2 Unit Overview: DNA to Protein

Name: ______________________________

Teacher: ____________________________

2.1 Structure of Genetic Material

2.1.1 DNA Replication: Study
2.1.2 DNA Replication: Lesson QUIZ — Scoring: 20 points

2.1.3 Viruses and Bacteria: Study
2.1.4 Viruses and Bacteria: Lesson QUIZ — Scoring: 20 points

2.2 From DNA to Protein

2.2.1 Transcription: Study
2.2.2 Transcription: Lesson QUIZ — Scoring: 20 points

2.2.3 Translation: Study
2.2.4 Translation: Lesson QUIZ — Scoring: 20 points

Instructions: Read each question and answer choice carefully. Choose the ONE best answer. Use CAPITAL letters to record your answers on this page.

Lesson Quiz 2.1.2	***Lesson Quiz 2.1.4***	***Lesson Quiz 2.2.2***	***Lesson Quiz 2.2.4***
1. ______	1. ______	1. ______	1. ______
2. ______	2. ______	2. ______	2. ______
3. ______	3. ______	3. ______	3. ______
4. ______	4. ______	4. ______	4. ______
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7. ______	7. ______	7. ______	7. ______
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9. ______	9. ______	9. ______	9. ______
10. ______	10. ______	10. ______	10. ______
Score: _____ out of 20	***Score: _____ out of 20***	***Score: _____ out of 20***	***Score: _____ out of 20***

Instructions:

Students please *annotate, by highlighting or underlining*, words or sentences in the Study sections to show that you have read and studied the study sections prior to taking the quizzes.

DNA to Protein

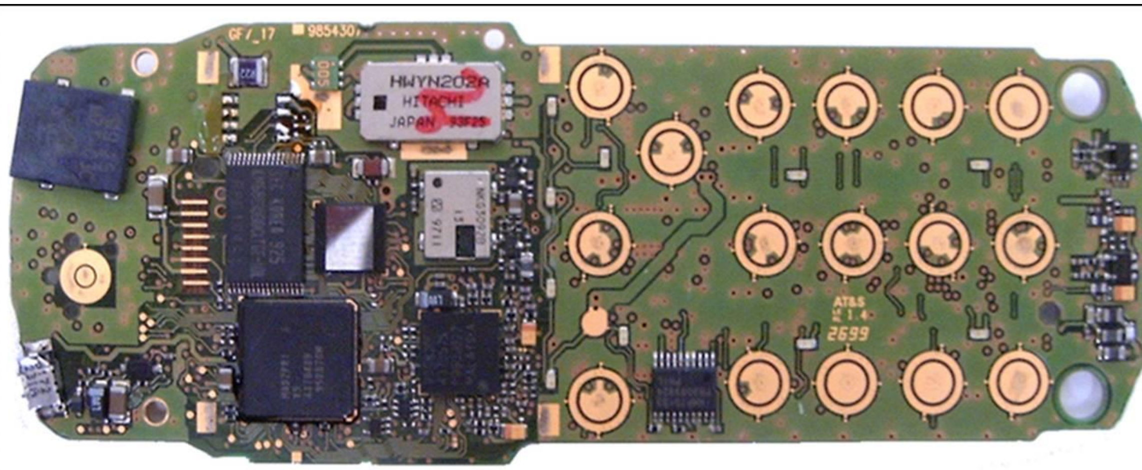
Understanding more about DNA has allowed scientists to understand how the DNA code leads to physical traits. Understanding more about the DNA code has also given scientists new tools to solve crimes, develop medicine, and create new technology.
What will understanding more about DNA do for you? Read on, study hard, and you may never see the world the same again.

Objectives:

- Describe the structure of a DNA molecule.
- Identify correct base pairing in DNA.
- Explain the process of DNA replication.
- Explain how viruses and bacteria transfer genetic information and cause infection.

2.1.1 Study: Organization of DNA

Structure of Genetic Material



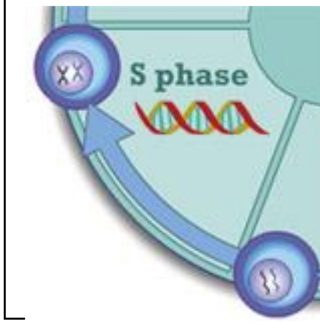
You may think the technology of communicating with a cell phone is amazing. But it's pretty simple compared with how information is carried in DNA. If you want to give some information to a friend, you might make a phone call or send a text or an e-mail. Cells transfer information to other cells by copying DNA.

Making a perfect copy of a DNA sequence is a highly regulated and precise process. Soon you'll find out how the millions of units in the DNA code get perfectly copied. You'll also find out how viruses and bacteria copy DNA in order to cause infection.

DNA Replication

DNA must be able to replicate without any errors.

DNA is replicated during the S phase.



Imagine a book with more than 1,000 pages. Your task is to copy this book, word for word, without making a single mistake. Is this possible? Now imagine that you have to copy the information in 1,000 books without a single mistake. This task may seem impossible, but this is what happens in a cell every time it divides. DNA is copied during the S phase of the cell cycle. The DNA in human cells contains over 10 billion atoms. Yet every time a cell divides, the copy of DNA in the new cell is perfect.

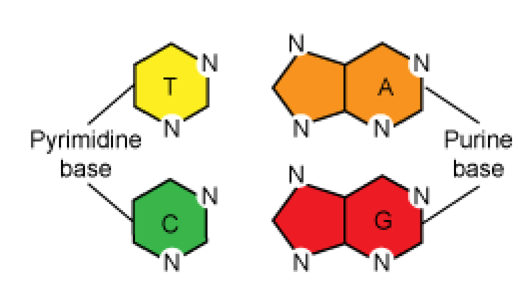
DNA Backbone

DNA is made of a sugar-phosphate backbone.

To understand how DNA can make a perfect copy of itself, it helps to first understand the structure of the molecule itself. The structure is what makes this replication possible.
DNA is a nucleic acid, made of many nucleotides bonded together. A nucleotide consists of three separate components: a base, a sugar, and a phosphate group. The sugar molecule found in DNA is called deoxyribose.
The nucleotides that form DNA join together in a chain. This chain makes up the backbone of the DNA molecule.

Nitrogenous Bases

DNA contains four different nitrogenous bases.



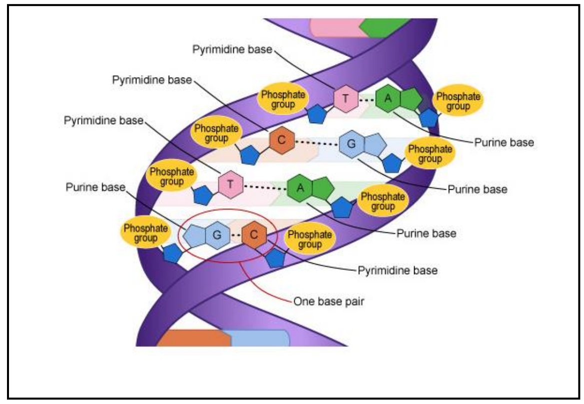
Attached to the phosphate backbone of DNA are four different bases. Each of the four bases contains atoms of nitrogen; this type of compound is sometimes referred to as a nitrogenous base. These bases are adenine, guanine, cytosine, and thymine. You'll often see them referred to by only the first letter in their names: A, G, C, and T. Adenine and guanine are each a purine, a double-ring nitrogenous base. Thymine and cytosine are each a pyrimidine, a single-ring nitrogenous base.
Scientists in the early 1900s knew about the bases that make up DNA. They also knew that DNA contained a phosphate group and a sugar molecule. They didn't know where the bases were located in the DNA or that DNA has a three-dimensional structure. Like other major scientific discoveries, it took the work of many scientists to discover the structure of DNA.

Discovering the Double Helix

The discovery of DNA's structure included the work of several scientists.

Mendel described how traits were passed down to offspring, without knowing that DNA was the molecule that carried these traits. Soon after, scientists discovered that genetic material was, in fact, DNA.
But no one knew the actual structure of the DNA molecule. They knew that it was made up of a backbone of sugar with phosphate groups and four nitrogenous bases, but not how it was all put together.
The scientists James Watson and Francis Crick were credited with the actual discovery, but many other scientists contributed.

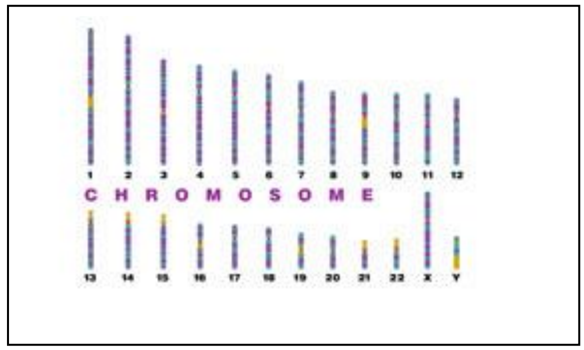
DNA Structure



DNA is shaped like a twisted ladder.

Watson and Crick described the DNA molecule as a double helix.
A double helix is shaped like a twisted ladder.
Each of the two strands has a sugar-phosphate group backbone on the outside and the bases on the inside.
Each rung of the DNA ladder is made of two bases held together by a hydrogen bond. These pairs of bases are called base pairs.

Chromosome 1



Each chromosome contains thousands of genes in millions of bases.

