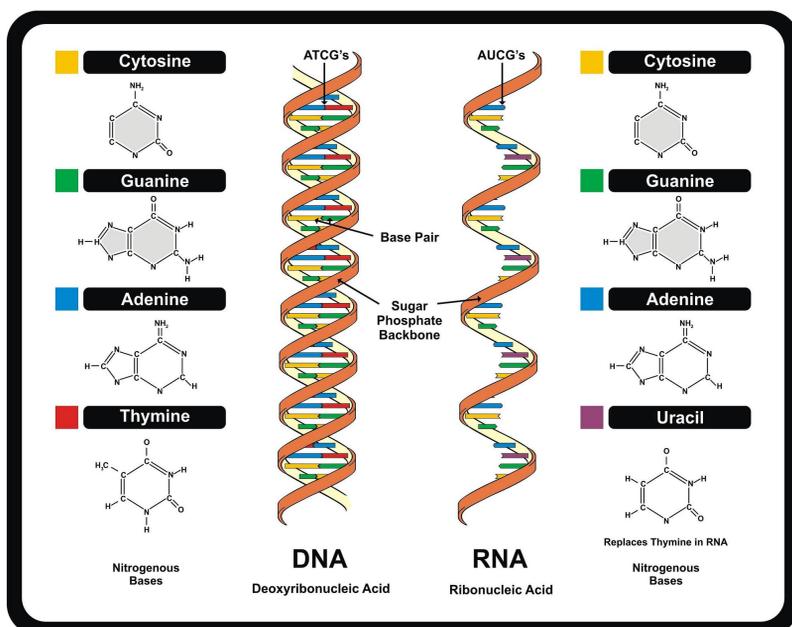
In 1985, German chemist Günter Wächtershäuser proposed the iron-sulfur world theory. He claimed that life began on the surfaces of mineral deposits near volcanic vents on the ocean floor. There, carbon reacted with metals, such as iron and nickel, creating organic compounds (carbon monoxide, carbon dioxide, hydrogen cyanide, and hydrogen sulfide) from gases spewed by the underwater volcanoes. This process took place under high pressure and high temperatures. According to Wächtershäuser's theory, these were the perfect conditions for organic synthesis. An evolving cycle of chemical reactions eventually formed acetic acid and pyruvic acid, two key elements in the citric acid cycle that organisms use to make energy. This theory accounts for metabolism, or how chemical energy is transferred within a cell, but it does not describe how the organism could duplicate itself. For this, the RNA world hypothesis offers a possible explanation.

RNA World Hypothesis

The first two hypotheses explain how inorganic molecules became organic monomers, such as amino acids, sugars, phosphates, and bases. The more difficult problem was describing how these simple chemical systems became complex enough to form organisms—how did monomers become polymers, such as proteins, carbohydrates, and lipids?

In the 1980s, American scientist Thomas Cech and his colleagues discovered that RNA (ribonucleic acid) can act as a **catalyst**, helping drive the chemical reactions necessary for many processes in an organism. Ribosomal RNA and transfer RNA are the primary molecules responsible for protein synthesis. RNA is also able to store and pass on information, allowing molecules to replicate, which is another essential aspect of living organisms. Thus, the RNA world hypothesis was introduced, proposing that RNA existed before DNA. This theory explains how simple molecules could become complex, self-replicating systems. However, scientists do not understand how RNA was originally formed. Debate and research still continue on many aspects of this theory.

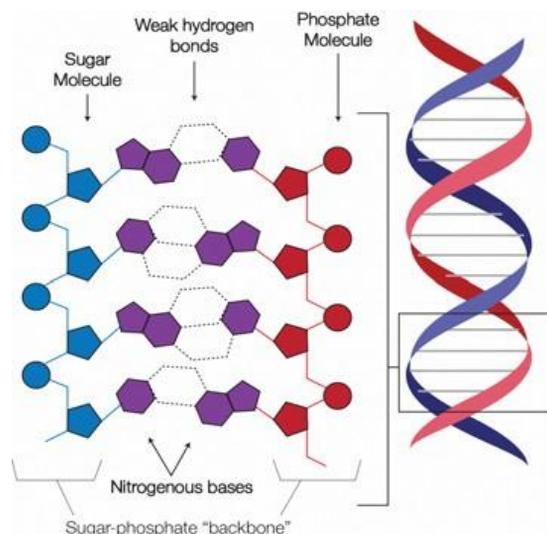
catalyst: a substance that helps start or increase the rate of a reaction



Look Out!

Discover Science: The Discovery of the Structure of DNA

The discovery of the structure of DNA in the 1950s answered many biologically important questions. For years, the hunt was on to determine what this molecule was made of and what it looked like. By the 1940s, scientists knew that nucleic acids, specifically containing the four bases—A, C, T, and G—composed the molecule of heredity. However, the arrangement and structure of this molecule remained a mystery until the following decade. Two scientists at Cambridge University, James Watson and Francis Crick, worked hard to reveal DNA's structure. They used various models, arranging atoms in a variety of ways. They made structural predictions based on what they knew about the atomic make-up of DNA.



At the same time, another scientist named Rosalind Franklin was also working hard to determine the structure of DNA. Franklin was using a sophisticated research technique called X-ray crystallography. In this technique, X-rays are shot at crystallized samples of the molecule in question. The technique reveals a vague, shadowy image, based on how the X-rays diffract off the molecule's atoms. Franklin generated such an image of the DNA molecule. Her research partner, Maurice Wilkins, showed this image to Watson and Crick. When they saw the image, they quickly deduced that it pointed to a double-helical structure. Watson and Crick soon published their findings that DNA was a double helix, with a sugar-phosphate backbone on the outside, and nucleotide bases on the inside. Watson, Crick, and Wilkins shared the Nobel Prize for this discovery in 1962. However, Rosalind Franklin was not included in the honor, because she had died before it was awarded. At the time, Franklin did not receive the credit that she deserved, but the scientific community today is well aware of her contribution to this momentous discovery.

Looking to The Future: Looking into *Your* Future by Knowing Your Own DNA Sequence

If you could see into your own future using a magic crystal ball, would you want to? At one time, people thought this was science fiction, but determining one's future based on genetics is quickly becoming a reality. The term *predictive medicine* refers to the concept of determining one's risks for disease and illness based on the person's specific genetic sequence. The groundbreaking Human Genome Project successfully determined the full sequence of human DNA in 2003. This project took about 13 years. Some estimates suggest that the total cost reached into the billions of dollars. Since then, many companies have been racing to develop commercial technology that can do the same thing for the average individual. The company Life Technologies announced such a service in January 2012. For one thousand dollars, and in one day, any individual could know his or her DNA sequence.

Look Out!

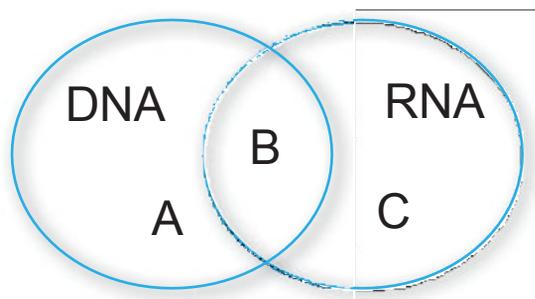
Full, individual genome sequencing would reveal genetic markers that indicate risks for cancer, neurological disease, cardiovascular disease, and much more. The implications of such technology are vast, and some are controversial. Of course, the ability to be proactive about lifestyle choices specific to one's own health risks would be hugely advantageous. However, should medical insurance companies have access to your DNA sequence? Would they use that information against you? How might you live your life differently if you knew your DNA?

What Do You Think?

What Do You Know?

Using the following list of phrases and the Venn diagram below, decide whether a phrase belongs in category A, B, or C. Write the correct letter next to each phrase.

- Directly translated into protein
- Double helix
- A nucleic acid
- Contains the sugar ribose
- Wrapped around histones
- Single stranded
- Contains nitrogenous bases
- Double stranded
- Sugar-phosphate association through covalent bonds
- Contains adenine, cytosine, guanine, and uracil





Guided Practice

Name: _____ Date: _____

DNA

Answer the questions below.

1. Which nitrogenous base is the complementary base for thymine?
2. Which nitrogenous base is the complementary base for guanine?
3. Which parts of a nucleotide make up the backbone of the DNA helix?
4. The DNA molecule is in the shape of a double helix and coils itself upon histone proteins. Why are these features important to DNA?
5. What type of bond can be found between complementary nitrogenous bases? Why is this type of bond significant to the DNA?

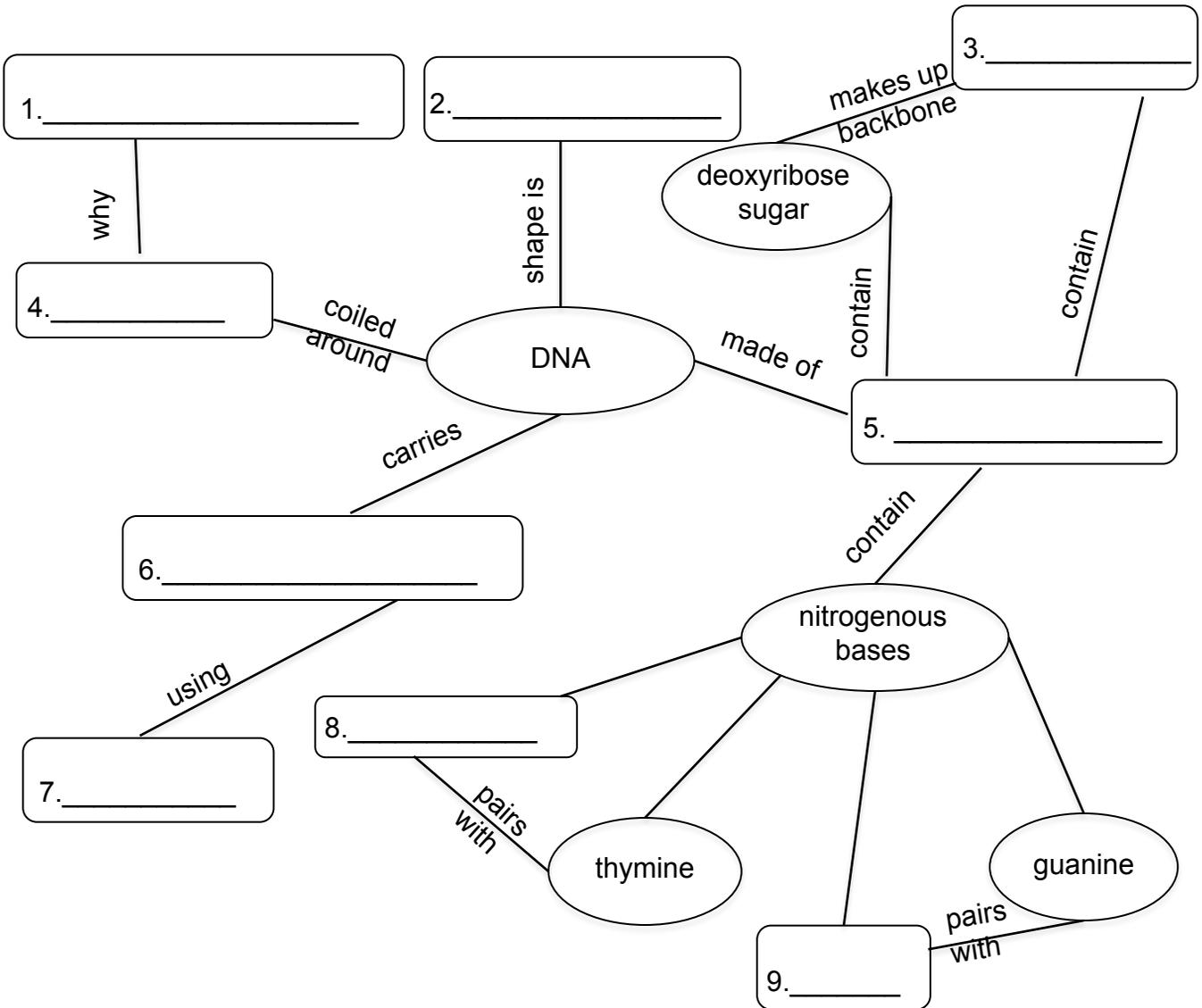


Guided Practice

DNA, continued

Using all of the following terms in the word bank, complete the graphic organizer.

