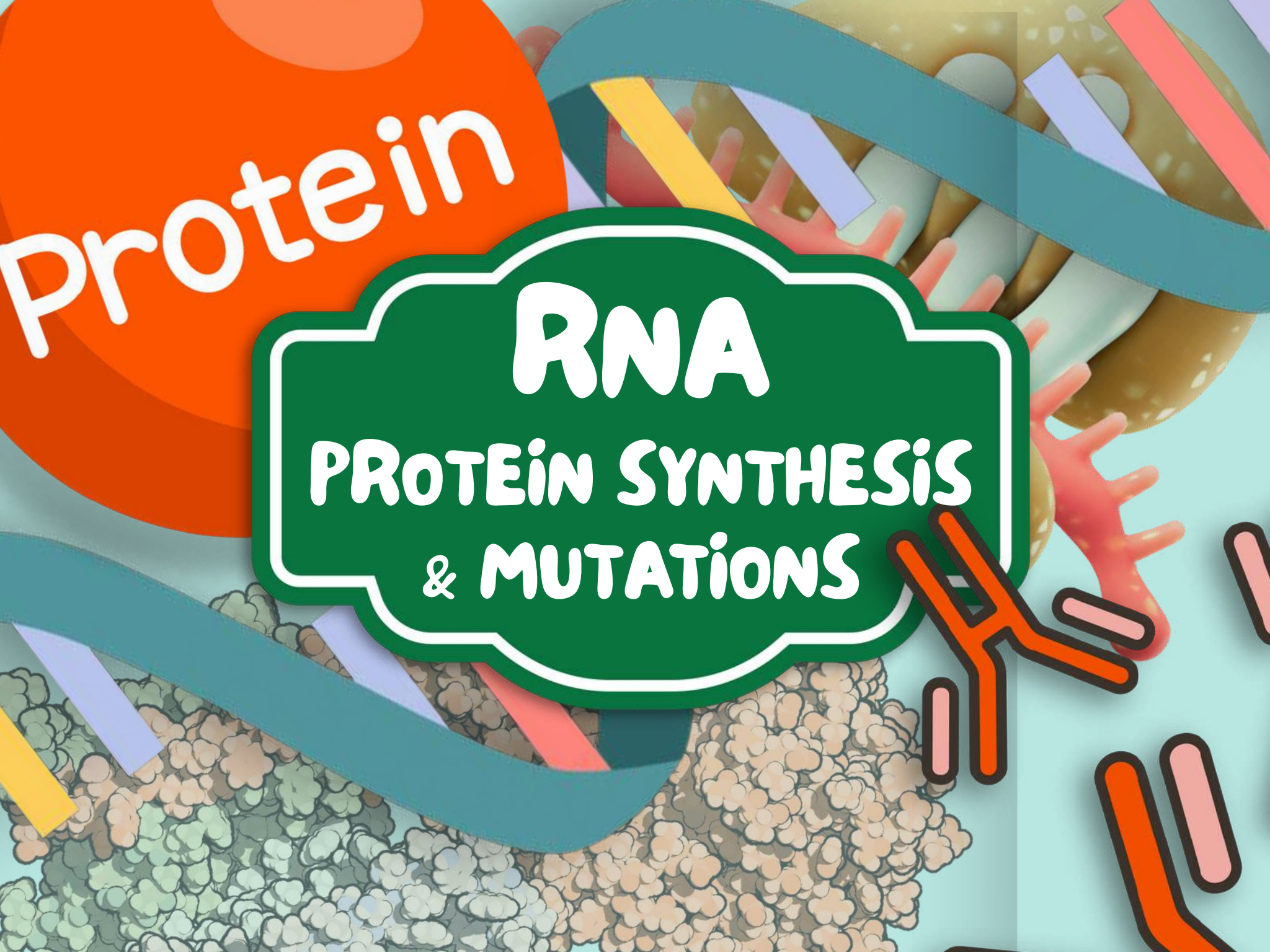

Protein
RNA
PROTEIN SYNTHESIS
& MUTATIONS

Imagine you're the CEO of a giant factory (your cell), and you need to make an important product: proteins. But here's the catch: you don't actually know how to make it yourself—you need instructions from someone who does! That's where DNA comes in. Think of DNA like the master blueprint of the factory, filled with all the detailed instructions you need to build every part of the factory. But, the twist? You can't take the blueprint to the machine room (the ribosomes) directly—it's locked up in a super-secret vault.