In the Human Genome Project, scientists from around the world figured out the entire sequence of DNA bases in the 23 pairs of human chromosomes.
In addition, they figured out thousands of genes that were coded for by these bases, and even determined sections of DNA that were involved in many diseases.
Click the image of the human chromosomes above to learn more about the Human Genome Project and to see what diseases have been mapped to certain chromosomes.

Base Pairing

Each of the DNA bases pairs in a very specific way.

A chromosome can contain up to 220 million base pairs. How can DNA make 220 million perfect copies of its bases?
The answer is surprisingly simple: Each of the bases can pair with only one of the other DNA bases.

- A and T pair with each other.
- C and G pair with each other.

These pairing rules are called Chargaff's rules, after Erwin Chargaff.

DNA Replication

DNA serves as its own template for reproduction.

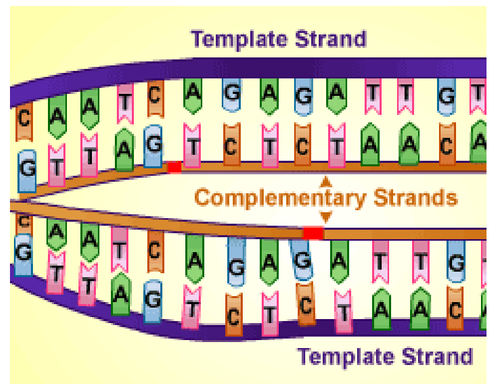
As soon as Watson and Crick discovered that DNA was a double helix with pairs of nitrogenous bases between the strands, they immediately understood what had previously been a mystery: how the process of DNA replication worked.
Each strand of the double helix functions as a pattern that the molecule uses to make a copy of the other strand. But before either strand of the helix can be used as a pattern, the DNA must unwind: the hydrogen bonds holding the strand together must be broken, and the double strand must separate.

This is achieved by the enzyme helicase. Helicase breaks the hydrogen bonds and unwinds a small section of DNA, creating a split between the two strands called a replication fork. At the replication fork, new nucleotides can be added.

Building the New Strand

As the double helix unzips, bases pair and make new strands.

Once the DNA is unzipped and separated, each strand is ready to be made into a new, complete DNA molecule. So what's missing from each strand? A second DNA strand. Where do the new DNA strands come from?



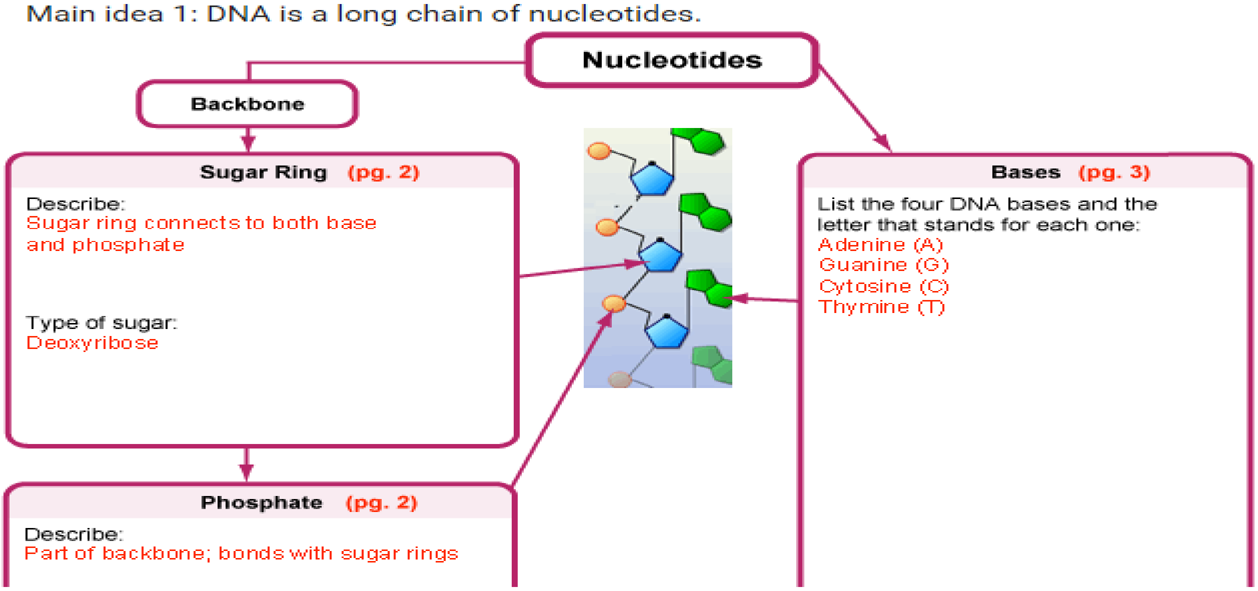
A DNA double helix unwinds to form two template strands. A complementary strand is built on each template strand. There are nucleotides floating around within the nucleus of each of your cells. The nucleus is where DNA is made. An enzyme called DNA polymerase is used to match up the floating nucleotides with each template strand. The new nucleotides become the second strand on each new DNA. This second strand is called the complementary strand.

DNA Enzymes

DNA ligase bonds together pieces of DNA; DNA polymerase checks the DNA.

Once all the new pieces of DNA are in place, how do they stick together? An enzyme called DNA ligase comes through and ties all of the chunks of new DNA together. The DNA polymerase is used at the end of the process of making new DNA. DNA polymerase checks the base pairs in each strand as they are built. This makes for a very accurate copy. And this may sound like a simple afterthought, but remember, the DNA polymerase may have to check 220 *million* base pairs to make sure they are right! That's a lot of checking.

Main idea 1: DNA is a long chain of nucleotides.



Main idea 2: The structure of DNA is a double helix. It was discovered through the work of several scientists.

Chargaff (pg. 4)

Main contribution:
The amounts of A and T and the amounts of G and C are equal in all living things.

Rosalind Franklin (pg. 4)

Method used:
X-ray crystallography

Main contribution:
Discovered DNA is in some kind of helix or spiral-shaped structure

Watson and Crick (pg. 4)

Main contribution:
Determined the structure of DNA

Describe the structure of DNA:
Backbone:
Sugar and phosphate

Base pairs:
Attached to the backbone; the bases point in

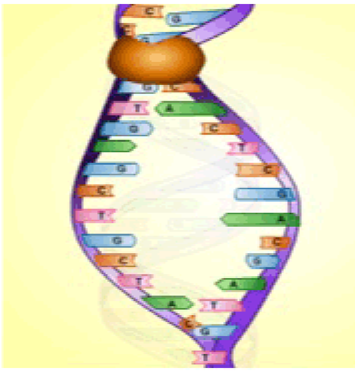
Double helix:
Two strands of complementary base pairs

A always paired with:
T

G always paired with:
C

Describe hydrogen bonding in DNA:
Hydrogen bonds form between complementary base pairs and hold the two strands of DNA together.

Main idea 3: The DNA double helix is replicated by the actions of enzymes that use each of the two strands as templates to make exact copies.

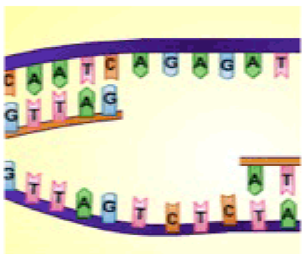


Beginning Replication: DNA Helicase (pg. 9)

Type of molecule:
Enzyme

What does DNA helicase do?
Breaks the hydrogen bonds and unwinds the double helix

Area just before the helicase:
Replication fork



Building the New Strand (pgs. 10-11)

DNA polymerase:
An enzyme that adds nucleotides to a growing strand of DNA

Complementary base pair:
Bases complementary to the template strand come in and form a new DNA strand.

DNA ligase:
Ties together strands of newly added nucleotides

Avoiding Errors (pg. 11)

Enzyme responsible:
DNA polymerase

Process for avoiding errors:
DNA polymerase "proofreads" the sequence.

2.1.2 Quiz: (20 POINTS)

Record your answers on the first page.

1.
What is the role of the DNA polymerase in DNA replication?

- **A.** It creates the replication fork.
- **B.** It checks the DNA for errors.
- **C.** It breaks apart the bases.
- **D.** It ties the chunks of DNA together.

2.

What is the role of the DNA polymerase in DNA replication?

- ◯ **A.** It creates the replication fork.
- ◯ **B.** It checks the DNA for errors.
- ◯ **C.** It breaks apart the bases.
- ◯ **D.** It ties the chunks of DNA together.

3.

What is the role of the DNA polymerase in DNA replication?

- ◯ **A.** It creates the replication fork.
- ◯ **B.** It checks the DNA for errors.
- ◯ **C.** It breaks apart the bases.
- ◯ **D.** It ties the chunks of DNA together.

4.

What complementary strand of DNA would be produced from the strand of DNA shown below?

TCG GA

- ◯ **A.** TGC CT
- ◯ **B.** TGA CT
- ◯ **C.** ACG GT
- ◯ **D.** AGC CT

5.

When is DNA replicated in a cell?

- ◯ **A.** During the G phases
- ◯ **B.** During mitosis
- ◯ **C.** During S phase
- ◯ **D.** During interphase

6.

Which molecule is active during the last step of DNA replication?

- **A.** DNA ligase
- **B.** Thymine
- **C.** Helicase enzyme
- **D.** nucleotidase

7.

Which of the following would cause an error in DNA replication?

- **A.** Helicase making a replication fork
- **B.** DNA ligase connecting chunks of DNA
- **C.** DNA polymerase pairing A with G
- **D.** DNA polymerase checking the DNA

8.