Word Bank				
adenine	condense	cytosine	double helix	genes
hereditary information	histones	nucleotides	phosphate	





Math Connections

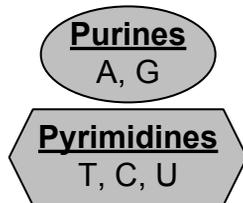
Name: _____ Date: _____

DNA

All living organisms have genes that are composed of nucleic acids (also known as nucleotides) made from the same nitrogenous bases (adenine (A), guanine (G), cytosine (C), thymine (T), uracil (U)). It is the combination of these bases that determines an organism's traits.

Part I: Watson-Crick Base Pairing and Chargaff's Rules

The five nucleotides in DNA and RNA can be separated into two types: purines and pyrimidines. In DNA and RNA, a purine always bonds with a pyrimidine through hydrogen bonding. Each pyrimidine bonds with only one purine nucleotide (known as Watson-Crick base pairs). All base pairs have the same length, which is what gives the DNA double helix its constant diameter as you move up or down the strand. Using your knowledge of base pairs and the information in the table provided, answer questions 1–7.



1. Which pyrimidine(s) bond with A? with G?
2. What base pair is only found in RNA?

Chargaff's rules state that purines and pyrimidines have a 1:1 ratio in DNA. In other words, there are equal amounts of the nucleotides for each set of pairs (amount of A = amount of T; amount of G = amount of C). Use this information to answer questions 3–7.

4.

Percentage of Nucleotides in the DNA of Different Species				
Species	A	T	C	G
Human	30%		20%	
<i>E. coli</i>			26%	26%
Mouse				21%

3. Write an equation for the relationship between the total amount of A and T nucleotides in DNA, where x represents A and y represents T. Remember, the amount of A = amount of T.
4. _____
5. Knowing the percentages of A, T, C, and G nucleotides for mouse DNA, what is the percentage of C-G pairs? (Add the percentage of C and the percentage of G.)
6. Which species in the table above has 48% A-T pairs (each A and T would have equal amounts of the 48%)?



Math Connections

Part II: DNA Thermodynamics

The strands in a DNA double helix can be separated using heat to break the hydrogen bonds between nucleotides. The amount of energy (heat) required to completely separate a strand depends on the number of hydrogen bonds that have to be broken (more bonds = more energy required). Pairs with cytosine have three hydrogen bonds, while pairs with adenine have two hydrogen bonds.

Scientists have found relationships to determine what temperature they need to raise DNA to achieve this separation (known as melting or denaturing). The following simplified equation relates the percentage of G-C pairs in a DNA double helix to the denaturing temperature in degrees Celsius (for a specific salt content and DNA length).

$$T = 70 + 0.4 \cdot x \quad (x = \%G-C \text{ pairs})$$

Use this information, equation, and your answers from page 1 to answer questions 7–11.

- As the percentage of G-C pairs increases, what happens to the temperature required to separate the DNA strand?
- Which would require a lower denaturing temperature: a DNA strand with 60% A-T pairs or a DNA strand with 60% C-G pairs? Why? (Consider the fact that the equation above uses %G-C pairs, and A-T and G-C total 100% when combined.)
- If a DNA strand is 48% A-T pairs, what temperature will cause the DNA strand to separate? (Include the unit in your answer.)

$$\%G-C = 100 - 48 = 52$$

$$T = 70 + 0.4(52) =$$

- What temperature do scientists need to raise a strand of mouse DNA to for it to completely separate? (Include the unit in your answer.) (From table on page 1, mouse %G-C = 42%)

- If a DNA strand is denatured at 80°C, what percentage of the strand is G-C pairs? (Hint: rearrange the above equation first.)

$$80 = 70 + 0.4(x) - \text{Solve for } x$$



Math Connections

Part III: Writing Nucleotide Strands

Determine the nucleotides of a section of one strand of a DNA double helix by solving the problems and matching the answers with the nucleotides in the key. Then complete the DNA section by matching these with their corresponding nucleotide pair.

Key					
Nucleotide	Adenine (A)	Cytosine (C)	Guanine (G)	Thymine (T)	Uracil (U)
Solution	2	5	7	3	11

Solve and Simplify	Nucleotide	Pair
$3x = 6$	A	
$13 = x + 8$		5
$28 = 4x$		
$x / 3 = 1$		
$4 + x = 9$		
$4x = -5x + 18$		
$6x - 2 = 10$		

12. 13. Is this a DNA or RNA nucleotide strand? Why?

14. What percent of the nucleotides of the strand shown are adenine? (There are 3 A's over a total of 7 nucleotides.)

15. What percent of the total nucleotides for both sides of this DNA section are adenine? (There are 4 A's over a total of 14 nucleotides.)

Solve and Simplify	Nucleotide	Pair
$2x - 6 = 8$		
$5x = 55$		
$2x + 1 = 23$		
$5x + 6 = 16$		
$x + 9 = 14$		
$14 = 4x - 6$		
$x + 5 = 12$		

16. 17. Is this a DNA or RNA nucleotide strand? Why?

18. What percent of the nucleotides for the strand shown are adenine?

19. What percent of the total nucleotides for both sides of this DNA section are adenine?



Name: _____ Date: _____

Too Hot: Temperatures Messing with Sex of Australian Lizards



WASHINGTON (AP) — Hotter temperatures are messing with the gender of Australia's bearded dragon lizards, a new study finds.

Dragons that are genetically male hatch as females and give birth to other lizards. And the way the lizards' gender is determined is getting changed so much that the female sex chromosome may eventually disappear entirely, the study authors say.

"This is the first time we have proved that sex reversal happens in the wild in any reptile at all," said Clare Holleley of the University of Canberra, lead author of the study in the journal *Nature* Wednesday. The study, she said, "is showing that climate extremes can very rapidly fundamentally alter the biology of an organism."

To understand what's happening, it helps to have a quick lesson in the birds and the bees—and the bearded dragons and other reptiles. Some reptiles, like alligators and some turtles, have their genders determined not by sex chromosomes, like humans and other mammals, but by temperature during incubation.

Until now, bearded dragons had their gender based on chromosomes. Like birds, their sex chromosomes are Z and W instead of X and Y. Males are ZZ. Females are ZW. In humans, everyone has an X and the presence of Y makes a person genetically male. In bearded dragons, everyone has a Z and the presence of a W makes them a genetic female.

In the past, scientists have shown in the lab that hot temperatures can switch that natural chromosome-based gender.



Science Today

Holleley and colleagues examined the genetic sex markers of 131 wild-caught bearded dragons in Queensland province and found that 11 of them were female outwardly—even having offspring—but had the ZZ chromosomes of a genetic male. Their sex determination was "switched into overdrive," Holleley said.

Holleley concedes 11 dragons is a small sample size, so she and colleagues will continue and expand their research.

The genetic-male-into-female dragons not only laid eggs, but in a way were better mothers than genetically determined females, laying more eggs, said study co-author Arthur Georges, chief scientist for the Institute for Applied Ecology at the University of Canberra.

The team also found that the offspring of these dragons no longer have their gender determined by chromosomes, but by temperature.

"They're throwing away the equivalent of the Y, which we call the W, chromosome," Georges said. "If the climate warms not much more at all, the percentage of sex reversal will increase and the W chromosome will be lost from the population."

This is happening in an area that is one of the fastest warming places in Australia over the past 40 years, Holleley said. Lab tests show that the switch from genetic sex determination to temperature sex determination seems to start at about 90 degrees Fahrenheit (32 degrees Celsius) and occurs 100 percent of the time at about 97 degrees (36 degrees Celsius), Holleley said.

Outside scientist Fredric Janzen at Iowa State University praised the work as thorough and convincing. He said in an email that the study can help "to better understand these remarkable animals in a rapidly changing world."

Holleley said the heat could be transformative for more than these lizards: "It certainly can happen to other species, but it's not going to happen to humans, more than likely."

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Science Today

1. The bearded dragon is an example of an influence on genetic outcome regardless of the presence or absence of a particular chromosome. What other variable plays a role in the sex determination of bearded dragons?
2. According to the article, if global temperature continues to rise, the W chromosome will disappear. Explain how this will impact genes passed on from one generation to the next.
3. How does this article support the statement that the variation and distribution of traits observed depend on both genetic and environmental factors?
4. Construct a Punnett square to show the potential offspring of the following parental combinations:

Female: ZW Male: ZZ

5. The Z chromosome is believed to carry a gene that codes for an enzyme that causes "maleness." Because enzymes are proteins, they do not function normally when temperatures are too cold or too hot. The temperature range for normal enzymatic function is around 70°F to 93°F. What would happen to the males from the above Punnett square if the eggs are exposed to an environment of 95°F?



Reading Science

Name: _____ Date: _____

Heredity Relates to Structure

1 What is DNA, and how does it relate to inheritance?

In the 1950s, scientists knew that the molecule deoxyribonucleic acid was a polymer. It is made of a nitrogenous base (a base that contains the element nitrogen), a pentose sugar known as deoxyribose, and a phosphate group. They also knew that the nitrogenous bases consisted of only four specific bases within the molecule. These are adenine (A), thymine (T), cytosine (C), and guanine (G). In 1947, a biologist named Erwin Chargaff noted that the number of certain nitrogenous bases within a species seemed to equal each other. More specifically, the number of adenine (A) and thymine (T) were relatively equal, and the percentage of cytosine (C) and guanine (G) were almost exactly equal. With this finding, he hypothesized that these bases must occur in pairs within the DNA molecule. The fact that $A = T$ and $C = G$ has become known as Chargaff's rule.



2 Scientists were also beginning to believe that the DNA molecule itself may be responsible for heredity. Previously, proteins had been thought to fill that role. Why? Scientists had closely observed the process of mitosis, or cell division, in eukaryotic cells. They noticed that not only was the DNA content of each cell precisely doubled, but it was also evenly distributed to each daughter cell created. What they did not know was how these components arranged themselves within the DNA molecule. They also did not know if (or how) the structure of DNA permitted it to be the carrier of genetic information. By the early 1950s, several scientists were taking all of the information known regarding DNA to answer these questions. They were determined to discover the true structure of the molecule, and how this structure may be involved in the passing of genetic information.

3 Scientists were using a process called X-ray crystallography to study the structure of the DNA molecule. In this process, images are produced from samples of the molecule that have been treated to form crystals. X-rays are passed through the crystals and then photographed as they are deflected from the crystalline structures. This deflection process is also known as X-ray diffraction. The diffracted images did not show the actual structure of the molecules. Instead, they showed distinct patterns that could be used to interpret the structure of molecules. Due to this process, a scientist named Linus Pauling had discovered that molecules may have helical shapes.



