Project: DNA to RNA to Proteins

Concept: DNA is the code to life, and the body creates different proteins from its instructions.

Introduction

DNA is the code of life. For many years, scientists looked for the answer of what holds the information for life to occur. After many experiments, scientists realized that **DNA** holds this necessary information.

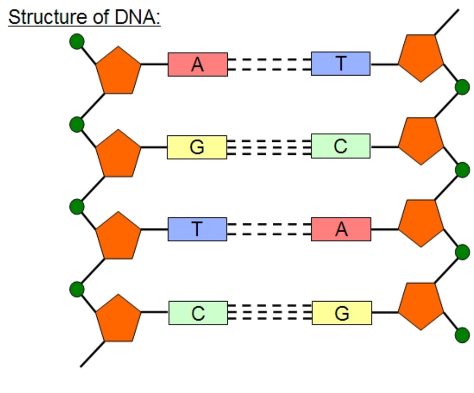
DNA is not enough to maintain life alone. It must be changed into proteins, which are able to interact with each other both inside the cell and between other cells. Imagine DNA as the boss; the boss knows what needs to be done, but there is no way that he/she could possibly complete it all. Therefore, this boss needs to hire workers that are specific to each thing that must be accomplished. The workers in this analogy are molecules called **proteins**. However, DNA cannot immediately read and understood. It must first be copied into **RNA** and then the RNA can then be read, and more proteins can be made.

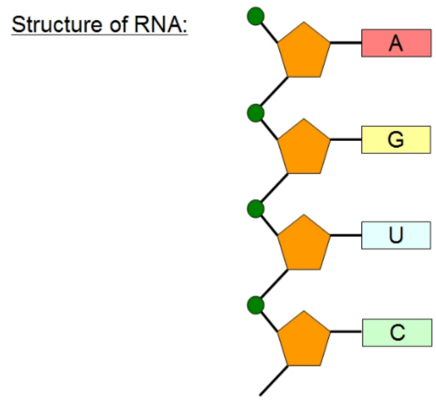
Remember when we talked about genotypes and phenotypes last week? Genotypes are seen in the DNA, and phenotypes happen because of proteins!

DNA → RNA → PROTEIN

DNA needs to be copied into RNA because DNA isn't allowed to leave its location in the cell, which is known as the nucleus. RNA, however, is allowed to leave the nucleus where RNA can be read by **ribosomes** to make proteins.

Picture DNA as your family recipe book. The recipe book is far too precious and valuable to take outside the house; after all, you might lose it on accident! Instead of taking it around with you, you can write down the recipe on a notecard and take that with you. The notecard represents RNA because it still gives the recipe for the food dish, but it is much smaller than the cookbook. You can then take the recipe card to your friend's house and then make the food. The food can be considered the protein in this example. The process of using the recipe notecard as instructions for making food is similar to RNA being used in your cells to make more proteins.





Today's Vocabulary:

1. A **<u>nucleotide</u>** is a small unit of that make up DNA and RNA. When many nucleotides are joined together, they form DNA or RNA. The nucleotides of DNA are represented by A, T, C, and G. The nucleotides of RNA are represented by A, U, C, and G.

2. The process of reading DNA to make new RNA is called **<u>transcription</u>**. This is done through a special type of protein called a **<u>polymerase</u>**, which will read the each of the nucleotides from the DNA and create a new strand of RNA. Today YOU will be acting as the polymerase!

3. The process of reading RNA to make proteins is called **<u>translation</u>**. This process is done by **<u>ribosomes</u>** found in cells. Ribosome are like little factories that build proteins.

4. The ribosomes read RNA **codons,** with are made of three RNA nucleotides in a row. Codons can then be translated to make a protein.

5. Just as DNA and RNA have small units that are put together (nucleotides), proteins also have small units called **<u>amino acids</u>**.

Today's Project:

In this project, you will be given a strand of DNA, and we want to create RNA from it. Then, we will take that new RNA strand and create a protein from it. We must first learn the different building blocks, so we will be using different charts to understand how to go from DNA to RNA.

Imagine your group of desks or table is a cell and notice a paper strand of DNA taped inside a circle on the table. We can see that DNA is double stranded, but RNA is single stranded. Therefore, we need to determine which strand we want to read (hint: look for the START). The circle represents the nucleus, where the DNA is housed. RNA is made inside the nucleus and then moves outside so it can travel freely within the cell. To show this, we will build the RNA by taping the correct set of paper RNA nucleotides together to make an RNA strand from the DNA. Once the strand of RNA is complete, it will travel outside the nucleus to a ribosome within the cell. Once the RNA is near the ribosome, it can be translated into a protein. Remember that proteins are made up of amino acids, and we will be using beads with the letters on them to represent the correct amino acid. The protein will be connected by adding each bead to the string as we go along. At the end, we will be able to see the process of how the central dogma works!

Part 1: Transcription

1. We need to first convert a strand of DNA to RNA, which is the process of transcription. We will act as the polymerase enzyme to read DNA and create the RNA.

2. First, let's practice reading DNA! Look in **Table 1** below to **transcribe** the five DNA nucleotides into RNA by writing the correct letter on the lines in the red box.