If this strand of DNA was used, what would be the complementary DNA produced?

CGA CT

- **A.** CGA CT
- **B.** GCG GA
- **C.** TAG TC
- **D.** GCT GA

9.

Which describes the correct pairing of DNA bases?

- **A.** A with A, and G with G
- **B.** A with C, and T with G
- **C.** A with T, and C with G
- **D.** A with G, and C with T

10.

What links the two strands in a DNA helix together in the middle?

- **A.** Proteins
- **B.** Sugar rings bonded together
- **C.** Bases with hydrogen bonds
- **D.** Phosphate groups

2.1.3 Study: Viruses and Bacteria

Viruses and Bacteria

Viruses are microscopic particles that infect living organisms.

A runny nose, aches and pains, a sore throat: Add these up and what do you get? The common cold. What people call the common cold is caused by a type of virus, called a rhinovirus, that attacks and infects human cells. Viruses can attack any type of organism, even plants and bacteria. In fact, the first identified virus was discovered on a plant.

Viruses and bacteria can be both harmful and helpful. They can also provide us with a greater understanding of how genetic codes work. In this study you'll learn why.

Viruses

Scientists have identified around 4,000 different kinds of viruses. Viruses are everywhere. A bottle filled with seawater from the surface of the ocean can contain over 10 billion virus particles.

Viruses are smaller than the smallest cell. Zoom in to see the relative size of some viruses: HIV and the measles virus. How big is an HIV or measles virus compared to the size of a red blood cell?

Living or Nonliving?

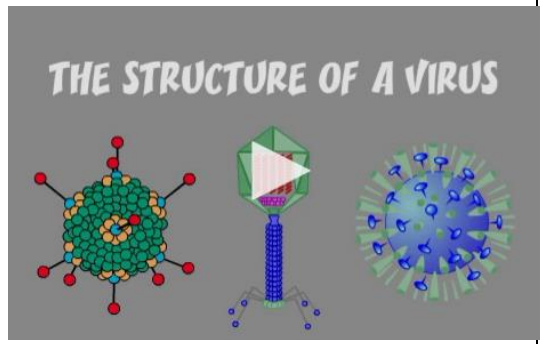
Living things share certain characteristics.

If a virus can invade your body, does that mean viruses are alive? Are they living organisms or some other type of particle?

A virus has its own nucleic acid code. To determine whether a virus is alive or not, you could compare the virus's characteristics to what many biologists consider the requirements of life. All living things have several common characteristics.

- Living things are made of cells.
- Living things have genetic material.
- Living things reproduce.
- Living things obtain and use energy.
- Living things grow, develop, and die.

The Structure of a Virus



The outer shell of a virus comes in many shapes and forms.

Although viruses are not considered to be living things, they have many things in common with living things. If you need help remembering the characteristics of living things, click the link to the right.

Viruses protect themselves from the outside world. A virus is surrounded by a coat of protein that forms a shell around the virus. This protective shell is called the capsid. The capsid not only protects the nucleic acids inside the virus, but it also contains proteins that help the virus to enter a host cell. The viral capsid can come in a variety of shapes.

Viral Genome

The viral genome can be DNA or RNA.

A virus takes over a cell and makes the cell start copying the virus's genome.

Every virus contains genetic information, or a genome.

The genome of a virus can be DNA or a nucleic acid that is slightly different from DNA, RNA.

Just like a cell, a virus must replicate in order to survive. But unlike a cell, a virus can't copy its own genome.

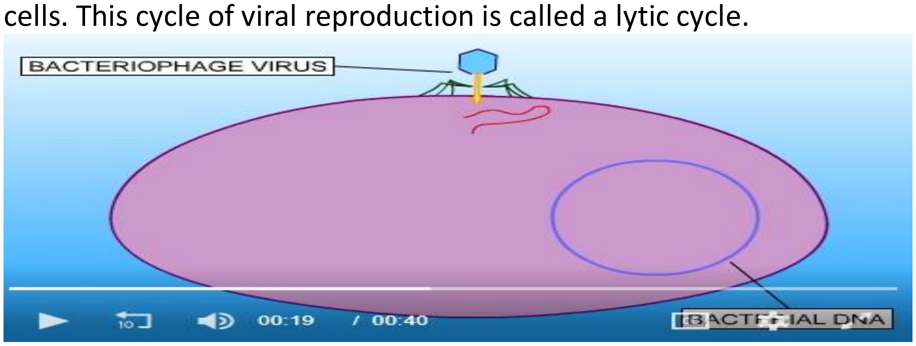
Instead, a virus takes over another cell. The virus enters a host cell, shuts down the functions of the host cell, and then uses the host cell to copy the virus's DNA.

Lytic Cycle

Viruses are copied and released in the lytic cycle.

When a virus has taken over a host cell, it has reprogrammed the host cell so that it will eventually destroy itself — and probably many other cells.

The host cell copies the viral genome, and then puts together the rest of the virus. Then the host cell is ripped open by the new viruses. This kills the host cell and releases the viruses to go invade, take over, and kill other cells. This cycle of viral reproduction is called a lytic cycle.



Lysogenic Cycle

Viruses can lie dormant in a host cell for many years in a lysogenic cycle.

Viruses like the common cold generally follow a lytic cycle. The virus enters a human body and begins to infect cells, the cells replicate the viral genome, and the cells break open and release the replicated virus particles. Other viruses follow a different pathway called the lysogenic cycle. These viruses can lie dormant in the DNA of the host for weeks or even years before becoming active. While dormant, the virus is replicated without damaging the host cells. Eventually, the dormant virus enters a lytic cycle, causing disease.

Diphtheria is a disease that can cause skin infection, breathing and heart problems, or nerve problems — and even lead to death. Diphtheria is caused by bacteria, not a virus. But in order for the diphtheria bacteria to be dangerous, a virus injects its DNA into the diphtheria bacteria. This virus has a lysogenic cycle. Once the virus has infected the diphtheria bacteria, the diphtheria bacteria begin producing the diphtheria toxins.

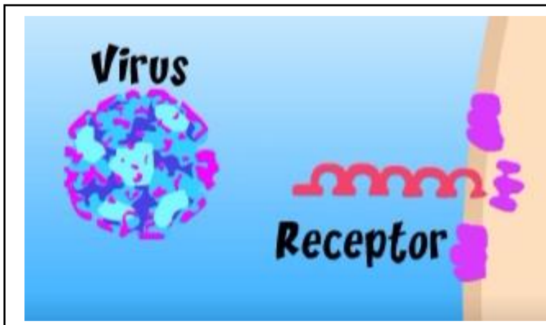
Treating Viral Infections

Viral infections can be treated by interrupting the lytic cycle.

How can disease caused by viral infection be prevented or cured? Many of the treatments used today involve disrupting steps in the viral cycle of reproduction. For this reason, it's important to understand the specific reproductive cycle of the virus that causes the disease being treated. All viruses must bind or attach to receptors on target cells to begin an infection. One way to block a viral infection is to create fake receptors that the virus can bind to. If the virus binds to a fake receptor, it will not be available to bind to a real receptor. Scientists have also developed antiviral drugs that block viral replication. Each antiviral drug is targeted to a specific kind of viral infection.

The Common Cold

The common cold virus attacks cells in the respiratory system.

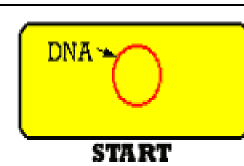


So what does all this information about viral cycles have to do with what happens when you get a cold? There are over 200 different viruses that cause coldlike symptoms. Many of these viruses are classified as rhinoviruses. When a rhinovirus enters the body, it attaches to receptors on cells in the respiratory system, like in the nose. The virus enters a lytic cycle, and quickly begins to replicate in the cells that it infects. The infected cells burst, releasing newly made cold viruses that can now go and infect other cells in the nose or respiratory system.

So why do you cough and sneeze when you have a cold? Coughing and sneezing are all part of the body's way of ridding itself of the invader.

Bacteria

Bacteria are single-celled living organisms with DNA.



So every time you get sick, do you have viruses invading your cells?
No. Viruses cause many of the diseases that infect humans and other organisms. But there are other disease-causing agents that are not viruses — bacteria. Unlike viruses, bacteria are living organisms. Bacteria are prokaryotes, which means they are made of only one cell but do not have membrane-bound organelles like a nucleus. Bacteria, like viruses, come in several shapes. Each shape has different properties and uses different means to move.

Bacterial Reproduction

Bacteria reproduce asexually.

There are no male or female types of bacteria, so bacteria must reproduce asexually. They do so by making copies of themselves in a process called binary fission. Because bacteria reproduce by making copies of themselves, the DNA of the parent cell is the same as the DNA of the offspring. One of the disadvantages of asexual reproduction is the lack of genetic variation in the offspring. A lack of variation makes a population less likely to survive environmental changes successfully. So does that mean the genetics of bacteria never change over time? No, it does not.

Bacteria Sharing DNA

Bacteria have three ways of adding variety to their DNA.

Bacteria make exact copies of themselves when they reproduce. So how is it that over time, bacteria can have variation in their DNA, and become stronger, bigger, weaker, or smaller?