Reading Science

- 4 It was at this time that four scientists stepped into the history books. The first were two scientists working at King's College in London, named Maurice Wilkins and Rosalind Franklin. Both had been working with the structure of the DNA molecule for quite a long time, but they could not solve the structural puzzle. In 1951, Rosalind Franklin, with a Ph.D. in physical chemistry, had been placed in charge of refining the X-ray crystallography work with DNA. Maurice Wilkins, with a Ph.D. in physics, worked with Franklin and her X-ray crystallography technique to study the structure of the DNA molecule.
- 5 During this time, a relatively unknown young American scientist named James Watson arrived at the Cavendish Laboratory at Cambridge University in London. He had a keen interest in genetics. Watson had heard that X-ray crystallography images were being made of DNA. At Cambridge, he met a young English physicist named Francis Crick, who was working on X-ray crystallography of blood cells. Wilkins showed Watson an X-ray crystallography image of a DNA molecule created by Franklin. Reportedly, Wilkins did this without Franklin's permission. This specific image was labeled "Photograph 51." It was this very image that allowed Watson to determine that the DNA molecule structure was double helical, or twisted.
- 6 He used this image to interpret the width of the helix and how the various bases were positioned within the molecule. Based on this information, Watson and Crick quickly built many models. They knew, based on Chargaff's rule, that the DNA molecule had specific base pairing. This was the key! Watson realized that if he paired the bases according to Chargaff's rule, then the bonds between the bases would be equal. This, in turn, made the rungs of the ladder of the double helix equal. Therefore, the sugar-phosphate backbone would be smooth. They concluded that it was the specific base pairing that allowed the DNA molecule to duplicate itself. Thus, the structure of DNA enables it to transfer genetic information during the process of replication, as seen in earlier studies of mitosis.
- 7 Watson and Crick were the first to solve the puzzle on February 21, 1953. Their findings were published in an article in the April 25, 1953, publication *Nature*. The article was called "Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid." However, it is important to note that Watson and Crick's findings were primarily based on the previous work of Wilkins and Franklin. Furthermore, Franklin and Wilson published two articles on the subject in that same issue of *Nature*. Nevertheless, Watson and Crick still received the credit for being the first to solve the puzzle. James Watson, Francis Crick, and Maurice Wilkins all received the Nobel Prize in Physiology or Medicine in 1962 for their discoveries of the DNA molecule and how its structure related to heredity. Unfortunately, Rosalind Franklin died of cancer in 1958 at the age of 37. Nobel Prizes are only awarded to the living. She was never able to receive this prestigious award, even though her image was the ultimate key to the puzzle.

<http://www.chemheritage.org/discover/online-resources/chemistry-in-history/themes/biomolecules/dna/watson-crick-wilkins-franklin.aspx>

http://www.nobelprize.org/nobel_prizes/medicine/laureates/1962/



Reading Science

- 1** Paragraph 1 discusses several important facts regarding the DNA molecule. Which of the following facts relates to Chargaff's rule?
- A** DNA contains a pentose sugar, nitrogenous bases, and a phosphate group.
 - B** DNA is a molecule in structure.
 - C** DNA contains adenine, thymine, cytosine, and guanine.
 - D** Cytosine and guanine appear in equal proportions in DNA.
-
- 2** With any major scientific discovery, the previous work of many different scientists helps contribute to final conclusions. Which of the following scientists' work did not contribute to the discovery of the structure of the DNA molecule?
- A** Gregor Mendel
 - B** Linus Pauling
 - C** Erwin Chargaff
 - D** Rosalind Franklin



Reading Science

- 3** X-ray crystallography is a very important process that is used to help identify the structure of molecules. What exactly does this process show?
- A** A photograph of the molecule
 - B** The atoms within the molecule
 - C** Patterns that can be used to interpret structure
 - D** The crystal structure of the molecule
-
- 4** In 1951, four scientists were working on solving the structural puzzle of the DNA molecule. Two of those scientists had worked for many years to try to solve the puzzle, and even though their work became the foundation for the actual discovery of the structure of DNA, they are not often remembered. Who were these two scientists?
- A** Watson and Crick
 - B** Chargaff and Pauling
 - C** Wilkins and Franklin
 - D** Mendel and Darwin



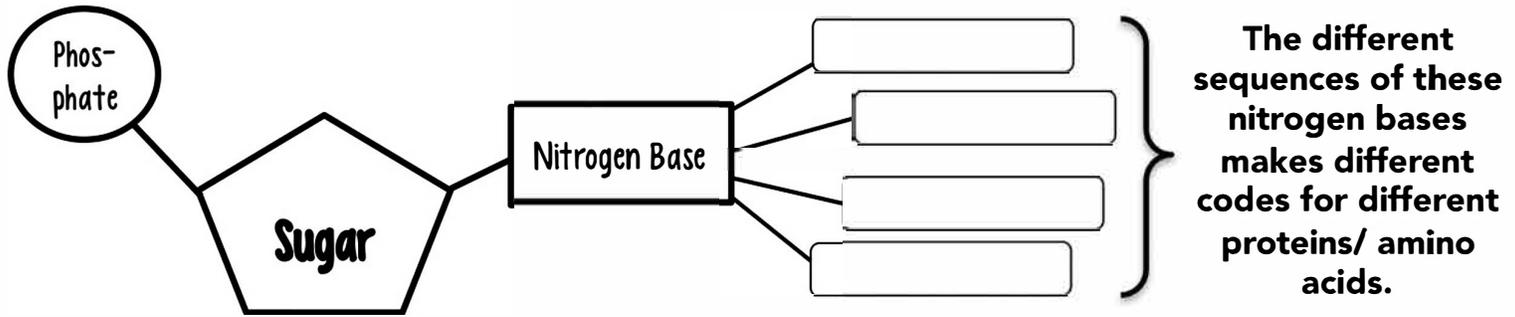
Reading Science

- 5** In 1962, three scientists who contributed to the discovery of the structure of the DNA molecule were awarded the Nobel Prize in Physiology and Medicine. The fourth scientist who contributed to this discovery, Rosalind Franklin, was not awarded the prize as she had died before this honor could be bestowed. What was her major contribution to this discovery?
- A** She determined that DNA was a crystal.
 - B** She captured the X-ray crystallography image that led to the discovery.
 - C** She determined that nitrogenous bases occurred in pairs.
 - D** She determined that DNA was a double helix.
-
- 6** Paragraph 6 discusses the importance of the discovery of the structure of the DNA molecule. What did this discovery allow scientists to confirm?
- A** Specific base pairing allowed DNA to duplicate itself.
 - B** If Chargaff's rule was followed, then the bonds between bases were equal.
 - C** Specific base pairing allowed for the transfer of genetic information.
 - D** All of the above

B.6 (A) Identify components of DNA, identify how information for specifying the traits of an organism is carried in the DNA, and examine scientific explanations for the origin of DNA.

I. The Structure of DNA.

1. DNA is made up of repeating units called _____.
2. The sugar found in DNA is called _____.
3. List the 4 possible nitrogen bases found in DNA in the boxes:



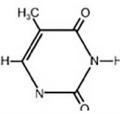
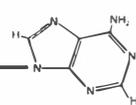
4. What is a codon (i.e., AAT, TCC, GGC)? _____

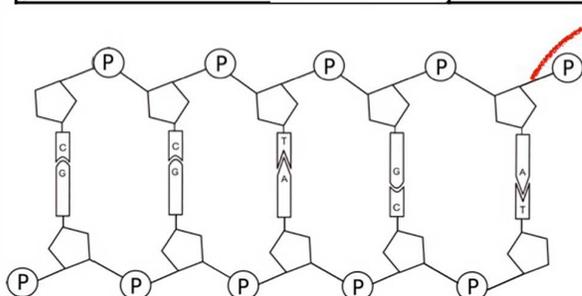
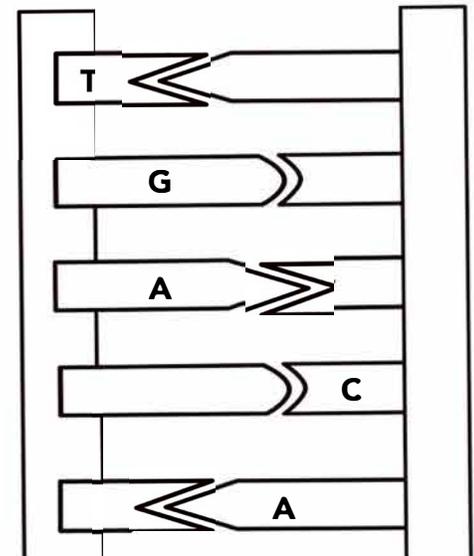
5. How does DNA serve as a genetic code? What does it code for? _____

6. Circle the appropriate word or phase found in the brackets to complete the sentence.

DNA is a (circle one) [double | single] stranded molecule. It is connected at the nitrogen bases by [ionic | hydrogen] bonds. The nitrogen bases are [complementary | random] to each other. The two strands make up the [triple backbone | double helix].

7. Fill out the table below that best represents the complementary bases found in DNA nucleotides. Then complete the model at right by writing the letter abbreviation of each complementary nitrogen base.

Purine/Pyrimidine	Nitrogen Base	Complementary to...
Pyrimidines	 Thymine	
	Cytosine	
Purines	 Adenine	
	Guanine	



8. The outer parts of the double helix make up the _____ backbone.

B.6 (A) Identify components of DNA, identify how information for specifying the traits of an organism is carried in the DNA, and examine scientific explanations for the origin of DNA.

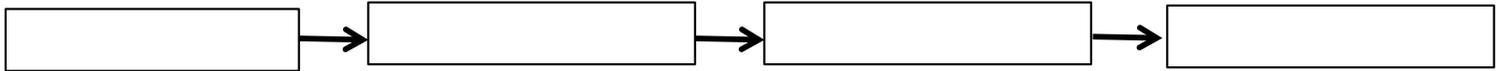
II. The Function of DNA- DNA provides instructions for the traits of an organism.

1. Which part of the DNA specifically codes for traits? _____

2. DNA provides the instructions for the physical characteristics of living things. This may include blood type (which is determined by proteins on the outside of red blood cells), eye color, bone structure, skin color, etc. How does the DNA within cells determine an organisms traits? (Hint: proteins)

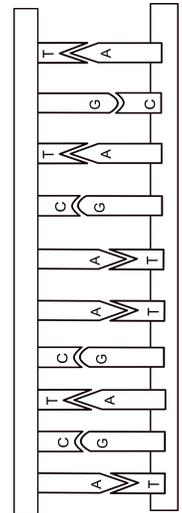
_____.

3. Fill in the boxes to put the following terms in the order that best explains the flow of physical characteristics from DNA to proteins: *amino acids, DNA, peptide chain, RNA*



4. How is it that some people have different DNA than others? What exactly about the DNA is different? _____

_____.



III. Scientific explanations for the origin of DNA

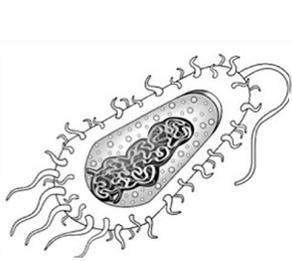


Scientist	Contribution to discovery of DNA
Rosalind Franklin	Franklin worked with Maurice Wilkins in the lab to help perfect X-ray crystallography, where her famous photo, Photo 51, helped reveal DNA's _____ structure.
Maurice Wilkins	His studies on X-ray diffraction images helped reveal the helical nature of DNA.
Erwin Chargaff	Discovered that DNA nucleotides was composed of 50% purines and 50% pyrimidines, which lead to the _____-_____ rules.
James Watson and Francis Crick	Used the works of other scientists to deduce that DNA's shape was a _____.

B.6 (B) Recognize that components that make up the genetic code are common to all organisms.

II. DNA is found in all living things.

Life can be classified into 6 kingdoms: archaeobacteria, eubacteria, animalia, fungi, plantae, and protista.