Table 1:

DNA	RNA
A (Adenine)	**U** (Uracil)
T (Thymine)	**A** (Adenine)
G (Guanine)	**C** (Cytosine)
C (Cytosine)	**G** (Guanine)

DNA: **A G C C T**

RNA: ___ ___ ___ ___ ___

3. Now let's look at the DNA strand on your desk. Both the strands are also shown in the **blue box** on the next page. We will read the **bottom** strand to make our RNA.

4. Transcribe each of the DNA nucleotides like we did in the red box, so we have an entire RNA strand written on paper in the **blue box.**

5. Let's start with the first DNA nucleotide. We will use the same DNA → RNA table above to get the correct RNA nucleotide. The first nucleotide in the DNA template strand is **T**, so we will write an **A** under it to represent our RNA nucleotide.

6. The next DNA nucleotide is **A**, so we would write a **U** on the line under it. The third DNA nucleotide is a **C**, so we will write a **G** under it.

7. Repeat this process for each of the DNA nucleotides so all the lines have an RNA nucleotide written in.

5' A T G A G T T G T A T T G A A A A C T G T G A A T A A **3'**

3' T A C T C A A C A T A A C T T T T G A C A C T T A T T **5'**

RNA: ___

8. Now let's make our RNA strand out of paper RNA nucleotides. Remember we are the polymerase! A polymerase does a lot of things to do transcription. Today, each of us will be a different part of the polymerase.

9. The first person locates the bag labeled **"RNA Nucleotides"**, pull out the different papers (nucleotides) and place them in a neat pile.

10. The second person finds the nucleotide that comes next.

11. The third person takes the glue stick and rubs it on the back of the nucleotide.

12. The last person sticks the nucleotide on the correct square on the paper RNA.

13. Repeat this step until you have a complete strand of RNA. It should be the same as the strand recorded in the **blue box** above.

14. Great job! You all are awesome polymerases! Now let's move the RNA strand out of the nucleus so we can start **translation.**

Part 2: Translation

The next step is **translation**, where RNA is read to make a protein. Remember that every 3 RNA nucleotides considered a **codon**. Each **codon** encodes for an **amino acid.** These amino acids form the protein. We will use **Table 2** to translate codons into amino acids. This table only contains the codons found in our RNA strand, so scientists need to use a table that is much larger when they are translating RNA. An RNA can be read to make multiple proteins, so today we will all be making our own protein from the RNA.

Table 2:

Codon (3 RNA nucleotides)	Amino Acid Letter Code
UGU	C
GAA	E
AUU	I
AAC	N
AUG	Go – grab string (with green bead)
AGU	S
ACU	T
UAA	Stop – add red bead and tie a knot

1. First, make sure your RNA strand is outside the nucleus, and near the **ribosome.**

2. Find the bag labeled **"Amino Acids"** and take out the strings.

3. Look at the first **three** RNA nucleotides. They are **A U G**! What does this codon represent in table 2? It says **"Go" – grab string (with green bead).** Every person of the group needs to grab a string with a green bead already tied on.

4. Place a slash **/** over the RNA nucleotides you just used.

5. Look at the next **three** RNA nucleotides (codon). They should be **AGU**. Look at Table 2 to find what amino acid this codon codes for. Remember to slash out those three nucleotides!

6. Find a bead in the **Amino Acid** bag that has the same letter on it. This will be our amino acid that we add to the string.

7. Repeat **steps 5 and 6** until all the codons are translated and the amino acids are added onto the strings.

8. The last codon is **"Stop – add red bead and tie a knot"**. Add the red bead and tie a knot.

9. What word does the protein spell? ________________________________

WOW! Although it looks strange at first, when we make the RNA into a protein we get the word SCIENCE! The "Go" just lets us know where to start reading, and the "Stop" lets us know when we stop reading, just like a period at the end of a sentence. Isn't science cool?

NOTES:

Although in this case the amino acids spelled out a word, this is not normally the case. Many times the amino acids will not spell out words, but our cells are smart enough to still read the polypeptide chain and use the proteins correctly!

Remember, we only used 8 codons (groups of 3 nucleotides) for deciding which amino acid to use. There are actually a lot more combinations! There are actually 20 amino acids and 64 different codon combinations. Here is an example of a chart that scientists often use to read the different codons to help them see how RNA will translated:

FIRST BASE	SECOND BASE				THIRD BASE
	UUU, UUC – Phenyl-alanine F UUA, UUG – Leucine L	UCU, UCC, UCA, UCG – Serine S	UAU, UAC – Tyrosine Y UAA – Stop codon UAG – Stop codon	UGU, UGC – Cysteine C UGA – Stop codon UGG – Tryptophan W	
	CUU, CUC, CUA, CUG – Leucine L	CCU, CCC, CCA, CCG – Proline P	CAU, CAC – Histidine H CAA, CAG – Glutamate Q	CGU, CGC, CGA, CGG – Arginine R	
	AUU, AUC, AUA – Isoleucine I AUG – Methionine start codon M	ACU, ACC, ACA, ACG – Threonine T	AAU, AAC – Asparagine N AAA, AAG – Lysine K	AGU, AGC – Serine S AGA, AGG – Arginine R	
	GUU, GUC, GUA, GUG – Valine V	GCU, GCC, GCA, GCG – Alanine A	GAU, GAC – Aspartic acid D GAA, GAG – Glutamic acid E	GGU, GGC, GGA, GGG – Glycine G	

(http://sabal.uscb.edu/SIMMER_translation/images/codon_table.jpg)

PART 3: Mutation Experiment

DNA should hopefully never change. However, sometimes there are changes in the nucleotides and these changes are called **mutations**. Let’s make a question and a hypothesis about what will happen if we make the change.