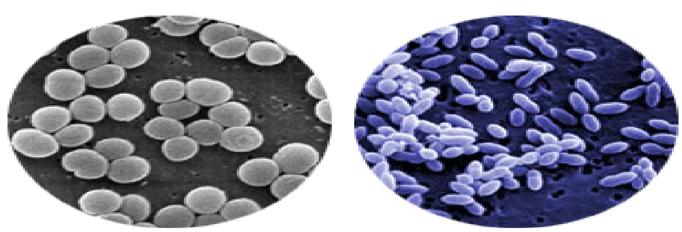
There are three things that bacteria do that ensure their bacterial DNA isn't exactly the exact same in every generation:

- In transformation, a bacterium takes up DNA from its environment and adds it to its own DNA.
- In transduction, DNA is transferred from one bacterium to another by a bacteriophage.
- In conjugation, a bacterium develops a thin tube called a pilus and then uses that tube to inject its DNA into other bacteria.

Pathogenic Bacteria

Pathogenic bacteria cause disease.

Bacteria can cause infection and disease. Bacterial disease is caused when a bacterium capable of causing illness enters an area of an organism where it's not normally found. Bacteria infect the organism by producing harmful proteins or other poisons. Bacteria that cause disease are called pathogenic bacteria. Most of the time, the human body can get rid of any bacteria that threaten it because the immune system is designed to fight these types of invasions. But sometimes, if the body has a weakened immune system, opportunistic bacteria can take over. Bacteria multiply very quickly, so once their numbers start to grow, they keep growing faster and faster.



Staphylococcus bacteria normally live on human skin and do not cause infection or other problematic symptoms.

Staphylococcus **bacteria normally live on human skin and do not cause infection or other negative symptoms. Under what conditions do you think this type of bacteria could cause a serious infection known as a** ***staph infection*****?**

Antibiotics

Antibiotics target bacteria and interrupt their life cycles.

The human body has some amazing ways to battle bacterial invaders. But people do get sick. Because of this, scientists have tried to find natural or chemical compounds that will kill or slow down the growth of bacteria.

Gangrene is caused by a bacterial infection that causes decreased blood flow.

These compounds are called antibiotics. Antibiotics interrupt function of a bacterial cell. Antibiotics like penicillin destroy the cell wall of a bacterium. Antibiotics like tetracycline block protein synthesis by blocking the bacteria's ribosomes. Antibiotics like rifamycin block bacterial replication. Much like medicines designed to fight viral infections, antibiotics target specific types of bacteria. Strangely enough, bacteria produce certain kinds of antibiotics as a way of discouraging other bacteria from taking over their space. However, bacteria are not harmed by their own antibiotics.

Uses of Bacteria and Viruses

Bacteria and viruses have many uses.

Did you know viruses and bacteria are being used for practical purposes that could improve your life? Because viruses can carry DNA from cell to cell, viruses are useful in many fields that use genetic technology, including agriculture. Bacteria have been used for a long time to make foods like yogurt and cheese. Now scientists are finding new uses for bacteria: to make electricity and clean up harmful waste.

STUDY GUIDE

Main idea 1: Viruses are particles with DNA or RNA, but they do not have the ability to reproduce without a host cell.

Virus (pg. 1)

Define:
A tiny, nonliving agent that multiplies inside a host cell and causes disease.

Location and size:
Viruses can attack any type of organism. Viruses are everywhere. Viruses are smaller than the smallest cell.

Living or Nonliving? (pg. 3)

What characteristics of living things do viruses share?
Grow, develop, and die; respond to environment

What characteristics of living things do viruses lack?
Viruses are not made of cells that can independently obtain and use energy to reproduce.

The Structure of a Virus (pg. 4)

Describe:
A virus is surrounded by protein that forms a shell around it, called the capsid, which protects the viral genome. The capsid contains the proteins that enable a virus to enter a host cell.

Lytic Cycle (pg. 6)

Describe:
A virus inserts its DNA into a cell. Because the cell cannot tell its own DNA from the viral DNA, it begins to make copies. The host cell produces a new capsid for each copy of the viral genome, and the new viruses are assembled in the host cell. The host cell ruptures and dies, releasing the newly formed viruses to find new host cells.

Lysogenic Cycle (pg. 7)

Describe:
A virus can lie dormant in the DNA of the host. While dormant, the virus is replicated without damaging the host cell. Eventually, something triggers the dormant virus and it enters a lytic phase, causing a disease.

Main idea 2: Bacteria are prokaryotic microscopic organisms. They can be helpful and can also cause disease.

Bacteria (pg. 11)

Describe:
Single-celled prokaryotes; living organisms

Describe prokaryotic cells:
They are much smaller than the cells of eukaryotes and don't have any membrane-enclosed organelles, such as a nucleus.

Describe bacterial shapes:
Sphere-shaped; rod-shaped; spiral-shaped

Bacterial Reproduction (pg. 12)

Describe:
Bacteria reproduce asexually but are able to exchange DNA with other cells.

Transformation:
Bacterial cells obtain DNA from their environment and incorporate it into their own genome.

Pathogenic Bacteria (pg. 14)

Describe:
Bacterial infections cause many human deaths. Bacterial disease is caused when a bacterium capable of causing illness enters an area of the body where it's not normally found.

Transduction:
DNA is transferred from one bacterial cell to another by a bacteriophage.

Conjugation:
Cells develop a thin tube called a *pilus* that can be used to inject DNA into another cell.

Uses of Bacteria and Viruses **(pg. 17)**

Describe new technology:
Fighting pests like mosquitoes; inserting DNA into cells; producing new antibiotics; creating new fuel technology; cleaning up toxic waste and oil spills

Antibiotics **(pg. 15)**

How do antibiotics work?
They target bacteria and interrupt their life cycle, destroy the cell walls of a bacterium, block the bacteria's ribosomes, and block bacterial replication

2.1.4 Quiz: (20 POINTS)

Record your answers on the first page.

1.

Why would a drug that damages capsids help treat a viral infection?

- **A.** Capsids help viruses enter cells.
- **B.** Capsids cause conjugation.
- **C.** Capsids are bacteria.
- **D.** Capsids are antibiotics.

2.

Which best describes how the common cold spreads in the human body?

- **A.** Viruses insert DNA into bacteria.
- **B.** Viruses replicate inside respiratory cells.
- **C.** Bacteria burst out of normal cells, killing them.
- **D.** Bacteria inject DNA into normal cells.

3.
Which best describes a pilus?

- ◯ **A.** A virus that causes a common cold
- ◯ **B.** A piece of DNA transferred by a virus
- ◯ **C.** A protective shell around a bacterium
- ◯ **D.** A tube that extends from a bacterium

4.
Which best describes conjugation in bacteria?

- ◯ **A.** Bacteria transfer DNA with a bacteriophage.
- ◯ **B.** Bacteria switch to the lysogenic cycle.
- ◯ **C.** Bacteria inject DNA into another cell.
- ◯ **D.** Bacteria take DNA from their environment.

5.
Which best describes a bacteriophage?

- ◯ **A.** The tube that extends from a bacterium
- ◯ **B.** The shell that protects a bacterium
- ◯ **C.** A virus that attacks bacteria
- ◯ **D.** The virus that causes colds

6.
The bacteria in a colony are unable to perform conjugation. How would this hurt the bacterial colony's chance for survival?

- ◯ **A.** The colony would have less genetic variation.
- ◯ **B.** The bacteria would lose all their RNA.
- ◯ **C.** The colony could not produce bacteriophages.
- ◯ **D.** The bacteria in the colony could not reproduce.

7.

Why are viruses considered to be nonliving?

- ◯ **A.** They do not respond to their environment.
- ◯ **B.** They cannot reproduce without a host cell.
- ◯ **C.** They cannot use energy.
- ◯ **D.** They have no genetic material.

8.

How are the lysogenic and lytic cycles different?

- ◯ **A.** The lytic cycle does not replicate viruses.
- ◯ **B.** The lytic cycle is much slower.
- ◯ **C.** The lytic cycle is used by RNA viruses.
- ◯ **D.** The lytic cycle kills a cell.

9.

Why are antibiotics unhelpful for treating the common cold?

- ◯ **A.** Colds are caused by antibiotics.
- ◯ **B.** Viruses are not killed by antibiotics.
- ◯ **C.** Antibiotics cannot treat illnesses.
- ◯ **D.** Colds are caused by bacteria.

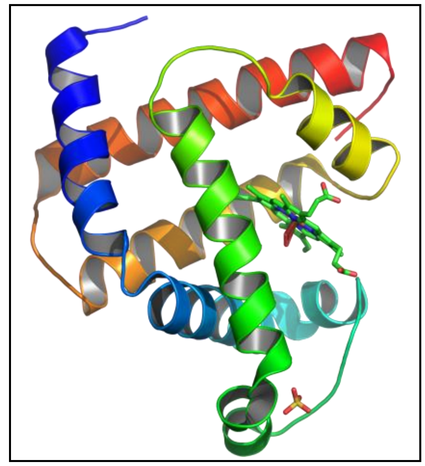
10.

How are viruses different from bacteria?

- ◯ **A.** Viruses contain only RNA.
- ◯ **B.** Viruses are unicellular.
- ◯ **C.** Viruses cannot replicate by themselves.
- ◯ **D.** Viruses are killed by antibiotics.

Lesson 2.2 Study: From DNA to Protein

2.2 From DNA to Protein



These aren't ribbons to tie on a birthday present. This is actually a figure describing the structure of a protein molecule that carries oxygen in your muscles.

DNA determines your appearance and how your cells function. But how does DNA do these things?

DNA is used to make proteins. Proteins perform essential tasks to keep your body alive, as well as determine what your physical features look like.

In this lesson, you'll learn how DNA is used to make proteins.