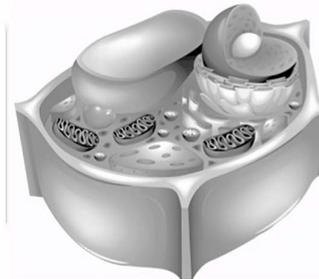
Bacteria single-celled organism



Protist single celled organism
(*euglena*)



Fungal cell
(mushroom)



Plant cell



Animal cell

1. Cells can vary throughout the kingdoms. For example, bacterial cells do not have organelles, but other cells do. However, there are also similarities among the different cell types. Examine the following list of terms and determine which ones are common to ALL cell types. Write the terms that are shared in the box below. Choose from the following terms:

DNA, nucleus, ribosomes, ability to photosynthesize, self-locomotion, membrane bound organelles, cell membrane

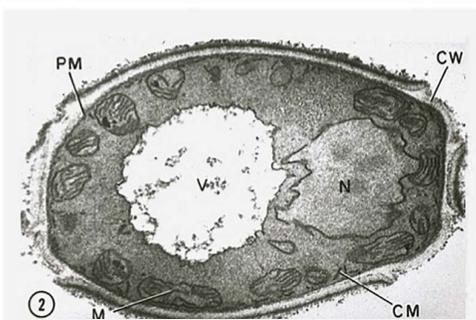
Common features among ALL cell types:

It was recently discovered that yeast (a type of fungus) can live with human genes. Though yeast do not have blood like humans do, they carry genes similar to the ones that humans have for regulating the growth of new blood vessels. Researchers decided to see if they could swap the genes found in yeast with the ones found in humans. They did this for over 400 different types of genes that were essential to the survival of yeast and were shared with humans, including genes for controlling metabolism and removing cellular waste.

What researchers found was that about half of the genes they tested could be swapped- the vital genes that were removed from the yeast were replaced with human versions of the same gene and allowed the yeast to survive.

Based on this information, the following conclusions could be made (circle all that apply):

- A. Yeast and humans depend on the same food supply.
- B. Yeast and humans have identical genes.
- C. Yeast and humans share a genetic code.
- D. Yeast are evolving into humans.
- E. All living things may have a common heritage.



Yeast cell
(Fungi Kingdom)

Assessment: DNA

1 The repeated unit of DNA, made up of a sugar, a phosphate, and a nitrogenous base, is known as a(n)–

- A** nucleotide.
 - B** double helix.
 - C** adenine.
 - D** thymine.
-

2 The genomes of an oak tree and a grizzly bear are similar in that–

- A** they share the same number of genes.
 - B** their DNA is made of the same components.
 - C** the DNA sequencing is identical.
 - D** they code for similar adaptations.
-

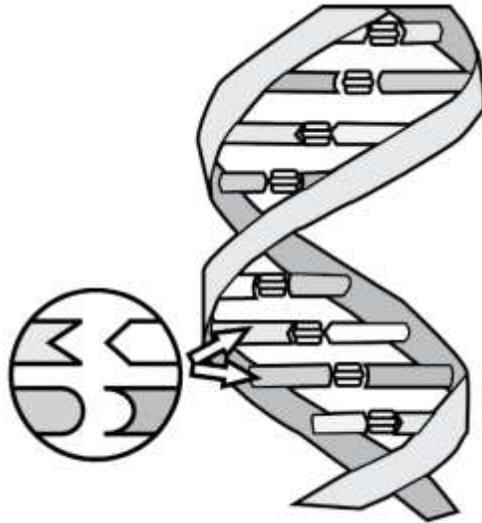
3 Which of the nitrogenous bases below would be classified as purines?

- A** Adenine and guanine
 - B** Adenine and cytosine
 - C** Thymine and guanine
 - D** Cytosine and thymine
-

4 A segment of a DNA strand is GTC TAG. Which of the following is the complementary DNA strand?

- A** GTC TAG
- B** GUC UTG
- C** CAG AUC
- D** CAG ATC

5 A diagram of the DNA double helix is provided.



The DNA components highlighted in the diagram can best be described how? They are–

- A** the sugar deoxyribose and a phosphate.
 - B** genes, one from each parent.
 - C** nitrogen bases held together by a hydrogen bond.
 - D** the amino acids that will code for a protein.
-

6 Which of the following factors determines the trait that a given gene will express?

- A** Type of gene being sequenced
 - B** Sequence of nucleotides in the gene
 - C** Number of times the gene appears
 - D** Amount of DNA replicated in the gene
-

7 The backbone of the DNA molecule is made up of–

- A** adenine and sugar.
- B** sugars and thymine.
- C** phosphates and adenine.
- D** phosphates and sugars.

- 8** In the 1960s, mitochondrial DNA was discovered with the use of an electron microscope. The presence of mitochondrial DNA in eukaryotic cells suggests what about the origin of life on Earth?
- A** Eukaryotic cells can function without DNA.
 - B** The DNA molecule existed before mitochondria.
 - C** Mitochondria may have been free-living cells.
 - D** Life originated from mitochondrial DNA.

Day	Objective/TEKS	Agenda
3 and 4	<p>TEKS B.6C (S): explain the purpose and process of transcription and translation using models of DNA and RNA</p> <p>TEKS B.6D (S): recognize that gene expression is a regulated process</p> <p>TEKS B.6E (R): identify and illustrate changes in DNA and evaluate the significance of these changes</p>	<ol style="list-style-type: none"> 1. Watch these videos: <ol style="list-style-type: none"> a. The Central Dogma of Biology https://youtu.be/9kOGOY7vthk  b. DNA Transcription https://youtu.be/SMtWvDbfHLo  c. mRNA Translation https://youtu.be/Tfyf_rPWUdY  d. Gene Regulation https://youtu.be/3S3ZOmleAj0  e. Mutations https://youtu.be/eDbK0cxKKsk  2. Read Transcription and Translation. While you read, complete Linking Literacy: Categorized Notes Chart 3. Guided Practice: Transcription and Translation 4. Math Connections: Transcription and Translation 5. Reading in Science: Gene Regulation and Expression

		<ul style="list-style-type: none">6. Writing Science: Transcription and Translation7. STAAR Tune-Up: Transcription and Translation and Gene Expression8. Assessment: Transcription and Translation
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Transcription and Translation

Reflect

Cookbooks contain the ingredients and steps needed to make many kinds of dishes. Some cookbooks contain hundreds of recipes. However, someone needs to use a cookbook in order to create the dishes. Without a chef as an intermediary, cookbooks are simply words on paper.

DNA (deoxyribonucleic acid) is similar to a cookbook. It contains a lot of information. But, until an intermediary makes that information useful, DNA is simply a string of nucleic acids. How is DNA turned into something useful?

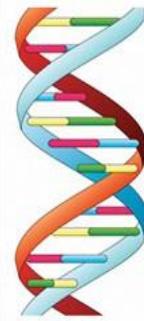


DNA Structure and Function

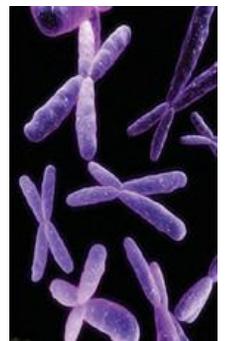
DNA is a nucleic acid made up of a string of nucleotides. These nucleotides are joined in a double-helix configuration, much like a winding staircase. In eukaryotic cells, DNA is packaged in the cell nucleus as **chromosomes**. The nucleus is the control center of the cell. When a cell divides, its chromosomes are replicated, and a complete set of genetic information is passed on to each daughter cell.

chromosome: a linear strand of DNA that is wrapped around protein structures; it carries the gene sequence of an organism

Genes are located on chromosomes and are sections of DNA that code for a specific protein. These proteins contribute to a specific hereditary trait or characteristic. When a gene's code is used to produce a protein, that gene is considered to be expressed.



Gene expression takes place in two steps: transcription and translation. *Transcription* is a process in which a complementary strand of RNA is formed from the section of DNA that contains a gene. The RNA is then used as a template to produce a protein through a process called *translation*. Each of these processes is tightly controlled. If something goes wrong at any step, the results can be deadly. You will learn more about the steps involved in transcription and translation later in the lesson.



Regulating Gene Expression

In addition to genes, a strand of DNA also contains a number of *regulatory elements* that help control gene expression. Regulators can help turn genes on, causing genes to be expressed, while other sections of DNA or proteins can turn genes off, or prevent gene expression. Some genes are *housekeeping genes* that are always turned on to code for proteins that are always needed. Certain proteins can make it easier for transcription to occur. These proteins help increase gene expression. Certain sections of DNA mark where a gene begins and ends, which helps the process of transcription occur in the correct area of DNA. Cells typically produce a specific protein only when it is needed.

DNA forms a double-helix, with hydrogen bonds between nucleotides holding the two strands together (left). DNA strands fold into larger chromosomes in eukaryotic cells (right).

Transcription and Translation

What Do You Think?

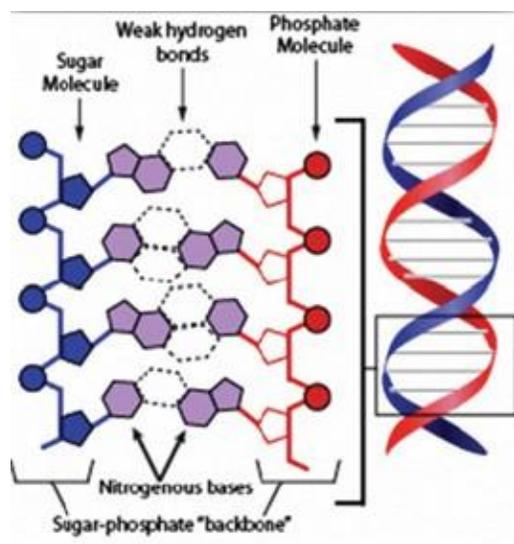
Drug companies are developing more specific drugs that target diseases with fewer side effects. This type of personalized medicine relies on identifying the genes involved in a person's disease. Some people worry that insurance companies will use this genetic information to deprive patients of insurance coverage. Is the risk of sharing your genetic information worth gaining access to life-saving drugs?

Transcription

Transcription uses DNA as the template for making RNA. Recall that DNA is made up of four nucleotides: adenine (A), guanine (G), thymine (T), and cytosine (C). Along the outer edges of each strand, the nucleotides are linked together by strong **covalent bonds**. These bonds form between the phosphate and deoxyribose sugars of adjacent nucleotides.

covalent bond: a chemical bond formed between atoms that share electrons

As shown in the diagram on the right, hydrogen bonds form between the two strands of DNA in a process called *base pairing*. Adenine bonds only with thymine, and cytosine bonds only with guanine. These are called *complementary base pairs*. Hydrogen bonds are much weaker than covalent bonds. This bonding structure allows the two complementary strands of DNA to separate from each other during transcription. Enzymes called *helicases* are responsible for separating the DNA strands.



Transcription takes place within the cell's nucleus, and is the first step in a process that will produce a protein with a specific function. First, the complementary DNA strands separate at the site of the gene to be expressed. Then, a series of proteins called *RNA polymerases* move in to the now-available DNA, and synthesize a strand of RNA based on the DNA template. (In the diagram on the right, the RNA strand is shown in green.) This RNA is called *messenger RNA*, or mRNA, because it is the message used to produce a protein.

Transcription and Translation

What Do You Think?