So, what do you do? You create a messenger—that's where RNA comes in! RNA copies the blueprint from DNA and then travels to the ribosome to deliver the instructions. Sounds like a simple task, right? Well, not so fast! RNA doesn't just copy; it has some cool jobs to do too. There are different types of RNA, each with its own role: mRNA (the messenger), tRNA (the transporter of amino acids), and rRNA (part of the ribosome itself). Together, they make sure the protein factory runs smoothly.

INTRODUCTION

Once the RNA reaches the ribosome, it's time for translation—this is where things get even cooler. mRNA gets read in groups of three nucleotides, called codons, and each codon is like a tiny instruction that tells the factory which amino acid to add to the protein. But what happens when the instructions aren't perfect? Maybe a tiny mistake slips in—an error in the codons. This can lead to mutations, which can change how the protein is made, sometimes causing genetic disorders like sickle cell anemia or cystic fibrosis.

In this unit, you'll explore how DNA becomes RNA, and how RNA makes sure your cells build the right proteins in the right way. You'll also dive into mutations, learning what happens when those instructions get messed up and how even small changes can cause big problems. Whether it's transcription or translation, RNA is always there, working hard to keep the factory running smoothly and making sure everything gets built correctly. Get ready to explore the DNA to protein highway, where the journey from gene to function is full of twists, turns, and surprises!

VOCABULARY

Vocabulary Word	Definition
Adenine	
Anticodon	
Base Pairing	
Codon	
Cytosine	
Deletion Mutation	
Deoxyribonucleic Acid (DNA)	

Vocabulary Word	Definition
Frameshift Mutation	
Gene Expression	
Genetic Code	
Guanine	
Insertion Mutation	
Messenger RNA (mRNA)	
Mutagen	
Mutation	

Vocabulary Word	Definition
Nitrogenous Base	
Nucleotide	
Phosphate Group	
Point Mutation	
Ribonucleic Acid (RNA)	
Ribosomal RNA (rRNA)	
RNA Polymerase	
Thymine	

Vocabulary Word	Definition
Transcription	
Transfer RNA (tRNA)	
Translation	
Uracil	

The Protein Glitch

PHENOMENON

Mission Log – Sol 89

Location: Mars HAB – Biolab 3

You're halfway through your second rotation on Mars when the mission's systems start glitching. The oxygen-releasing algae tanks are slowing down, the hydroponic strawberries are mutating with spots and curled leaves, and the lab mouse colony—used for long-term space adaptation studies—is showing signs of strange behaviors. One mouse even developed muscle weakness overnight.

At first, the crew blames radiation or soil contamination. But when you examine the cells under the nanoscope, the truth is far more complex—and a lot weirder. Inside the cells, the DNA looks fine. The master code is untouched. But the proteins being made? Totally wrong. Some are the wrong shape. Some are incomplete. Others aren't being made at all.

You run a test and track the process: Transcription—the step where DNA is copied into mRNA—seems normal. But when that mRNA reaches the ribosome for translation, the codons aren't being read correctly. Even worse? The tRNA molecules are bringing the wrong amino acids—or sometimes none at all. It's like the crew's cells are building the wrong parts from the right blueprints.

You look closer at the mRNA. That's when you spot it: mutations.