Objectives

- Explain the process of DNA transcription.
- Explain the process of DNA translation.
- Using a given DNA sequence, write the mRNA and protein sequences that would be made during transcription and translation.

2.2.1 Transcription

Transcription

The genetic code found in DNA determines what an organism looks like and what its cells do.

So how does DNA actually determine what you look like? Is it because your hair, eyes, and skin are made of DNA, and DNA comes in different colors? Not exactly. To begin finding out how DNA does the enormous task of determining what you look like, watch the following animation to review what you have learned about DNA and chromosomes.

Proteins and Phenotype

The presence or absence of a protein changes what an organism looks like and how its cells function.

DNA contains genes, and genes code for proteins. Meat is full of protein, and beans have a good amount of protein too. But did you know the presence or absence of a protein could change what you look like, how your body functions, and when your cells do their tasks? Look back at Mendel's peas. One trait he studied was how tall a pea plant grew. Each gene of DNA codes for one protein. The gene for pea plant height has two alleles: One allele has a code for a particular protein, and one does not.

Gene Expression

Not all of an organism's DNA is used in every cell of the organism.

Every cell in a pea plant contains the same DNA. But not every cell in a pea plant looks the same — some cells are making proteins that make the plant strong. Some cells are making proteins in the peas you eat.

Gene regulation controls which part of this cat expresses each color of fur.

What happens in an organism and when is determined by a process called gene expression. Gene expression controls whether or not a piece of DNA is being "read" and used to make a protein. So even though every cell has the same DNA, not every piece of the DNA is used in every cell. For example, in a cat with orange and brown fur, in some cells the DNA to make orange fur proteins is activated and used to make proteins. In other cells, the DNA to make brown fur proteins is activated. In the winter, gene expression could also lead to a cat growing more fur in order to keep warm, because gene expression controls the timing of proteins being made.

Proteins and Life

Making proteins is essential for life.

Genes don't just code for proteins that affect how tall an organism is or other traits that you can see. Genes code for proteins that do things you can't see, such as carry oxygen to your cells, digest your food, or make up your muscles. Eating these mushrooms would kill you because they stop protein synthesis in humans. To see how important it is to have proteins in the body, take a look at these mushrooms. They don't look much different from the ones you'd buy at the grocery store. But don't be fooled — the common name for these mushrooms is *death cap*. How do these mushrooms kill you? Death cap mushrooms contain a substance called *alpha-amanitin*. It shuts down the process of making proteins, which is called protein synthesis. Protein synthesis is so important to your body that without it, you would quickly die.

Specialization

Gene expression leads to specialization of cells.

Every one of your cells contains the same DNA sequence. As you progressed from a blastocyst to a fetus, how did a toe cell get to be a toe cell and a heart cell get to be a heart cell?

A very complicated process of gene expression controls the differentiation of cells during development. As the cells of the human body grow from undifferentiated stem cells into fully differentiated adult cells, a nearly unthinkable sequence of events must unfold — most of which scientists are still working to discover.

What scientists do know is that a cell has the genes needed to synthesize every protein, but it only produces, or expresses, the proteins it needs.

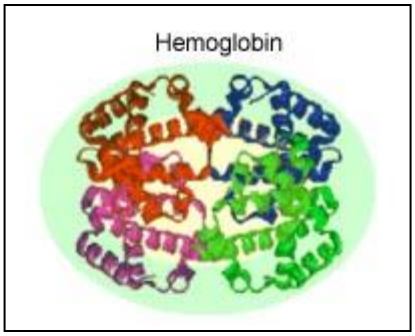
DNA to RNA to Protein

The code to manufacture proteins is contained in DNA.

Everything that happens in your body is done by proteins, but all the information on *what* to do comes from DNA. So how does information get from DNA to proteins? There are two steps. In the first step, transcription, the code in the DNA is copied to a different nucleic acid, RNA. In the second step, translation, the nucleic acid code in RNA is changed into a new form: amino acids. This step is called *translation* because the nucleic acid language is being "translated" into the protein language.

Protein Function

Protein structure and function depends on the amino acid chain.



Proteins are made of long chains of amino acids. These chains can contain hundreds of amino acid units. Although there are only 22 different amino acids used in the human body, over 100,000 different protein molecules are produced. Each protein has a different amino acid sequence. Some contain only a few amino acids. Some contain hundreds. The specific shape of hemoglobin allows it to carry four molecules of oxygen If even one amino acid is different, the entire shape and function of the protein molecule can change. The hemoglobin molecule is the perfect shape to hold an atom of iron. If the shape were different, the molecule could not carry the atom.

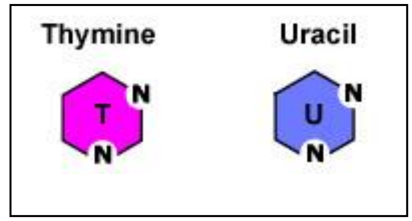
One Amino Acid

Each amino acid in a protein is significant.

Changing just one amino acid in a large protein can make a huge difference. Keep in mind that *Leu* and *Gln* are abbreviations for two of the 22 amino acids found within living things.

Base Pairs in RNA

RNA carries information from the nucleus to the ribosomes.
DNA forms the code of life by providing a code for making proteins. But DNA is in the nucleus and protein making happens in ribosomes, which are outside of the nucleus. So how does the information stored in DNA get out to the ribosomes? The answer is RNA.



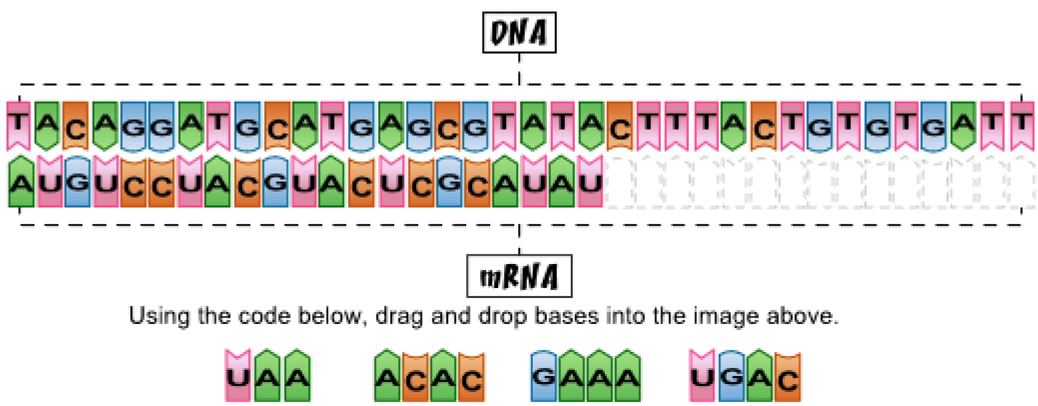
RNA has one different base than DNA.
Uracil, not thymine, is present in RNA molecules.
Like DNA, RNA is made up of nucleotides, but RNA has one different base than DNA.

- In DNA, A and T pair.
- In RNA, A pairs with the base uracil (symbolized by U).

This may seem like a small difference, but it makes a big difference in how the molecules work.

T and U

During transcription, an A in DNA pairs with an RNA U.
If DNA is being copied, an A will be base paired to a T. If DNA is being used to make mRNA, an A will be paired to a U.
In the exercise below, part of the DNA in the gene that codes for the amylase enzyme is shown on the top. During transcription, this DNA sequence is used as a template to make mRNA.
Drag and drop the correct chunks of mRNA bases to complete the new mRNA sequence. Remember, when DNA is used as a template to make mRNA, an A in DNA will base pair with a U in mRNA.



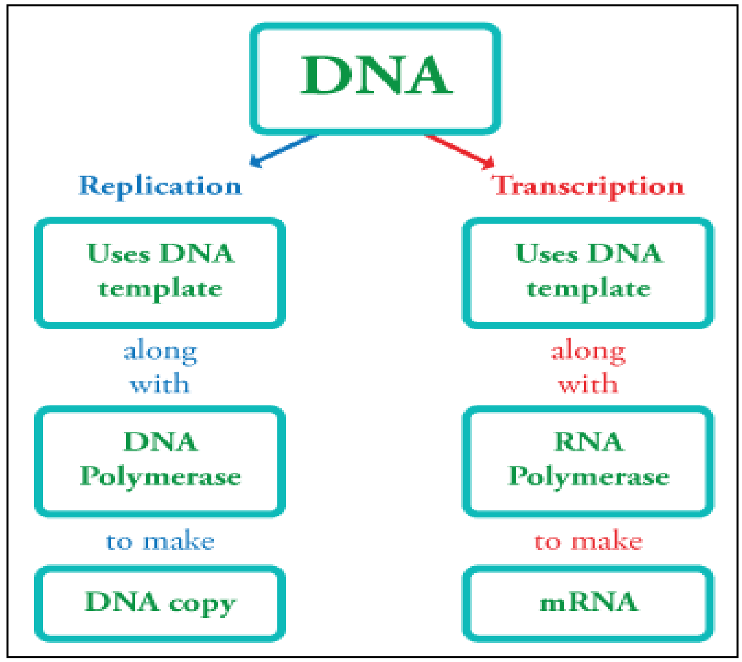
Transcription Process

RNA polymerase quickly matches mRNA bases to DNA bases.
In the nucleus of the cell is a large molecule called RNA polymerase.
RNA polymerase is used to build mRNA molecules, using DNA as a guide.
RNA polymerase uses the DNA as a template and matches the bases in the strand. Bases are added one by one, with U matching with A and G matching with C.
How fast does mRNA get built? RNA polymerase works at a rate of 50 new mRNA bases per second!