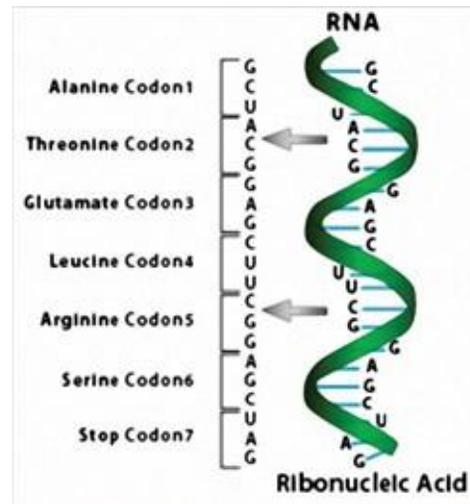
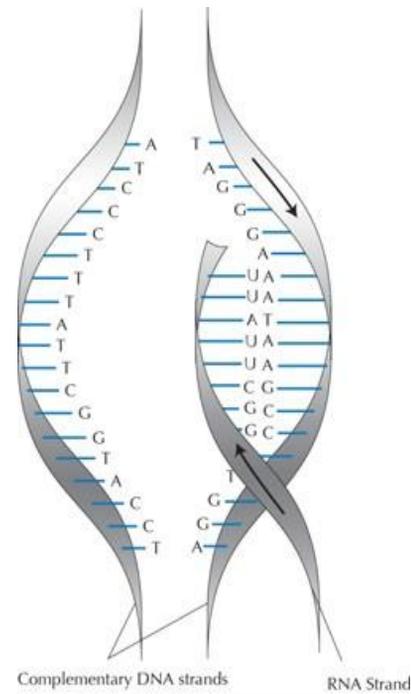
Similar to DNA, RNA is also made up of nucleotides. However, the nucleotides in RNA are slightly different: adenine, cytosine, guanine, and uracil. When mRNA is being formed, guanine is matched to cytosine in the DNA, and cytosine to guanine. Adenine still pairs with thymine in DNA. However, it is uracil that is added to mRNA as the partner for adenine.

After it is made, the mRNA separates from the DNA and then leaves the nucleus and enters the cytoplasm for the next steps in the protein production process, translation.

Translation

The purpose of translation is to convert the information in the mRNA into an amino acid sequence, which will form a protein. Translation takes place in a cell's cytoplasm, after the mRNA has exited the nucleus. Translation depends on "translating" three-letter groups of nucleotides in the mRNA, called *codons*. Most codons correspond to specific amino acids. Three of the codons are *stop codons*. When one of these codons occurs, it is the signal to stop adding amino acids.

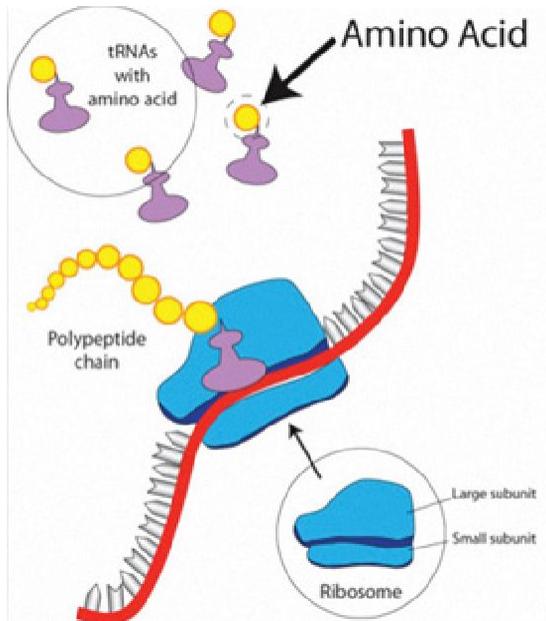
You can remember *transcription* if you create a mental image of someone rewriting/transcribing your class notes (a scribe is someone who copies). You can remember *translation* if you think of RNA as being a nucleic acid language that is **translated** into an amino acid language.



Codons are sets of three nucleotides in mRNA that determine which amino acids are linked together to make a protein.

Transcription and Translation

What Do You Think?



Translation is carried out by organelles called *ribosomes*. Ribosomes either float freely in the cytoplasm or, in eukaryotes, can be found attached to the endoplasmic reticulum. Ribosomes are responsible for “reading” the nitrogenous bases of the mRNA and forming the polypeptide chain that forms the primary structure of a protein. Ribosomes are miniature protein production factories made of ribosomal RNA (rRNA).

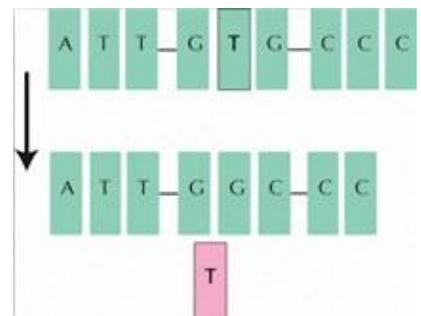
When mRNA is available in the cytoplasm, a ribosome attaches to the mRNA molecule and reads the mRNA one codon at a time. Another type of RNA called transfer RNA, or tRNA, is responsible for bringing amino acids to the ribosomes. Each tRNA carries a different kind of amino acid; tRNA molecules recognize specific codons through complementary base pairing. The recognition sequence is the opposite of the codon, so it is called the *anticodon*.

tRNA carries amino acids to the ribosomes, where they are added to the polypeptide chain formed by ribosomes.

As each amino acid is brought to the ribosome, it is added to the growing polypeptide chain. Amino acids link together through peptide bonds between neighboring amino acids. This process continues until a stop codon is reached and no additional amino acids are added to the polypeptide chain. The ribosome releases the polypeptide chain, which may undergo further processing elsewhere in the cell before it reaches its final form as a fully functional protein.

Mutations

Changes to DNA are called *mutations*. Think about a recipe for pizza dough in a cookbook. If you substituted sugar for salt, would your dough taste the same? Probably not! In a similar way, if the genetic message changes, the protein may change, or it may not be created at all. Mutations are heritable, permanent changes that are passed on to the next generation of cells when the cell divides.



Removing a single DNA nucleotide shifts the entire reading frame. Different codons are produced in the ribosome, resulting in a very different protein.

What Do You Think?

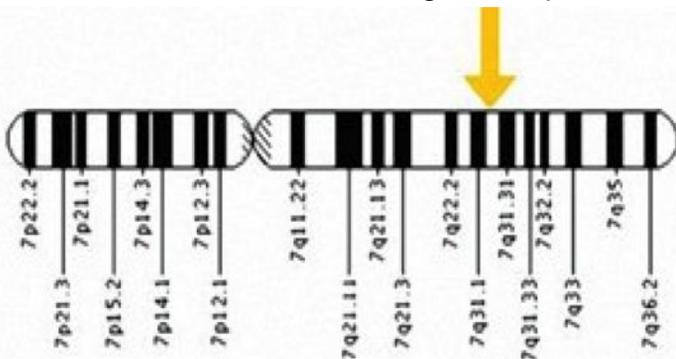
Some mutations are called *point mutations*. They occur in a single area of DNA. One type of point mutation is a substitution. For example, consider what happens if the codon UAC changes to UAA. UAC codes for tyrosine. UAA is a stop codon. By substituting a single nucleotide for another, the message changes from “add a tyrosine” to “stop adding nucleotides here.” This results in a shorter-than-normal peptide that may not be functional in this shorter form. This single change can “knock out” the protein. Sometimes substitutions do not affect the final protein. Consider a change from UAC to UAU. Although the third nucleotide has changed, both codons code for tyrosine, so the final protein is the same.

Sometimes point mutations result in a *frame-shift mutation*. In this case, a single nucleotide is added or deleted to the DNA sequence. This causes a shift in what is called the reading frame. Because DNA is read three bases at a time in a ribosome, an insertion or deletion can cause the wrong amino acids to be added to the chain. This usually results in the assembly of a nonfunctional protein.

Mutations happen on a daily basis. Some are caused by errors in the cell replication process. Others are caused by exposure to chemicals or ionizing radiation. There are proteins in the cell whose job is to constantly scan DNA looking for damage that needs repair. However, sometimes they miss damaged DNA, and the damage is passed on to the next generation of cells. Sometimes, the damage takes place in areas of DNA that are not expressed. In these cases, the changes are considered harmless. Mutations that affect cell growth cause *cancer* (uncontrollable cell division in the body.)

Getting Technical: Gene Knockouts

Scientists will sometimes deliberately cause genetic mutations in an organism. A *gene knockout* is a process in which a gene in an organism has been made nonfunctional by a directed mutation. This process can help scientists understand the function of a gene. For example, suppose scientists inactivated a particular gene in a mouse genome, and the resulting mouse was hairless. The scientists would know the gene in question was related to hair growth. Knockout organisms scientists have bred knockout mice with various fibrosis. This disease is caused by mutations



The CTFR gene is on chromosome 7, at the location indicated by the yellow arrow. Changing a single amino acid in this gene can cause cystic fibrosis.

Transcription and Translation

What Do You Think?

A DNA mutation is not always harmful. If a section of DNA is changed that has no real use in a cell, the resulting mutation is harmless. In addition, if the mutation occurs in a non-coding section of the DNA, it is unlikely to cause any harm. Some mutations even increase the survival rates of individuals and are therefore more likely to be passed on to future generations. For example, if a mutation causes a color change in an animal and the color change helps the animal hide from predators, that animal will likely survive and reproduce.

What do you know?

Use what you have learned about transcription and translation to complete the chart below. Read each description in the left column. Then, in the right column, write whether each is associated with transcription, translation, or both.

Description	Transcription, Translation, or Both?
A process that is a vital step in protein production	
DNA strands separate from each other	
Amino acids are linked together in a polypeptide	
Takes place in the cytoplasm	
Takes place in the nucleus	
Involves the use of helicase	
Requires tRNA and mRNA	
Uses information from a gene to produce a specific protein	



Linking Literacy

Name: _____ Date: _____

Categorized Notes Chart

As you read, look for information on the following three topics and record details about each one.

Topic: DNA	Topic: Transcription	Topic: Translation
Detail:	Detail:	Detail:



Guided Practice

Name: _____ Date: _____

Transcription and Translation

Answer the questions below.

1. Do the processes of transcription and translation occur in the same cellular structure? Why or why not?
2. What type of biomolecule does the process of transcription result in?
3. What type of biomolecule does the process of translation result in?
4. How does the resulting strand of RNA differ from the original strand of DNA during the process of transcription?
5. What is the relationship between the processes of transcription and translation? How do the results of one contribute to the other?