Statement of Question:

Hypothesis:

Here is the new DNA strand with the single nucleotide change (it is colored) in it:

5' A T G A G T T G T A **C** T G A A A A C T G T G A A T A A **3'**

3' T A C T C A A C A T **G** A C T T T T G A C A C T T A T T **5'**

Try doing the following steps to see what will happen to a protein when there is a mutation in the DNA. Remember that scientists take really good notes! Make sure to write down everything as you go.

1. Transcribe the DNA into RNA (Hint: Remember the RNA strand will be very similar to the one who wrote down in Part 1 if you need more help)

DNA	RNA
A (Adenine)	**U** (Uracil)
T (Thymine)	**A** (Adenine)
G (Guanine)	**C** (Cytosine)
C (Cytosine)	**G** (Guanine)

Write down your new RNA strand here:

__ __

2. Now add the changed nucleotide where there was the change on the RNA molecule.
3. Translate the RNA strand into the single letter amino acids which will form the polypeptide chain (Look at the chart below and part 2 for more help). This time we are just going to write down the new protein instead of making it with the beads.

Codon (3 RNA nucleotides)	**Amino Acid Letter Code**
UGU	**C**
GAA	**E**
AUU	**I**
AAC	**N**
AUG	**Go – grab string (with green bead)**
AGU	**S**
ACU	**T**
UAA	**Stop – add red bead and tie a knot**

1. Look at the first **three** RNA nucleotides. They are **A U G**! What does this codon represent in table 2? It says **"Go" – grab string (with green bead).** Write down the word Go
2. Place a slash **** over the RNA nucleotides you just used.
3. Look at the next **three** RNA nucleotides (codon). They should be **AGU**. Look at Table 2 to find what amino acid this codon codes for. Write down this amino acid. Remember to slash out those three nucleotides!
4. Repeat **steps 2 and 3** until all the codons are translated and the amino acids are written down.
5. The last codon is **"Stop – add red bead and tie a knot"**. Just write down the word stop

   Write down your amino acid polypeptide chain here (the final word):

   ____

4. Read the word and see what happens.

When there was a mutation in the DNA, was there a change in the final protein or the "word?" YES or NO (Circle One)

Did the other groups get the same “word”? YES or NO (Circle One)

Was your hypothesis correct? YES or NO (Circle One)

PART 4: Proteins and Eye Color

Proteins are really cool things in the body. They have a lot of functions, and without them, we wouldn’t be alive today! Remember when we learned about different eye colors last week? Well, the color of your eyes happen because of a protein! When changes happen in the DNA and RNA, or in other words a mutation occurs, it changes the protein at the end. Since the proteins are now different, they create different colors in your eyes, and this all happens because of small changes caused by mutations.

Follow-up Questions:

Where is DNA located in the cell?

What is a mutation?

What performs translation in the cell?

What transcribes DNA to RNA in the cell?

Describe something you learned today:

Did you enjoy performing this scientific experiment? (Please circle one)

YES NO NOT SURE

Checklist:

Checklist Item	Answers should be “yes”, if not, go back and complete the steps before moving on.
1. Did you record the hypothesis you are testing?	
2. Have you worded the hypothesis so that it can be tested and answered by the experiment?	
3. Did you record the RNA strands and the polypeptide chains (both with the 3 letter amino acids and the 1 letter amino acids)?	
4. Did you compare your results with other groups?	
5. Were you consistent, careful, and accurate when you made your observations?	
6.Did you answer all the questions?	
7. Did you record if your hypothesis was true or false?	
8. If false, did you develop a new hypothesis that can be tested?	

“The Central Dogma: DNA to RNA to Proteins” Outreach Program

Instructor Guidelines

INTRODUCTION

Introduce yourself, where your work, and others along with you

GOALS OF BEING HERE

Today, we will be investigating how DNA (deoxyribonucleic acid) is used to make proteins, a process used by essentially every living thing. The concept of transcribing DNA to RNA (ribonucleic acid), and then translating RNA into proteins is known as the “central dogma” [mention how you will learn about what these words mean in just a little bit]. Maybe you have heard of proteins before, probably relating to food. What are some examples of food with protein? [let a student answer].

Great! Well our bodies are also made up of proteins, and each cell of our body needs special proteins. When we eat food, those proteins get broken down into smaller units, and our body can rebuild these sub-units, called amino acids, into the specialized proteins that we need.

But how do you think our cells know how to make these new proteins? That’s why we have DNA, they act as a set of instructions for our cells by providing a code that can be translated to reveal how a new protein should be made. Today, we are going to learn about the central dogma, and how DNA is the code to making proteins.

Let’s look at the introduction of our workbook (go over introduction in workbook):

(Items in student work book are in **blue**)

Introduction

DNA is the code of life. For many years, scientists looked for the answer of what holds the information for life to occur. After many experiments, scientists realized that **DNA** holds this necessary information.