Comparing Processes

DNA replication and transcription are similar processes.

DNA replication and transcription have several things in common. DNA is used as a template for both DNA replication and transcription. In DNA replication, copies of DNA are made. In transcription, DNA is used as a template to make mRNA. Both processes use polymerases.
In DNA replication, A pairs with T.
In transcription, A pairs with U.



STUDY GUIDE

Main idea 1: Genes contain the instructions for making proteins.

DNA and Protein Function

Function of Proteins in the Body

Describe: **(pgs. 2,6-9)**
Proteins perform essential functions in cells.
Proteins also determine how traits appear.

What determines the function of a protein?
The amino acid sequence determines the shape of the protein, which often determines the function.

How can changing even one amino acid affect the protein?
It can change the shape and function of the protein.

Proteins and Phenotype **(pg. 2)**

How could the presence or absence of a protein determine a phenotype?
If a protein is produced, an organism will have a certain trait; if the protein is absent, it will have a different trait.

Gene Expression (pg. 3)

Define:
This controls when proteins are made and by what cells. Genes are transcribed and translated only at certain times and in certain cells.

Do different cells have different genes?
Every cell in an organism contains the same genetic material, but not all cells produce the same proteins.

DNA and Proteins (pg. 2)

Describe the relationship between DNA and proteins:
The code to manufacture proteins is contained in DNA.

Describe the relationship between genes and proteins:
Each gene contains the information to make one type of protein.

Main idea 2: Transcription is the creation of an mRNA using DNA as a template.

Transcription (pg. 13)

Describe process:
The DNA strands separate, and the helix unwinds. The RNA polymerase uses the DNA as a template and matches the bases in the strand. Bases are added individually — each U matches with A, and each G with C. The nucleotides bind together to make a strand of mRNA. DNA is converted into mRNA, which leaves the nucleus.

Occurs in:
Nucleus

Role of RNA polymerase:
Finds beginning of a gene; assembles mRNA sequences from DNA

Transcription versus DNA Replication (pg. 14)

Things in common:
- DNA is used as a template.
- Similar steps are followed.
- Relies on a polymerase enzyme to unwind the double helix and break the hydrogen bonds between the strands
- Uses complementary base pairing to form new molecules

Differences:
- Different end results
- In DNA synthesis, T binds with A, but in mRNA synthesis, U binds with A.

2.2.2 Quiz: (20 POINTS)

Record your answers on the first page.

1.

Which best describes how mRNA is produced in a cell?

- **A.** mRNA is made by breaking apart DNA and reusing the pieces.
- **B.** mRNA is made by duplicating RNA found in the nucleus.
- **C.** mRNA is made by DNA, using RNA polymerase as a template.
- **D.** mRNA is made by RNA polymerase, using DNA as a template.

2.

Which best describes the flow of genetic information?

- **A.** DNA to RNA to protein
- **B.** Protein to DNA to RNA
- **C.** Protein to RNA to DNA
- **D.** RNA to DNA to protein

3.

What happens right before transcription begins?

- **A.** The transcription process stops.
- **B.** RNA polymerase is guided to the correct place.
- **C.** mRNA is produced from nucleic acids.
- **D.** DNA is produced from the mRNA.

4.

Which best describes a difference between transcription and DNA replication?

- **A.** Transcription does not require DNA.
- **B.** DNA replication takes place in the ribosomes.
- **C.** Transcription uses uracil.
- **D.** DNA replication does not use thymine.

5.

What is the purpose of transcription?

- ○ **A.** To produce DNA
- ○ **B.** To produce RNA
- ○ **C.** To produce lipids
- ○ **D.** To produce amino acids

6.

What is gene regulation?

- ○ **A.** The total number of genes a person has
- ○ **B.** The manner in which phenotypes differ from genotypes
- ○ **C.** The number of proteins an organism can produce
- ○ **D.** The control of when and where proteins are made

7.

What happens right after transcription ends?

- ○ **A.** The DNA double helix unwinds.
- ○ **B.** RNA polymerase binds to the beginning of a gene.
- ○ **C.** mRNA detaches and moves to the ribosomes.
- ○ **D.** Nucleic acids attach to the bases in the DNA.

8.

How could an error during transcription affect the protein that is produced?

- ○ **A.** The protein would have complementary base pairs.
- ○ **B.** The protein would become RNA polymerase.
- ○ **C.** The protein would become too specialized.
- ○ **D.** The protein would be made of the wrong amino acids.

9.

Which strand of mRNA would be made during transcription using the DNA strand shown below?

CGA TCT

- **A.** GCU AGA
- **B.** GCT AGU
- **C.** GCU UGU
- **D.** GCA UGT

10.

Which of the following *best* describes how genes produce traits in an organism?

- **A.** Genes are produced from proteins in the organism's DNA.
- **B.** Genes are codes for proteins that determine traits.
- **C.** Genes are produced by chromosomes during transcription.
- **D.** Genes are codes used to build alleles.

2.2.3 Study: Translation

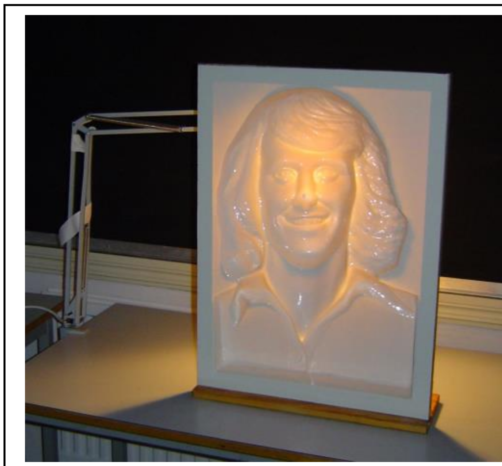
Translation

During translation, mRNA is used as a template to make proteins.

A mask of Swedish tennis player Björn Borg on display at Uppsala University, Sweden. Would you say the face in the image to the right is coming out toward you? This mask is part of an exhibit that shows the effect light can have on what we see.

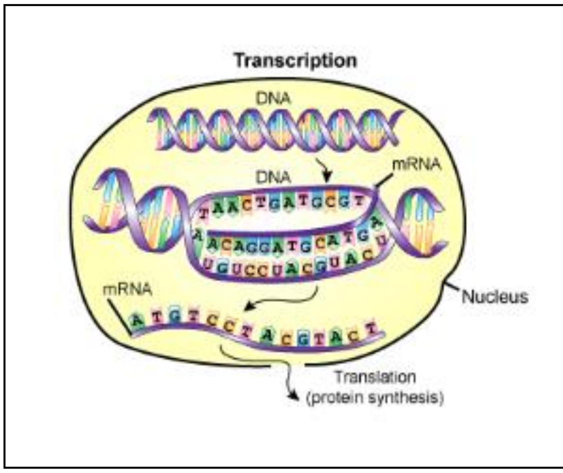
If you wanted to make a detailed mask like this of your face, how do you think you'd do it? The easiest way, by far, would be to use your face directly as a template.

The process of translation is like the process of making a mask. During translation, mRNA is used to make proteins. You could think of the mRNA as being like your face, and proteins as being like the mask.



A mask of Swedish tennis player Björn Borg on display at Uppsala University, Sweden

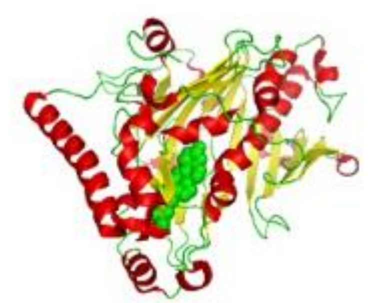
Translation Builds Proteins



In translation, proteins are built by combining amino acids.

Remember that the processes of transcription and translation together are needed to make proteins.
DNA is used as a template to make mRNA during transcription. The mRNA is then used as a template to build proteins during translation. Because the actual building of the proteins happens in translation, it is also called *protein synthesis.*
What is a protein? A protein is a long chain of amino acids. Translation is really the process of making amino acid chains, using mRNA as a guide.

Amino Acids and mRNA


This is a protein. It is made up of amino acids combined in a specific order.

The type of protein created depends on the order of amino acids.

There are 22 total different amino acids in all living organisms. Can you imagine? There are millions of different living things that contain millions of different proteins, and all those proteins are made with just 22 different amino acids. A human eyelash, the petal on a flower, a single scale on a fish — all of these things come from different combinations of just 22 amino acids. All of these combinations of amino acids are determined by the mRNA template in each cell, which comes from the cell's DNA.

From Base to Amino Acid

Four bases must code for 20 different amino acids.

To make all of the proteins an organism needs, the ribosomes of living things use 22 amino acids. Of these, 20 are coded by DNA; the other 2 amino acids are synthesized by modifying other amino acids.
Several nitrogenous bases on the mRNA code for one amino acid.
In a sequence of mRNA — which includes only the bases A, U, C, and G — how many bases must code for each amino acid?

Codons

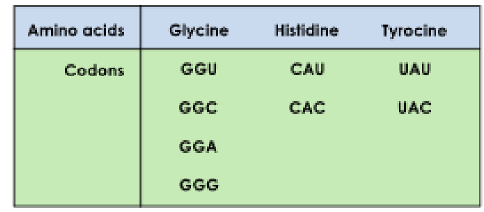
A string of three bases in mRNA codes for one amino acid.