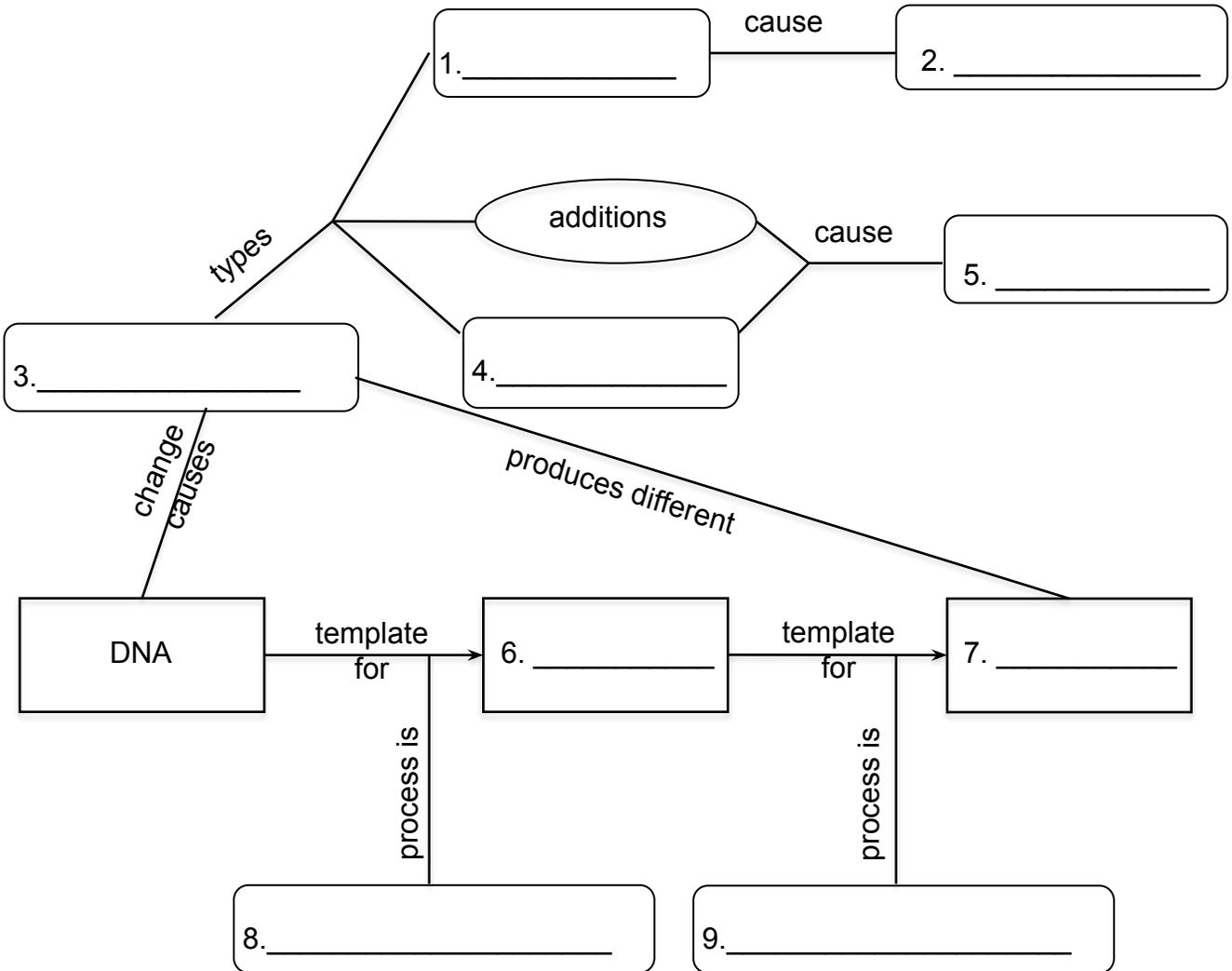


Guided Practice

Transcription and Translation, continued

Using all of the following terms in the word bank, complete the graphic organizer.

Word Bank
 deletions frameshift mutations mutations point mutations
 proteins RNA substitutions transcription translation





Math Connections

Name: _____ Date: _____

Transcription and Translation

Transcription is the process of synthesizing RNA from DNA code. Translation is the process of synthesizing proteins by linking specific amino acids together in an order determined by the codons found in the messenger RNA (mRNA). Codons are sets of three specific nucleotides. Each codon designates a specific amino acid, except for the three “stop” codons, which cause the newly synthesized polypeptide to be released from the ribosome. Ribosomes contain ribosomal RNA (rRNA) and, in combination with transfer RNA (tRNA) and mRNA, facilitate translation by allowing the mRNA to be read and the amino acids to be linked together to form a protein.

DNA Codon Usage

For most amino acids, there is more than one codon that can be translated into that particular amino acid. For these amino acids, some codons are used more often than others in the DNA sequence.

1. If there are 4 different bases (A,T,C, and G) that can make up a triplet codon, how many different codons are possible? How can you represent this mathematically without counting all the combinations below? (Hint: Think exponents.)

Amino Acid	DNA Codons
Isoleucine	ATT, ATC, ATA
Leucine	CTT, CTC, CTA, CTG, TTA, TTG
Valine	GTT, GTC, GTA, GTG
Phenylalanine	TTT, TTC
Methionine	ATG
Cysteine	TGT, TGC
Alanine	GCT, GCC, GCA, GCG
Glycine	GGT, GGC, GGA, GGG
Proline	CCT, CCC, CCA, CCG
Threonine	ACT, ACC, ACA, ACG
Serine	TCT, TCC, TCA, TCG, AGT, AGC
Tyrosine	TAT, TAC
Tryptophan	TGG
Glutamine	CAA, CAG
Asparagine	AAT, AAC
Histidine	CAT, CAC
Glutamic acid	GAA, GAG
Aspartic acid	GAT, GAC
Lysine	AAA, AAG
Arginine	CGT, CGC, CGA, CGG, AGA, AGG
Stop codons	TAA, TAG, TGA



Math Connections

2. A protein consisting of 110 amino acids has been translated from a mRNA strand. Below is a table of the DNA codons transcribed to the mRNA used to build the protein. Using the DNA codon table from page 1 and your knowledge of DNA, RNA, and amino acids, complete the table below and answer the following questions. (Hint: total times is 110. Find percent by division.)

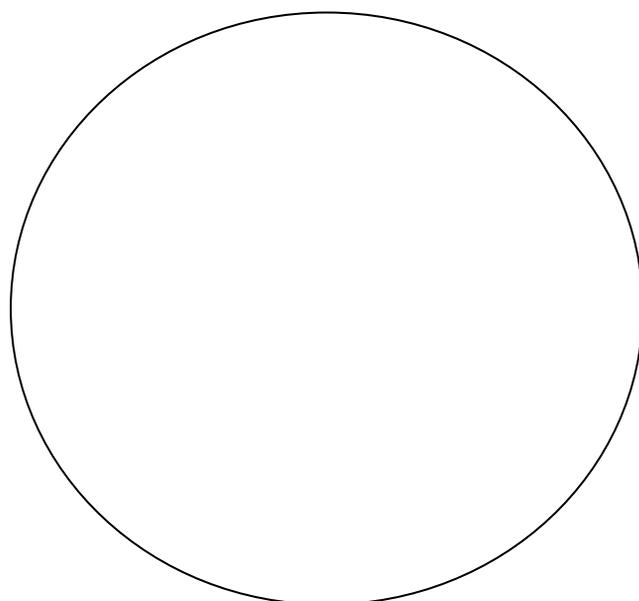
DNA Codon	Number of Times Used in DNA Sequence	% Used in DNA Sequence	Amino Acid
GGT	8		
TTT	4		
TGG	3		
GGG	13		
CAA	6		
CAG	19		
GGC	18		
TAT	9		
GGA	13		
TTC	6		
TAC	11		

3. Each codon contains 3 nucleotides. How many nucleotides are in the protein represented in the chart? (Remember that codons are used 110 times.)

4. Which amino acid made up the largest portion of the protein? What percent did it represent? (Add up percent for each amino acid.)

5. For the amino acid named in question 4, list all of the codons representing that amino acid in the protein. Calculate the percent usage for each one. Create a circle graph to represent the data in the table.

Codon	Number of Times Used in DNA Sequence	Codon Usage (%)
Total:		100%



LEGEND

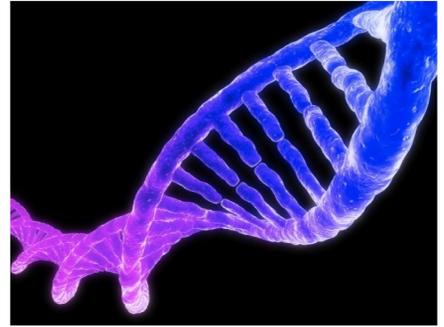


Reading Science

Name: _____ Date: _____

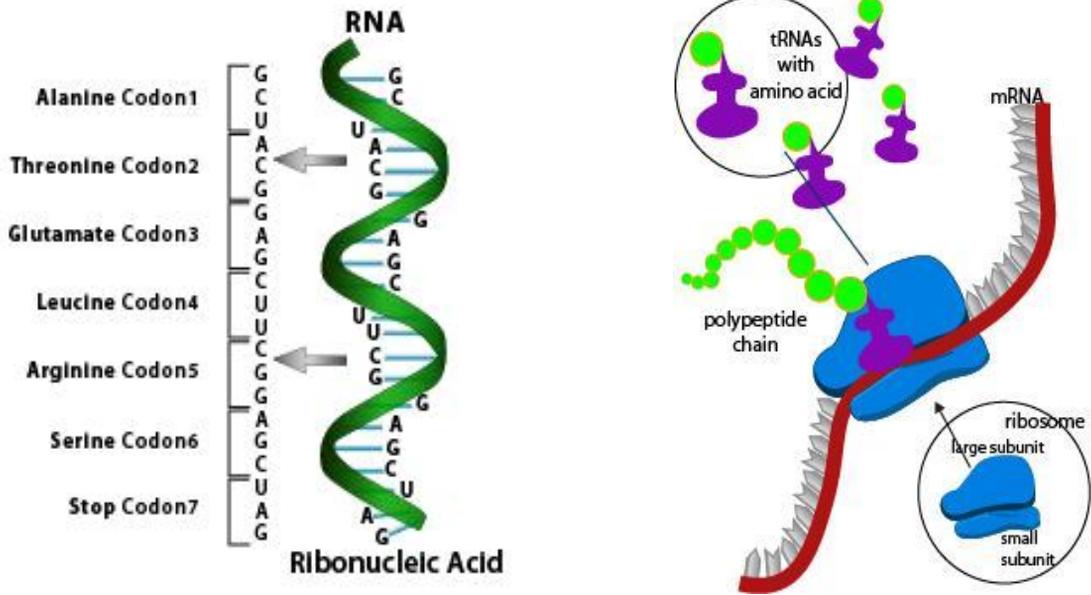
Gene Regulation and Expression

1 Most of the traits that can be observed in organisms come from the genetic information contained within their genes. The genes found in our DNA control everything about us: our hair color, our skin color, our sex, our height, etc. Imagine looking at a picture of two parents and their children. You can see that the mother has certain traits, and the father has certain traits. Their children usually have a mixture of those traits.



- 2 But, how does this occur, and how is it regulated? These genes are signaled at specific times. The information contained in those genes will then be used to manufacture proteins that perform specific functions. Our traits are determined by the proteins which are produced. It is important to understand that this process does not just work for humans. This process of gene regulation and expression works for all living organisms.
- 3 So, what is a gene? In order to understand what a gene is, you must first understand what DNA is. DNA, or deoxyribonucleic acid, is the molecule that contains all of an organism's genetic information. Each single-celled prokaryote contains a single strand of DNA. Eukaryotic cells contain a greater amount of DNA, coiled into several separate structures called chromosomes. Each cell carries the same set of chromosomes, an exact copy of that organism's genetic material. There are non-coding regions on the DNA strand. There are also coding regions. These coding regions are known as genes. If you look at the illustration above, you will see that a gene is simply a coding section of the DNA strand. But, how does the information contained in the gene become a useful protein?
- 4 There are internal and external signals that will trigger the process that transcribes a gene and ultimately, results in a needed protein. The signal is registered, and the required coding section of the DNA is uncoiled and made ready for the initiation of the process. The information contained in that gene is transcribed from the DNA strand to an RNA strand template. This RNA template is also known as mRNA. In a eukaryotic cell, the RNA template must travel out of the nucleus, where it was created, and into the cytoplasm. The mRNA carries the information from the gene. That information will be translated into a polypeptide strand that will become a functional protein. Let us break this process down into its individual steps.

Reading Science



- The first illustration above shows a model of an RNA strand. This strand holds the transcribed information from the master DNA strand coding section, or gene. You will see that the information on this strand occurs in a series of 3-letter nucleotide units, or codons. Each of these codons will then code for a specific amino acid (listed to the left of the RNA strand.) But, how does this process create a protein?
- The second illustration shows a model of how the information contained on an mRNA strand is translated into a protein. This process occurs in the cytoplasm on the ribosomes. The mRNA strand will be “pulled” through the ribosome. The ribosome will “read” the codons. A complementary tRNA molecule will then attach the appropriate amino acid to the growing polypeptide chain. It is the codon sequence on the mRNA strand that determines the amino acid sequence of the polypeptide. The polypeptide chain will continue to grow until a “Stop” codon is reached, signaling the ribosome to stop the translation process. The polypeptide chain will then be released to take on its functional shape as a protein. The protein may be used as a structural protein, as an enzyme to catalyze a specific chemical reaction, or as a chemical message to communicate with other cells.