DNA alone however is not sufficient to maintain life. It must be changed into proteins, which are able to interact with each other both inside the cell and between other cells. Imagine DNA as the boss; the boss knows what needs to be done, but there is no way that he/she could possibly complete it all. Therefore, this boss needs to hire workers that are specific to each thing that must be accomplished. The workers in this analogy are molecules called **proteins**. However, DNA cannot immediately read and understood. It must first be copied into **RNA** and then the RNA can then be read, and more proteins can be made. This process of translating DNA to RNA, and then RNA to proteins is what scientists call “The Central Dogma”.

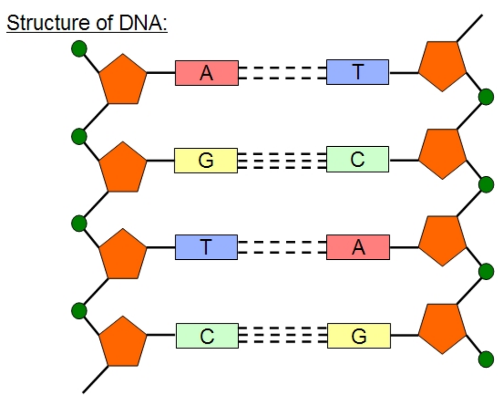
The Central Dogma: ***Need to emphasize this

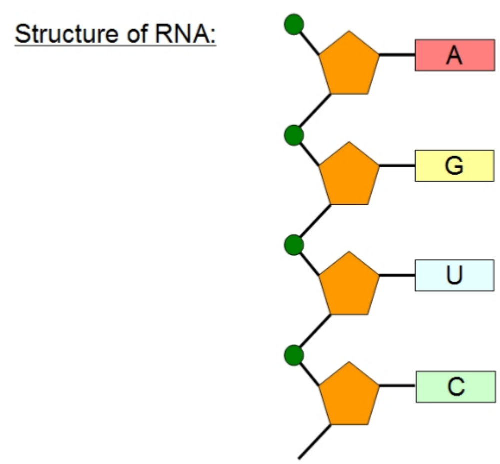
DNA → RNA → PROTEIN

DNA needs to be copied into RNA because DNA isn't allowed to leave its location in the cell, which is known as the nucleus. RNA, however, is allowed to leave the nucleus where RNA can be read by **ribosomes** to make proteins.

Picture DNA as your family recipe book. The recipe book is far too precious and valuable to take outside the house; after all, you might lose it on accident! Instead of taking it around with you, you can write down the recipe on a notecard and take that with you. The notecard represents RNA because it still gives the recipe for the food dish, but it is much smaller than the cookbook. You can then take the recipe card to your friend's house and then make the food. The food can be considered the protein in this example. The process of using the recipe notecard as instructions for making food is similar to RNA being used in your cells to make more proteins.

You can see the structure of DNA and RNA in the pictures. Look how DNA has two strands that are connected by dashed lines, and RNA only has one strand. Also, there are different letters for the RNA and DNA. DNA has AGTC, and RNA has AGUC.





Now let's go over some vocabulary that scientists use to describe this process. (IN WORKBOOK)

Today's Vocabulary:

- A **nucleotide** is a small unit of that make up DNA and RNA. When many nucleotides are joined together, they form DNA or RNA. The nucleotides of DNA are represented by A, T, C, and G. The nucleotides of RNA are represented by A, U, C, and G.
- The process of reading DNA to make new RNA is called **transcription**. This is done through a special type of enzyme called a **polymerase**, which will read the each of the nucleotides from the DNA and create a new strand of RNA.
- The process of reading RNA to make proteins is called **translation**. This process is done by **ribosomes** found in cells. Ribosome are like little factories that build proteins.
- The ribosomes read RNA **codons,** with are made of three RNA nucleotides in a row. Codons can then be translated to make a protein.
- Just as DNA and RNA have small units that are put together (nucleotides), proteins also have small units called **amino acids**. Scientists call a chain of amino acids a **polypeptide chain**, and many people also call them **proteins**.

Today's Project:

In this project, you will be given a strand of DNA, and we want to create RNA from it. Then, we will take that new RNA strand and create a protein from it. We must first learn the "languages" of the central dogma, so we will be using different charts to understand how to translate these different languages.

Imagine your group of desks or table is a cell and notice a paper strand of DNA taped inside a circle on the table. We can see that DNA is double stranded, but RNA is single stranded. Therefore, we need to determine which strand we want to read (hint: look for the START). The circle represents the nucleus, where the DNA is housed. RNA is made inside the nucleus and then moves outside so it can travel freely within the cell. To show this, we will build the RNA by taping the correct set of paper RNA nucleotides together to make an RNA strand from the DNA. Once the strand of RNA is complete, it will travel outside the nucleus to a ribosome within the cell. Once the RNA is near the ribosome, it can be translated into a protein. Remember that proteins are made up of amino acids, and we will be using beads with the letters on them to represent the correct amino acid.

The protein will be connected by adding each bead to the string as we go along. At the end, we will be able to see the process of how the central dogma works!

Part 1: Transcription ***Make sure to walk them through step by step

1. We need to first convert a strand of DNA to RNA, which is the process of transcription. (Pick someone to be the polymerase enzyme to read DNA and create the RNA). RNA is like DNA, but RNA is a different language!
2. First, let's practice reading DNA! Look in **Table 1** below to **translate** the five DNA nucleotides into RNA by writing the correct letter on the lines in the red box.

Table 1: ***Put on board (transparency?)