If you could examine a molecule of mRNA, you would see bases lined up in a chain. The chain of bases in an mRNA molecule looks a lot like one strand of a DNA molecule.
The bases in mRNA specify what amino acid should be used to build a protein molecule.
The string of bases that codes for each amino acid is called a codon. Each codon has three bases and is called a *triplet code.*
The codons code for 20 of the amino acids that appear in all living organisms. The other two of the 22 total amino acids are just modified from other amino acids.

Each of these three-letter sequences, or triplets, is a codon for one amino acid.

Codons to Amino Acids

A series of codons codes for a chain of amino acids.
Use this exercise to determine the amino acid sequence of a protein. Proteins are chains of amino acids, coded for by a series of codons in mRNA.



Amino acids	Glycine	Histidine	Tyrocine
Codons	GGU	CAU	UAU
	GGC	CAC	UAC
	GGA		
	GGG		

Codons to Amino Acids

Start and Stop Codons

Specific codons signal where translation begins and ends.
The mRNA that codes for each protein has the same codons for where translation should start and stop. They are the start codon and the stop codon. There are actually three different stop codons, but all three mean the same thing: time to STOP adding amino acids to the protein. The image on this page shows the start codon, and one of the stop codons. Every time a protein is made, the process of translation begins at the start codon, and ends at a stop codon.

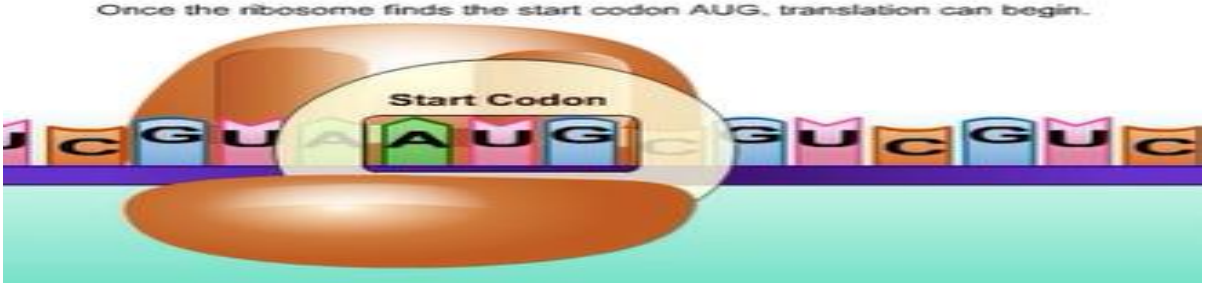
Ribosomes Make the mRNA Code

Ribosomes read the mRNA codons and then line up the amino acids.
Translation of codons to amino acids takes place in the ribosomes. Ribosomes are large structures made of rRNA (ribosomal RNA) and proteins. During translation, they travel along the mRNA and read the codons.

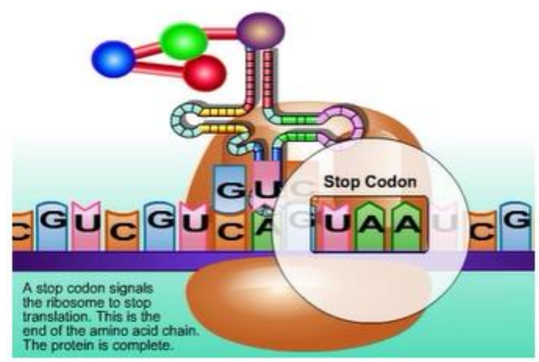
tRNA Carries Amino Acids

A protein is formed as tRNAs bring amino acids to a ribosome.
Once the ribosome finds the start codon, it calls for another type of RNA called tRNA. The tRNA has a codon that matches, or is complementary to, the mRNA codon. It is called an anticodon.
The tRNA also carries an amino acid. tRNA is like a delivery truck, carrying amino acids to the ribosome. Once the tRNA matches up with the mRNA, the amino acids attach to the amino acid chain with a peptide bond. After the amino acids are attached, the tRNA breaks off, leaving the mRNA and the amino acid chain.

Once the ribosome finds the start codon AUG, translation can begin.

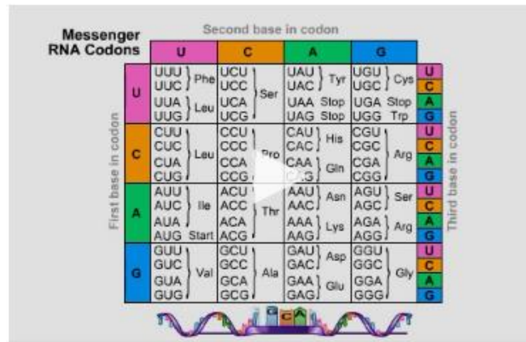


Final Steps of Translation



A ribosome stops when it hits a stop codon.
After all the amino acids are bonded together and the ribosome reaches a stop codon, the ribosome falls off the mRNA, leaving an empty mRNA and a completed protein. Watch the animation below to see the final steps of translation.

Codon Table



Messenger RNA Codons

First base in codon	U	C	A	G	Third base in codon
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Start	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

The amino acids that match the codons are found in a codon table.
So how does a tRNA know which amino acid to bring to the growing amino acid chain during translation?
Each codon in mRNA signals for a tRNA to bring a specific amino acid.
Look at the table below to see which codons code for each amino acid. Note that the names of the 20 amino acids have been shortened to three letters in the table.

From DNA to Protein

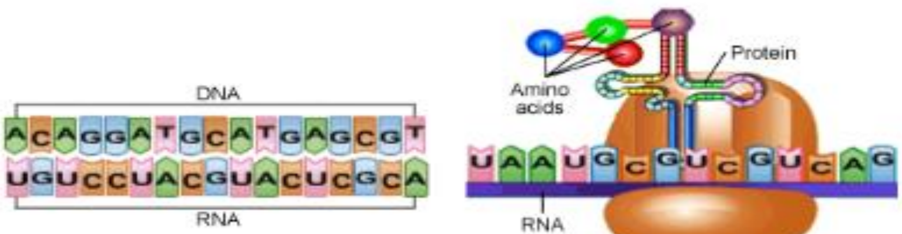
The order of amino acids coded for by mRNA can be determined using the codon table.
In an earlier study, you created an mRNA strand for the amylase gene, based on the DNA sequence. The mRNA strand looks like this:

This mRNA strand was built using the amylase gene as a template.

Now it is time to use the **codon** table to determine the **amino acid** sequence of this section of salivary amylase **protein**.

Translating into Amino Acids

During translation, nucleotides are translated into amino acids by tRNA.
So why is translation called *translation*?
DNA and RNA are nucleotides that contain bases — A, C, G, T, and U. But proteins are made of amino acids that do not have bases and do not form complementary base pairs.
Because of this difference, amino acids cannot read mRNA and then line up in the correct order to make the right protein. The amino acids use tRNA to match up to the right bases for the process to happen.
In this way, tRNA translates the bases by matching up with the mRNA codon and aligning the amino acids so they can bond together.



These molecules use the same language — nucleic acid. It is easy to convert from one to the other.

The language of nucleic acids must be translated into the language of amino acids.

Checking for Errors

Cells have several methods to ensure that errors are discovered and repaired.

So are there errors during translation, or does everything get translated perfectly? Does the translation get checked? In transcription and translation, there is little to no proofreading performed. RNA polymerase doesn't check its work as it transcribes DNA into RNA. If it makes a mistake, it just keeps going.

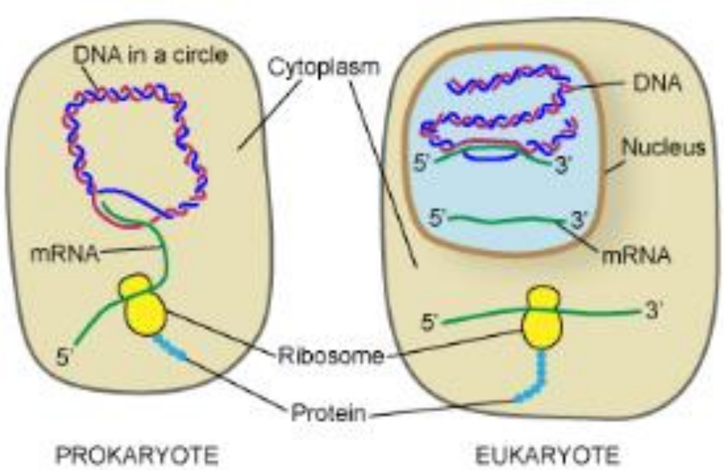
The same is true during translation — if the ribosome adds the wrong amino acid, polymerase just continues on! But it is more important for DNA replication to be exact than for transcription or translation to be exact.

Transcription and Translation in Prokaryotes

In prokaryotes, proteins are built at the same time as mRNA is made from DNA, and prokaryotic DNA is circular.

The processes of transcription and translation are a little different in prokaryotes than in eukaryotes. In part, this is because DNA structure is a little different in prokaryotes and eukaryotes.

- You learned that DNA in prokaryotes is in the cytoplasm of the cell.
- This allows transcription and translation to occur at the same time in prokaryotes. As the mRNA detaches from the DNA, it is already being translated into a protein molecule.
- In addition, DNA in prokaryotes is actually in a circle. There is only one starting point for DNA replication in prokaryotes, whereas there are multiple places DNA replication can begin in eukaryotes.



STUDY GUIDE

Main idea 1: In translations, the base code sequence in mRNA is converted into an amino acid sequence to form a protein molecule.