Reading Science

- 7 So, why is this process important to you – and all other organisms? Every cell within a multicellular organism carries the same set of chromosomes. Each set of DNA strands carries all of the necessary genes, but not all of the genes are used (expressed) at the same time. Even in a prokaryote, with its one simple strand of DNA, only a small number of genes might be expressed at any particular time. Think of the DNA molecules as being a set of recipe books with all of the directions for everything a cell needs to make. Some proteins need to be made early in the life of a cell, while some proteins are needed as it grows and matures. Some proteins are needed for it to function throughout its life.
- 8 Signal molecules are sent to the genes of an embryo that will regulate which genes are transcribed during this phase in order to regulate the development of the embryo. Once the embryonic phase is completed, new signals will trigger other genes to regulate the growth of the organism. Once mature, there are still other genes that regulate the daily functions of the organism. All of these genes code for different specific proteins. It is these proteins that regulate the specific functions and traits of the organism during each phase of its life.



Reading Science

1 What does the codon sequence on the mRNA strand determine?

- A The gene sequence of the DNA
 - B The amino acid sequence of the polypeptide
 - C The codon that is signaled
 - D The signaling sequence
-

2 What portion of the DNA is also known as a gene?

- A The coding sections
 - B The non-coding sections
 - C The mRNA strand
 - D The polypeptide sequence
-

3 Which is of the following statements **best** describes the structure, or makeup, of a codon?

- A A codon is a 3-letter nucleotide sequence found on the tRNA.
- B A codon is a growing polypeptide chain.
- C A codon is a gene sequence found on the DNA strand.
- D A codon is a 3-letter nucleotide sequence found on the mRNA.



Reading Science

- 4** What is true regarding genes and DNA?
- A** Each DNA strand contains identical genes.
 - B** The DNA only transcribes the genes that it needs at specific times.
 - C** Both A and B
 - D** None of the above
-
- 5** Where in the cell is the information from the mRNA strand translated into a polypeptide chain?
- A** The ribosomes
 - B** The cell membrane
 - C** In the nucleus
 - D** On the DNA strand
-
- 6** Why is gene regulation and expression important to all living organisms?
- A** Specific signals trigger specific genes to be transcribed and translated.
 - B** The proteins created from this process determine most of the organism's traits.
 - C** Different phases of the life cycle require specific genes for growth and development.
 - D** All of the above

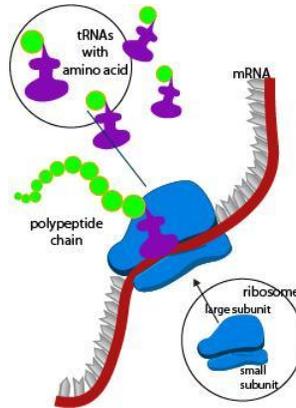


Writing Science

Name: _____

Date: _____

Look



Think

Think about how your proteins are synthesized in your body.

Codons found on RNA, or ribonucleic acid, code for one of 20 amino acids. Which amino acids translated from the 3-nucleotide sequences can be determined using a codon chart like the one on Page 2? The sequence of amino acids creates a strand of polypeptides and eventually a protein.

For example, your cell signals the need for a certain protein. The code for the protein was transcribed from the DNA strand to the mRNA strand as GUA UUU GGA CGU UGA. The mRNA strand is translated using the codon chart, and the amino acid sequence would be valine, phenylalanine, glycine, arginine, and stop.

Sometimes there are errors that occur during transcription and the formation of the mRNA strand. These errors known as mutations can lead to further errors during the translation process.

Example: DNA: TTA CGC AAC TGG CTA ATT
mRNA: AAU GCG UGA CCG AUU AAC

Write

Identify the type of mutation that occurred in the sequence above and evaluate the significance of these changes.

Be sure to –

- Address the prompt, provide support, and conclude your thoughts.
- Write legibly and concisely.

Writing Science

CODON CHART

	U	C	A	G			
U	UUU UUC	<u>Phenyl</u> alanine	UCU	UAU UAC	<u>Tyrosine</u>	UGU UGC	U C G A
	UUG UUA	<u>Leucine</u>	UCC UCA UCG	UAA STOP	UGA STOP	UGG <u>Tryptophan</u>	
				UAG STOP			
C	CUU CUC CUA CUG	<u>Leucine</u>	CCU CCC CCA CCG	CAU CAC	<u>Histidine</u>	CGU CGC CGA CGG	U C G A
				CAA CAG	<u>Glutamine</u>		
A	AUU AUC AUA	<u>Isoleucine</u>	ACU ACC ACA ACG	AAU AAC	<u>Asparagine</u>	AGU AGC	U C G A
	AUG START or <u>Methionine</u>			AAA AAG	<u>Lysine</u>	AGA AGG	
G	GUU GUC GUA GUG	<u>Valine</u>	GCU GCC GCA GCG	GAU GAC	<u>Aspartic</u> Acid	GGU GGC GGA GGG	U C G A
				GAA GAG	<u>Glutamic</u> Acid		

B.6 (C) Explain the purpose and process of transcription and translation using models of DNA and RNA

I. Role of DNA and RNA in protein synthesis

- DNA provides the (circle one) [genetic instructions | carbohydrates] required to build [proteins | lipids].
- Fill in the table below. Provide a description and/or function of each type of RNA: mRNA (messenger RNA; tRNA (transfer RNA) and rRNA (ribosomal RNA).

Type of RNA	Description/Function
mRNA	
tRNA	
rRNA	A type of RNA that is found within _____ and help to link together _____ acids during translation.

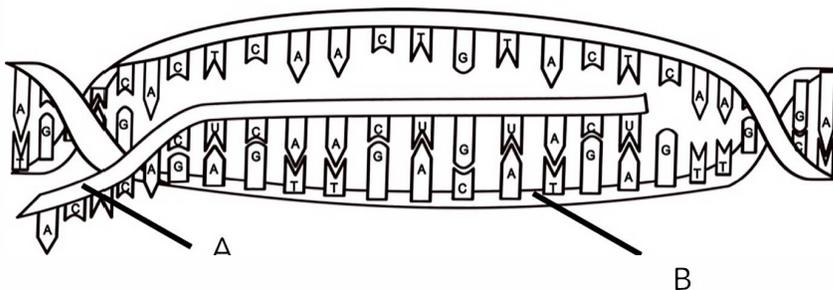
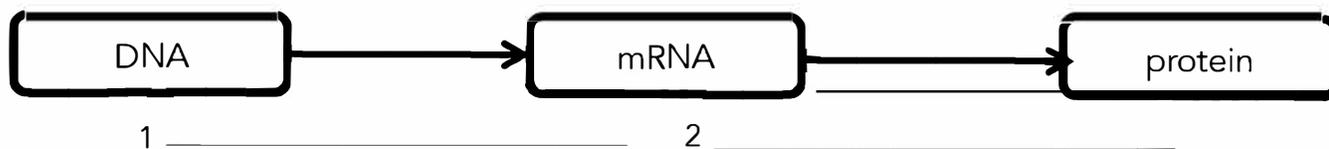
- Why does DNA rely on RNA? Why can't DNA deliver the instructions to the ribosomes directly?
-

4. DNA contains the sugar _____; RNA contains the sugar _____.

5. DNA contains the nitrogen bases adenine, cytosine, guanine, and _____. RNA contains the nitrogen bases adenine, cytosine, guanine and _____.

II. Transcription and Translation

Below is a simple flow chart. Notice two arrows: one between DNA and mRNA, and one between mRNA and protein. On each line, determine whether to write transcription or translation to best place each process.



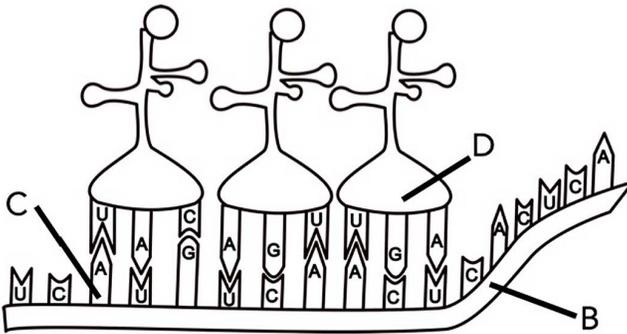
3. What is the name of the process illustrated at left? _____

4. Write the names of the molecules labeled on the illustrated in the spaces below:

- A. _____
 B. _____

B.6 (C) Explain the purpose and process of transcription and translation using models of DNA and RNA

II. Transcription and Translation continued



5. What is the name of the process illustrated at left? _____

6. Write the names of the molecules labeled on the illustrated in the spaces below:

- C. _____
D. _____

Process	Where it occurs:	Molecule it creates:
7. Transcription		
8. Translation		

III. Decoding the Genetic Code

Use the DNA code below to make proteins! Start with transcribing the DNA into mRNA, and then translating the mRNA into proteins.

T A C G G C A A T C C C A T T

		Second Position				
		U	C	A	G	
First position (5'end)	U	UUU } Phenylalanine UUC } UUA } Leucine UUG }	UCU } Serine UCC } UCA } UCG }	UAU } Tyrosine UAC } UAA } Stop UAG }	UGU } Cysteine UGC } UGA } -stop UGG } -Tryptophan	U C A G
	C	CUU } Leucine CUC } CUA } CUG }	CCU } Proline CCC } CCA } CCG }	CAU } Histidine CAC } CAA } Glutamine CAG }	CGU } Arginine CGC } CGA } CGG }	U C A G
	A	AUU } Isoleucine AUC } AUA } Methionine AUG }	ACU } Threonine ACC } ACA } ACG }	AAU } Asparagine AAC } AAA } Lysine AAG }	AGU } Serine AGC } AGA } Arginine AGG }	U C A G
	G	GUU } Valine GUC } GUA } GUG }	GCU } Alanine GCC } GCA } GCG }	GAU } Asparagine GAC } GAA } Glutamic Acid GAG }	GGU } Glycine GGC } GGA } GGG }	U C A G

- mRNA codons= _____
- tRNA anticodons= _____
- Amino acid sequence= _____

B.6 (D) Recognize that gene expression is a regulated process.**II. Gene Regulation**

Gene expression is regulated by processes that control the rate of gene expression. Use the following terms to fill in the paragraph below:

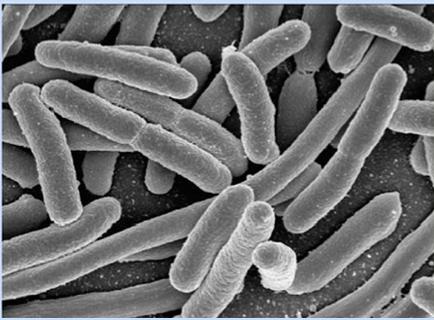
Turned on; environment; DNA sequence; function; regulation

1. All cells within an organism contain the same _____, but not all the same genes are used by all cells. What genes are used depends on the cell's _____.

- *Example, nerve cells and muscle cells create different proteins.*

Genes that are not expressed all the time need to be turned on or off, like a light switch. Gene _____ is the ability of a cell to control which genes are _____ in response to the _____.