DNA	RNA
A (Adenine)	**U** (Uracil)
T (Thymine)	**A** (Adenine)
G (Guanine)	**C** (Cytosine)
C (Cytosine)	**G** (Guanine)

DNA:	**A**	**G**	**C**	**C**	**T**
RNA:	___	___	___	___	___

3. Now let's look at the DNA strand on your desk. Both the strands are also shown in the **blue box** on the next page. We will read the **Template** strand to make our RNA.

4. Translate each of the DNA nucleotides like we did in the red box, so we have an entire RNA strand written on paper in the **blue box.**

5. Let's start with the first DNA nucleotide. We will use the same DNA → RNA table above to get the correct RNA nucleotide. The first nucleotide in the DNA template strand is **T**, so we will write an **A** under it to represent our RNA nucleotide.

6. The next DNA nucleotide is **A**, so we would write a **U** on the line under it. The third DNA nucleotide is a **C**, so we will write a **G** under it.

7. Repeat this process for each of the DNA nucleotides so all the lines have a RNA nucleotide written in.

Non-Template:

5' A T G A G T T G T A T T G A A A A C T G T G A A T A A **3'**

Template:

3' T A C T C A A C A T A A C T T T T G A C A C T T A T T **5'**

RNA: ___

ANSWER:
5' AUG AGU UGU AUU GAA AAC UGU GAA UAA 3' **RNA**

8. Now let's make our RNA strand out of paper RNA nucleotides. We will use the same process of translating DNA into RNA, but instead of writing down the RNA nucleotides, we will tape the paper nucleotides together.

9. Locate the bag labeled **"RNA Nucleotides"**, pull out the different papers (nucleotides) and place them in a neat pile.

10. Place the RNA paper under template DNA strand.

Can you figure out which strand is the template? Look at the DNA in the blue box above.
Answer: Bottom strand (3' → 5')

11. Find the correct RNA nucleotide for first DNA nucleotide. It will be the same letter as in **step 5**. Tape this RNA nucleotide onto the #1 spot in the RNA paper.

12. Find the correct RNA nucleotide for the second DNA nucleotide and tape it to the #2 position on the RNA paper. You should be left with an **A** and a **U** RNA nucleotide taped to the first 2 positions on the RNA paper.

13. Repeat this step until you have a complete strand of RNA. It should be the same as the strand recorded in the **blue box** above.

14. Great job! Now let's move the RNA strand out of the nucleus so we can start **translation.**

Part 2: Translation

The next step in the Central Dogma is **translation**, where RNA is read to make a protein. Remember that every 3 RNA nucleotides considered a **codon**. Each **codon** encodes for an **amino acid.** The chain of amino acids is called a **polypeptide chain** and it will form the protein. We will use **Table 2** to translate codons into amino acids. This table only contains the codons found in our RNA strand, so scientists need to use a table that is much larger when they are translating RNA.

Table 2:

Codon (3 RNA nucleotides)	Amino Acid Letter Code
UGU	C
GAA	E
AUU	I
AAC	N
AUG	Go
AGU	S
ACU	T
UAA	Stop – tie a knot

1. First, make sure your RNA strand is outside the nucleus, and near the **ribosome.**

2. Find the bag labeled **"Amino Acids"** and take out the strings.

3. Look at the first **three** RNA nucleotides. They are **A U G**! What does this codon represent in table 2? It says **"Go."** This means each student should grab a string.

4. Place a check mark ✓ over the RNA nucleotides you just used.

5. Look at the next **three** RNA nucleotides (codon). They should be **AGU**. Look at Table 2 to find what amino acid this codon codes for.

6. Find a bead in the **Amino Acid** bag that has the same letter on it. This will be our amino acid that we add to the string.

7. Repeat **steps 5 and 6** until all the codons are translated and the amino acids are added onto the strings.

8. The last codon is **"Stop – tie a knot"**. This means tie a knot at the end out the string.

9. What word does the protein spell? ________________________________

ANSWER:
5' AUG AGU UGU AUU GAA AAC UGU GAA UAA 3' **RNA**
Go S C I E N C E Stop

WOW! Although it looks strange at first, when we make the RNA into a protein we get the word SCIENCE! The "Go" just lets us know where to start reading, and the "Stop" lets us know when we stop reading, just like a period at the end of a sentence. Isn't science cool?

NOTES:
Although in this case the amino acids spelled out a word, this is not normally the case. Many times the amino acids will not spell out words, but our cells are smart enough to still read the polypeptide chain and use the proteins correctly!

Also, we only used 8 codons (groups of 3 nucleotides) for deciding which amino acid to use. There are actually a lot more combinations! There are actually 20 amino acids and 64 different codon combinations. Here is an example of a chart that scientists often use to read the different codons to help them see how RNA will translated:

FIRST BASE	SECOND BASE				THIRD BASE
	UUU, UUC – Phenyl-alanine F UUA, UUG – Leucine L	UCU, UCC, UCA, UCG – Serine S	UAU, UAC – Tyrosine Y UAA – Stop codon UAG – Stop codon	UGU, UGC – Cysteine C UGA – Stop codon UGG – Tryptophan W	
	CUU, CUC, CUA, CUG – Leucine L	CCU, CCC, CCA, CCG – Proline P	CAU, CAC – Histidine H CAA, CAG – Glutamate Q	CGU, CGC, CGA, CGG – Arginine R	
	AUU, AUC, AUA – Isoleucine I AUG – Methionine start codon M	ACU, ACC, ACA, ACG – Threonine T	AAU, AAC – Asparagine N AAA, AAG – Lysine K	AGU, AGC – Serine S AGA, AGG – Arginine R	
	GUU, GUC, GUA, GUG – Valine V	GCU, GCC, GCA, GCG – Alanine A	GAU, GAC – Aspartic acid D GAA, GAG – Glutamic acid E	GGU, GGC, GGA, GGG – Glycine G	

(http://sabal.uscb.edu/SIMMER_translation/images/codon_table.jpg)

PART 3: Mutation Experiment

DNA should hopefully never change. However, sometimes there are changes in the nucleotides and these changes are called **mutations**. Let's make a question and a hypothesis about what will happen if we make the change.