Translation (pgs. 6-10)

Describe:
The information in the mRNA sequence is used to produce an amino acid chain that forms a protein.

Step 1: Start codon
Describe process:
AUG; tells the ribosome to start translation

Step 2: tRNA
Describe process:
A tRNA with the correct anticodon temporarily binds to the mRNA, bringing an amino acid to the ribosome.

Step 3: Ribosome moves to the next codon
Describe process:
Causes another tRNA with the correct anticodon to bind. The amino acids on the tRNAs bind together, creating a peptide bond.

Step 4: Stop codon
Describe process:
A stop codon is the code UAA, UAG, or UGA. At this point, translation stops, the ribosome detaches, and the amino acid chain folds into its final protein structure.

Components (pgs. 8-9)

tRNA
Describe:
One end has an anticodon that matches with the codon in mRNA, and the other end has an amino acid.

Ribosomes:
Large structures made of RNA. During translation, they travel along the mRNA and read the codons.

Codons (pg. 5)

Define *codon:*
The string of bases that codes for each amino acid

Main idea 2: The triplet code for each of the 20 amino acids coded in DNA has been identified and can be found in a codon table.

Codon Table (pg. 12)

Describe:
The relationship between mRNA codons and the amino acids they make

The table shows:
How to read the genetic code

Stop codons:
Tells the ribosome where to stop;
UAA, UAG, UGA

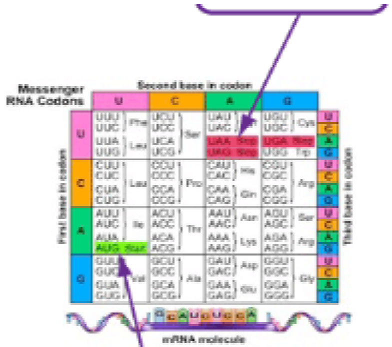
Using the Table (pgs. 12-14)

To find the amino acid of a codon:
Locate the codon on the table. The amino acid abbreviation is next to it.

To find the codon of mRNA bases:
First base:
Find the codon on the left.

Second base:
Locate the second codon on the top columns.

Third base:
Locate third base on the far-right column.



Start codon:
Tells the ribosome where to start, AUG

Transcription and Translation in Prokaryotes (pg. 18)

Describe:
In prokaryotes, proteins are built at the same time as RNA is synthesized. Prokaryotes do not have a nucleus or other membrane-enclosed organelles.

2.2.4 QUIZ (20 points)

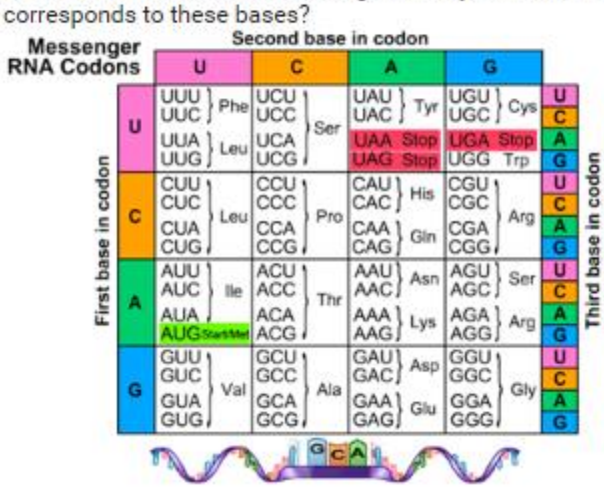
1.

Which of the following is on one end of all charged tRNA molecules?

- ◯ **A.** An amino acid
- ◯ **B.** A protein
- ◯ **C.** A stop codon
- ◯ **D.** A DNA strand

2.

A strand of mRNA has the bases guanine-cytosine-uracil. Which amino acid corresponds to these bases?



- ◯ **A.** Cys
- ◯ **B.** Ser
- ◯ **C.** Ala
- ◯ **D.** Arg

3.

Which best describes a protein?

- A. A chain of codons and anitcodons
- B. A chain of amino acids
- C. A strand of DNA
- D. A bond between amino and nucleic acids

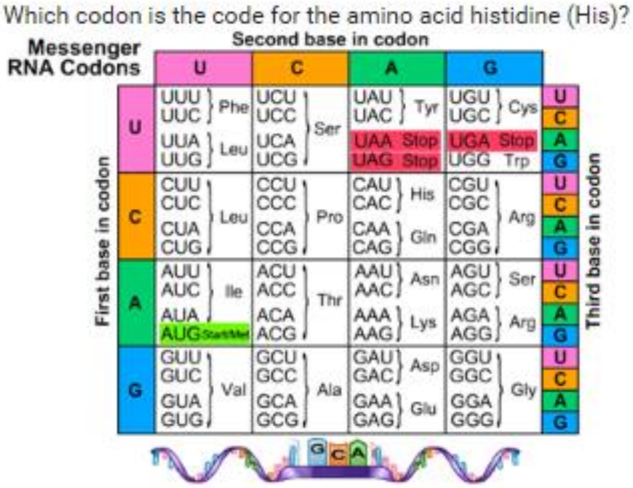
4.

Why is protein synthesis different in prokaryotes and eukaryotes?

- A. Prokaryotes have no ribosomes.
- B. Prokaryotes have no proteins.
- C. Prokaryotes have no DNA.
- D. Prokaryotes have no nucleus.

5.

Which codon is the code for the amino acid histidine (His)?



Messenger RNA Codons

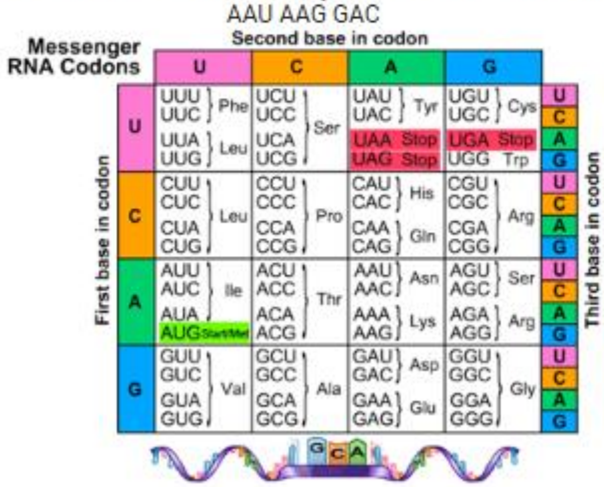
First base in codon	Second base in codon: U	C	A	G	Third base in codon
U	UUU, UUC Phe; UUA, UUG Leu	UCU, UCC, UCA, UCG Ser	UAU, UAC Tyr; UAA Stop; UAG Stop	UGU, UGC Cys; UGA Stop; UGG Trp	U C A G
C	CUU, CUC, CUA, CUG Leu	CCU, CCC, CCA, CCG Pro	CAU, CAC His; CAA, CAG Gln	CGU, CGC, CGA, CGG Arg	U C A G
A	AUU, AUC, AUA Ile; AUG Start/Met	ACU, ACC, ACA, ACG Thr	AAU, AAC Asn; AAA, AAG Lys	AGU, AGC Ser; AGA, AGG Arg	U C A G
G	GUU, GUC, GUA, GUG Val	GCU, GCC, GCA, GCG Ala	GAU, GAC Asp; GAA, GAG Glu	GGU, GGC, GGA, GGG Gly	U C A G

- A. CAA
- B. CAU
- C. AAC
- D. UAC

6.

Which amino acid chain will be formed by the codons shown below?

AAU AAG GAC



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C	CUU, CUC, CUA, CUG Leu	CCU, CCC, CCA, CCG Pro	CAU, CAC His; CAA, CAG Gln	CGU, CGC, CGA, CGG Arg	U C A G
A	AUU, AUC, AUA Ile; AUG Start/Met	ACU, ACC, ACA, ACG Thr	AAU, AAC Asn; AAA, AAG Lys	AGU, AGC Ser; AGA, AGG Arg	U C A G
G	GUU, GUC, GUA, GUG Val	GCU, GCC, GCA, GCG Ala	GAU, GAC Asp; GAA, GAG Glu	GGU, GGC, GGA, GGG Gly	U C A G

- A. Asn Lys Asp
- B. Asn Lys Glu
- C. His Ser Pro
- D. Asp Lys Glu

7.

Why is it more important to check for errors during DNA replication than during translation?

- ◯ **A.** Proteins function normally even when they have errors.
- ◯ **B.** An error in translation affects only one cell.
- ◯ **C.** Translation does not use a nucleic acid code.
- ◯ **D.** Errors in DNA replication are not passed to more generations.

8.

What happens next after the ribosome reaches the start codon?

- ◯ **A.** tRNA molecules attach to codons.
- ◯ **B.** Peptide bonds between amino acids are broken.
- ◯ **C.** The ribosome finds the stop codon.
- ◯ **D.** The ribosome detaches from the amino acids.

9.

What macromolecule is produced during translation?

- ◯ **A.** Protein
- ◯ **B.** DNA
- ◯ **C.** Carbohydrate
- ◯ **D.** RNA

10.

How does the process of translation convert information?

- ◯ **A.** From an RNA code to a DNA code
- ◯ **B.** From a DNA code to an RNA code
- ◯ **C.** From an amino acid code to a nucleic acid code
- ◯ **D.** From a nucleic acid code to an amino acid code

Next Week's Lessons:
Lesson 2.3 and 2.4
February 08 -12, 2021

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