E. coli

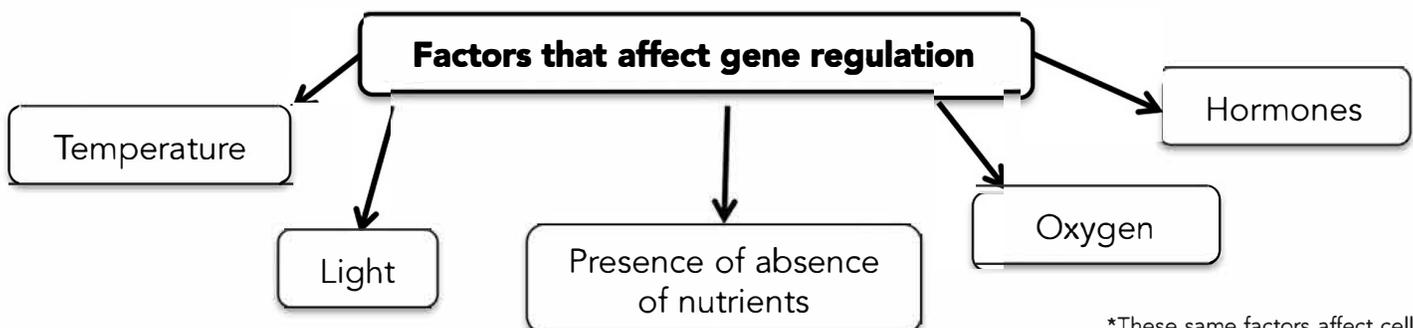


E. Coli can obtain its energy from glucose or lactose. Both are sugars, but glucose is a monosaccharide and lactose is a disaccharide.

In order to use lactose, E. Coli needs to digest it first using the enzyme **lactase**. (Recall that enzymes are proteins!)

Typically, E. Coli does not create the enzyme lactase, though it can if it needs to. An **operon** is a gene that controls transcription of genes in response to changes in the environment. E. Coli contains a gene called the **lac operon**, which is usually turned off. However, if no glucose is available, but lactose is present, the lac operon will turn on in response to the presence of lactose and the absence of glucose. When lac operon is turned ON, lactase is produced. Lactase breaks down lactose so E. Coli can use it as energy.

2. Explain how genes respond to the environment in the case of E. Coli's lac operon gene:



*These same factors affect cell differentiation. This is because gene regulation determines cell differentiation.

B.6 (D) Recognize that gene expression is a regulated process.**II. Gene Expression can be Influenced by the Environment**

Recall that gene expression is the process by which the information from a gene is used to make proteins or RNA. This also includes the expressed phenotype that is the result attributed to a particular gene.

Thomas Morgan Hunt was a biologist that did several experiments with insects and genetics. He exposed some caterpillars of the same butterfly species to different colored lights before they made their chrysalises to undergo metamorphosis. When they transformed into butterflies, they had different colors depending on which color light they were exposed to during development as caterpillars.

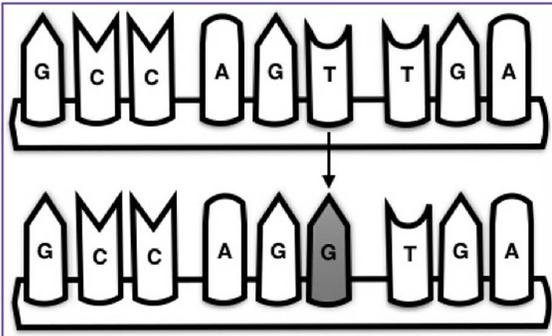


Color of Light Exposed to as Caterpillars	Color of Wings that Resulted from Experiment
No Light / Dark	Pale Blue
Blue Light	Pale Blue
Red Light	Brightly colored wings
Green Light	Dark colored wings

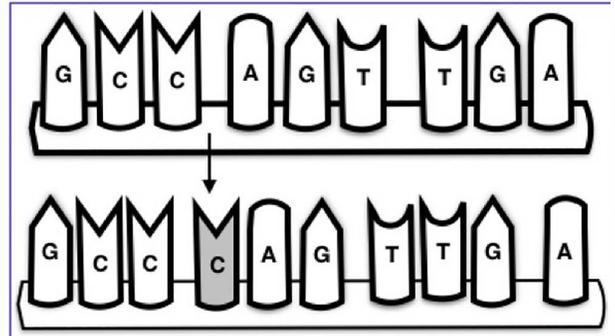
1. A classmate tries to argue that this result is because the butterfly wings must have absorbed the colors. Explain to them how gene expression played a role in the butterflies phenotypes.

B.6 (E) Identify and illustrate changes in DNA and evaluate the significance of these changes

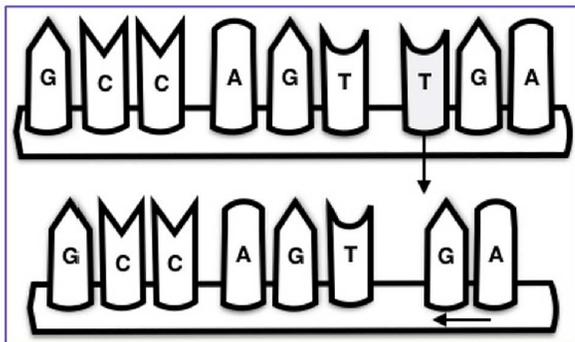
I. Types of Gene mutations- For each type of mutation illustrated below, determine if it is a deletion, insertion, or substitution.



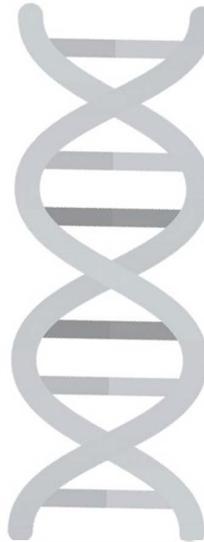
1. _____



2. _____



3. _____



4. Define mutation in your own words:

II. Frameshift Mutation vs. Point Mutation.

In the table below, determine if each type of gene mutation is a frameshift or point mutation.

Type of Gene Mutation	Check one		Description
	Frameshift	Point	
Insertion			
Deletion			
Substitution			

III. Mutations and their affect on the individual

1. Are all mutations a negative thing? Explain your answer.

B.6 (E) Identify and illustrate changes in DNA and evaluate the significance of these changes

		Second Position				
		U	C	A	G	
First position (5'end)	U	UUU } UUC } Phenylalanine UUA } UUG } Leucine	UCU } UCC } UCA } Serine UCG }	UAU } Tyrosine UAC } UAA } Stop UAG }	UGU } Cysteine UGC } UGA } -stop UGG } -Tryptophan	U C A G
	C	CUU } CUC } Leucine CUA } CUG }	CCU } CCC } CCA } Proline CCG }	CAU } Histidine CAC } CAA } Glutamine CAG }	CGU } CGC } Arginine CGA } CGG }	U C A G
	A	AUU } Isoleucine AUC } AUA } AUG } Methionine	ACU } ACC } Threonine ACA } ACG }	AAU } Asparagine AAC } AAA } Lysine AAG }	AGU } Serine AGC } AGA } Arginine AGG }	U C A G
	G	GUU } GUC } Valine GUA } GUG }	GCU } GCC } Alanine GCA } GCG }	GAU } Asparagine GAC } GAA } Glutamic GAG } Acid	GGU } GGC } Glycine GGA } GGG }	U C A G

IV. How mutations affect proteins

A DNA segment codes for the following peptide chain when translated:

Methionine Isoleucine Arginine Tyrosine Threonine

A substitution mutation occurs and causes the DNA segment to change to the following:

3' - TAC TAG GCA ATG AGG ACT -5'

1. What is the new peptide chain when the mutated DNA is translated?

In the same original DNA sequence, a substitution mutation occurs in a different codon, resulting in this new DNA segment:

3' - TAC TAG GCA ATT TGG ACA -5'

2. How does this affect the protein? _____

V. Passing on mutations

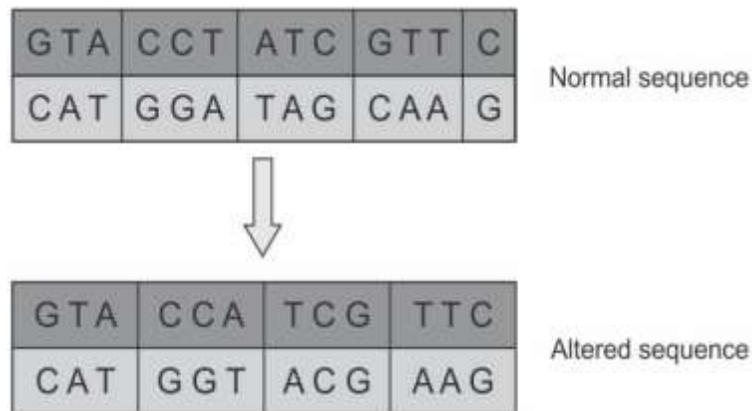
- _____ If a mutation occurs in an individual's body cells,
 - The individual begins to show a different phenotype to reflect the mutation.
 - Most likely nothing will occur as a result of the mutation.
 - Depending on the type of gene mutated, it may lead to cancer but most likely will not.
 - Both (b) and (c)
- _____ If a mutation occurs in a gamete (sex cell),
 - The individual will start showing a different phenotype to reflect the mutation.
 - The individual may pass on the changed gene to its offspring, which may have a different phenotype.
 - The individual will pass it on to its mating partner.
 - The individual will not be able to pass on mutated DNA.

Assessment: Transcription and Translation

- 1** The process of translation is responsible for producing which type of molecule?
- A** Polypeptide
 - B** RNA strand
 - C** DNA strand
 - D** New gene
-
- 2** A defective protein can be produced by a cell when a mutation has which of the following effects?
- A** Messenger RNA is prevented from being made.
 - B** It causes cells to divide in an uneven way.
 - C** An additional mRNA strand is caused to form.
 - D** The amino acid sequence coded by the gene is altered.
-
- 3** Which of the following is the best explanation of the process of translation?
- A** An mRNA strand is copied from the original DNA sequence.
 - B** Amino acids are placed in order to build a protein.
 - C** A piece of DNA is moved along the chromosome.
 - D** DNA is changed due to a mistake or environmental factor.
-
- 4** A strand of DNA is made of a segment of nucleotides in this order: GTCTAG. Which of the following sequences would be the correct complementary strand of RNA?
- A** GTCTAG
 - B** CAGATC
 - C** GUCUAG
 - D** CAGAUC

- 5 There are many factors that may cause a mutation in a gene. Which of the following events would be most likely to cause a mutation?
- A mRNA travels out of the nucleus.
 - B mRNA is released from the DNA strand.
 - C A nucleotide is inserted into a DNA strand.
 - D An enzyme transcribes mRNA in the nucleus.
-

- 6 The illustration shows a specific type of mutation that can occur during DNA replication.



Which type of mutation is represented by the illustration?

- A Insertion
- B Deletion
- C Point
- D Chromosomal

7 Which of the following stages is the first step during the process of transcription?

- A** A polypeptide strand is made.
 - B** Codons are read to produce an amino acid.
 - C** DNA is turned into an mRNA copy.
 - D** A section of DNA helix is unwound by an enzyme.
-

8 Sickle cell anemia is a disease in which red blood cells become irregularly shaped. The disease is caused by the presence of an incorrect amino acid in a certain protein. The disease most likely occurred due to an altered sequence of nitrogenous bases in the –

- A** original DNA in the nucleus.
 - B** transcribed mRNA strand.
 - C** tRNA on the ribosome.
 - D** complementary DNA strands.
-

9 All of the following are reasons for regulation of gene expression in eukaryotes EXCEPT –

- A** cell differentiation.
- B** embryonic development.
- C** expression of every gene.
- D** cell repair and replacement.

Day	Objective/TEKS	Agenda
5	<p>TEKS B.6.A (R): identify components of DNA, identify how information for specifying the traits of an organism is carried in the DNA, and examine scientific explanations for the origin of DNA</p> <p>TEKS B.6B (S) recognize that components that make up the genetic code are common to all organisms</p> <p>TEKS B.6C (S): explain the purpose and process of transcription and translation using models of DNA and RNA</p> <p>TEKS B.6D (S): recognize that gene expression is a regulated process</p> <p>TEKS B.6E (R): identify and illustrate changes in DNA and evaluate the significance of these changes</p>	<p>Use today to catch up and complete any assignments from this week that you did not finish.</p>