Statement of Question:

(If students are stuck) What happens if DNA changes…. If DNA changes, do proteins change?

Hypothesis:

IF, THEN statements

(IF DNA changes, then proteins will change)

Here is the new DNA strand with the single nucleotide change (it is colored) in it:

Non-Template:

5' A T G A G T T G T A C T G A A A A C T G T G A A T A A **3'**

Template:

3' T A C T C A A C A T G A C T T T T G A C A C T T A T T **5'**

Try doing the following steps to see what will happen to a protein when there is a mutation in the DNA. Remember that scientists take really good notes! Make sure to write down everything as you go.

1. Transcribe the DNA into RNA (Hint: Remember the RNA strand will be very similar to the Non-Template strand and look at Part 1 if you need more help)

DNA	RNA
A (Adenine)	**U** (Uracil)
T (Thymine)	**A** (Adenine)
G (Guanine)	**C** (Cytosine)
C (Cytosine)	**G** (Guanine)

Write down your new RNA strand here:

2. Translate the RNA strand into the single letter amino acids which will form the polypeptide chain (Look at the chart below and part 2 for more help).

Codon (3 RNA nucleotides)	Amino Acid Letter Code
UGU	C
GAA	E
AUU	I
AAC	N
AUG	Go
AGU	S
ACU	T
UAA	Stop

Write down your amino acid polypeptide chain here (the final word):

3. Read the word and see what happens.

When there was a mutation in the DNA, was there a change in the final protein or the "word?" YES or NO (Circle One)

Did the other groups get the same "word"? YES or NO (Circle One)

Was your hypothesis correct? YES or NO (Circle One)

PART 4: Proteins and Eye Color

Proteins are really cool things in the body. They have a lot of functions, and without them, we wouldn't be alive today! Remember when we learned about different eye colors last week? Well, the color of your eyes happen because of a protein! When changes happen in the DNA and RNA, or in other words a mutation occurs, it changes the protein at the end. Since the proteins are now different, they create different colors in your eyes, and this all happens because of small changes caused by mutations.

Follow-up Questions:

How many different amino acids are there?

Where is DNA located in the cell?

What is a mutation?

What performs translation in the cell?

What transcribes DNA to RNA in the cell?

Describe something you learned today:

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Did you enjoy performing this scientific experiment? (Please circle one)

YES NO NOT SURE

Checklist:

Checklist Item	Answers should be “yes”, if not, go back and complete the steps before moving on.
1. Did you record the hypothesis you are testing?	
2. Have you worded the hypothesis so that it can be tested and answered by the experiment?	
3. Do you think other students would be able to follow these steps to go from DNA to RNA to protein?	
4. Did you record the RNA strands and the polypeptide chains (both with the 3 letter amino acids and the 1 letter amino acids)?	
5. Did you compare your results with other groups?	
6. Were you consistent, careful, and accurate when you made your observations?	
7.Did you answer all the questions?	
8. Did you record if your hypothesis was true or false?	
9. If false, did you develop a new hypothesis that can be tested?	

Workbook answers

Mutation Experiment

DNA should hopefully never change. However, sometimes there are changes in the nucleotides and these changes are called mutations. Let's make a question and a hypothesis about what will happen if we make the change.

Statement of Question:

Question: Will a change in the DNA sequence result in a change in the protein "codeword".

Hypothesis:

Hypothesis: having a mutation on the DNA will result in a change or not a change on the protein "codeword."

Here is the new DNA strand with the change in it:

5' ATG AGT TGT ACT GAA AAC TGT GAA TAA 3' **Non-Template**
3' TAC TCA ACA TGA CTT TTG ACA CTT ATT 5' **Template**

Try doing the following steps to see what will happen to a protein when there is a mutation in the DNA.

4. Transcribe the DNA into RNA (Hint: Remember the RNA strand will be very similar to the Non-Template strand)
5. Translate the RNA strand into the 3 letter amino acids which will form the polypeptide chain (Look at Figure 1 for the chart).
6. Change the 3 letter amino acids into the single letter amino acids (Look at Figure 2 for these amino acids)
7. Read the word and see what happens. Remember that scientists take really good notes! Make sure to write down everything as you go!

Write down your new RNA strand here:

5' AUG AGU UGU ACU GAA AAC UGU GAA UAA 3'

Write down your 3 letter amino acid polypeptide chain (the amino acids that are formed by the RNA) here:
Met Ser Cys Thr Glu Asn Cys Glu Stop

Write down your 1 letter amino acid polypeptide chain here:
MSCTENCE

Write down your final new word:

SCTENCE

When there was a mutation in the DNA, was there a change in the final protein or the "word?"

YES, there is a change in the final protein

Did the other groups get the same "word"? YES or NO (Circle One)

Was your hypothesis correct? YES or NO (Circle One)

Follow-up Questions:

How many different amino acids are there?

20

Where is DNA located in the cell?

DNA is located in the Nucleus.

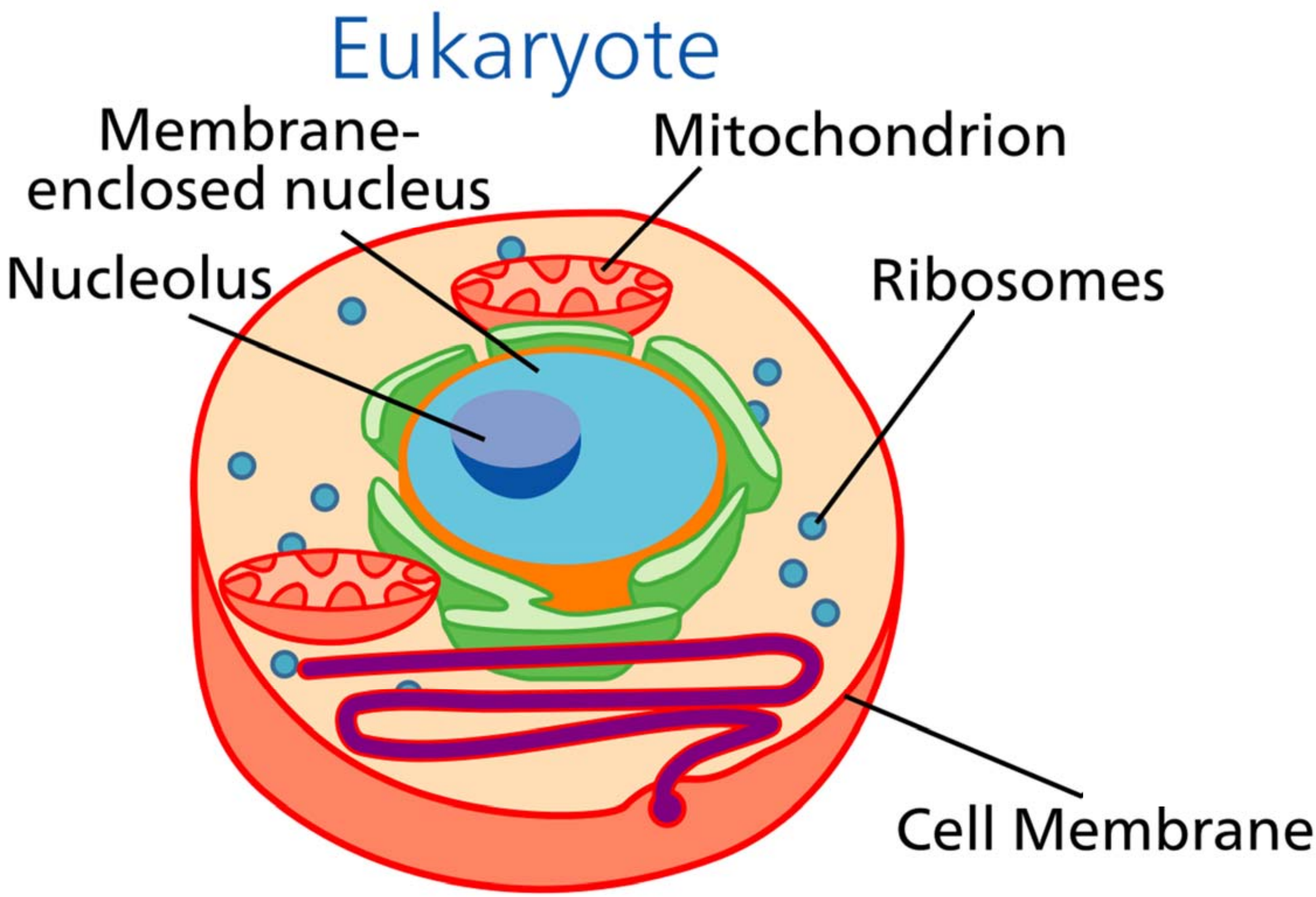
What is a mutation?

A mutation is a change in the DNA sequence.

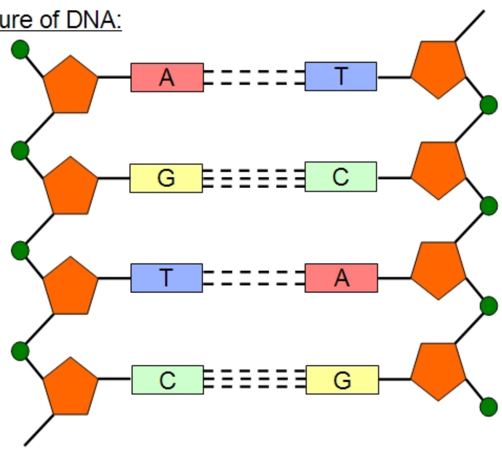
What does translation in the cell?

Ribosomes are used by the cell to translate RNA into proteins.

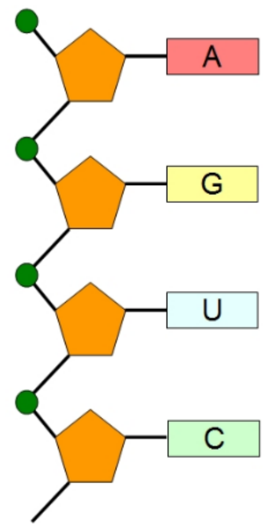
What transcribes DNA to RNA in the cell?
A polymerase transcribes DNA into RNA.


Eukaryote
Membrane-
enclosed nucleus
Mitochondrion
Nucleolus
Ribosomes
Cell Membrane

Structure of DNA:



Structure of RNA:

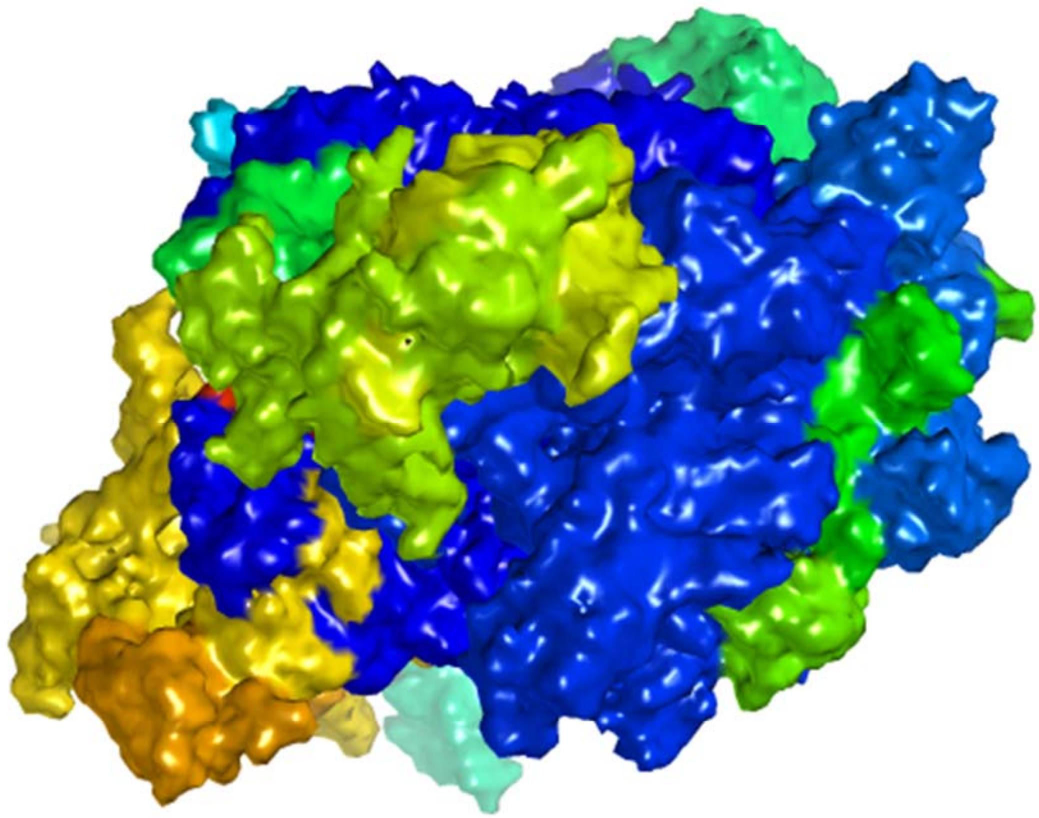


SIMILAR

- Contain information
- Both are made of building blocks called nucleotides

DIFFERENT

- DNA has two strands and RNA only has one strand
- DNA has the nucleotide “T” but RNA has “U”



How are proteins different?

- Also have building blocks, but they are different and are called amino acids.
- There are 20 building blocks instead of 4.
- Instead of having information, proteins go do things.

DNA	RNA
A (Adenine)	**U** (Uracil)
T (Thymine)	**A** (Adenine)
G (Guanine)	**C** (Cytosine)
C (Cytosine)	**G** (Guanine)

5' A T G A G T T G T A T T G A A A A C T G T G A A T A A **3'**

3' T A C T C A A C A T A A C T T T T G A C A C T T A T T **5'**

RNA: ___

RNA:

5'- AUG AGU UGU AUU GAA AAC UGU GAA UAA – 3'

Codon (3 RNA nucleotides)	Amino Acid Letter Code
UGU	C
GAA	E
AUU	I
AAC	N
AUG	Go – grab string (with green bead)
AGU	S
ACU	T
UAA	Stop – add red bead and tie a knot

PROTEIN:

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DNA	RNA
A (Adenine)	**U** (Uracil)
T (Thymine)	**A** (Adenine)
G (Guanine)	**C** (Cytosine)
C (Cytosine)	**G** (Guanine)

5’ A T G A G T T G T A **C** T G A A A A C T G T G A A T A A **3'**

3' T A C T C A A C A T **G** A C T T T T G A C A C T T A T T **5’**

RNA:

5'- AUG AGU UGU ACU GAA AAC UGU GAA UAA – 3'

Codon (3 RNA nucleotides)	Amino Acid Letter Code
UGU	C
GAA	E
AUU	I
AAC	N
AUG	Go – grab string (with green bead)
AGU	S
ACU	T
UAA	Stop – add red bead and tie a knot

PROTEIN:

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