Some codons have been changed, others deleted, and a few have been shifted so badly the whole message is unreadable. It's a cellular disaster. And here's the wild part: it's not random. The same codon glitch appears in both plant and mouse RNA. It's like something—or someone—is targeting the way RNA is copied or read.

You've got a mission now:

- Figure out how RNA works in the cell
- Decode the process of transcription and translation
- Identify how point, insertion, or deletion mutations change the message
- Decide what happens when a codon shifts and a protein doesn't work properly

And most important—find out what's rewriting the code before it spreads to the human crew. You turn back to the monitor. A fresh sequence scrolls across the screen.

The mRNA isn't just glitched anymore...

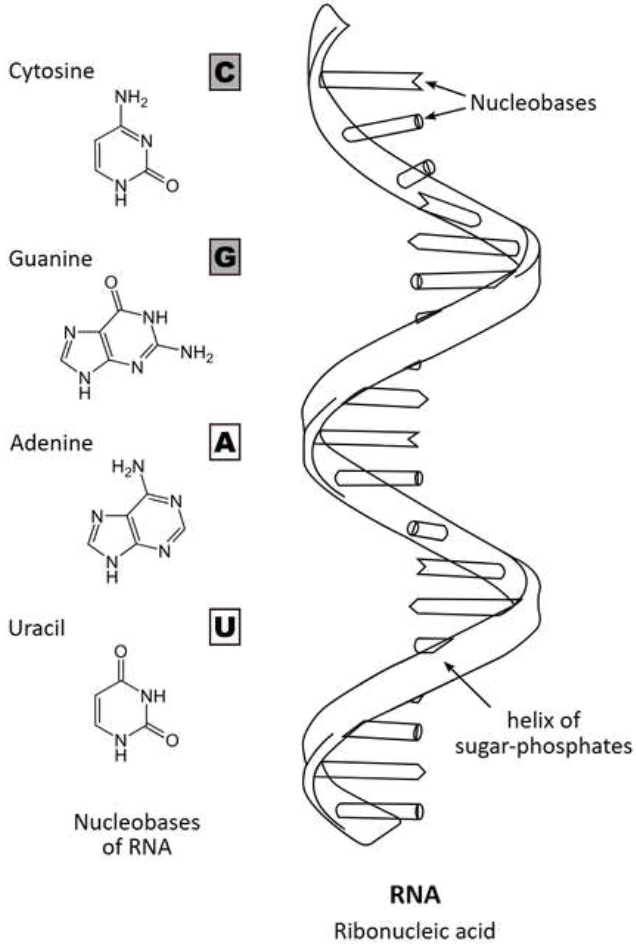
It's evolving.

- . What clues in the story suggest that the problem is not with the DNA, but with the RNA or protein being made?
  - "The story says the DNA looks fine, but the proteins are _____."
  - "This shows the problem might be happening during _____ or _____."
  - "One clue is that the wrong amino acids are being added, which means the _____ might be mutated."
- What is the purpose of transcription, and how is it shown working in the story?
  - "Transcription is the process where the DNA code is copied into _____."
  - "In the story, transcription is working normally because _____."
  - "This step happens before the RNA moves to the _____."
- How does translation work, and why is the process breaking down in the Mars HAB?
  - "Translation is when the cell reads the mRNA codons and builds a _____."
  - "In the story, the translation process is not working because _____."
  - "This could be caused by codons being _____, leading to the wrong protein being made."
- What are codons, and how do mutations like point, insertion, or deletion mutations affect them?
  - "Codons are groups of _____ bases on mRNA that code for one _____."
  - "A point mutation changes _____, which can affect the whole protein."
  - "An insertion or deletion changes the _____, which shifts how the ribosome reads the message."
- Why is it important that proteins are built correctly, and what can happen if they are not?
  - "Proteins need to be built correctly because they help cells with _____."
  - "If the wrong protein is made, it might not _____ or it could cause _____."
  - "In the Mars HAB, this is causing problems in both _____ and _____."

WHAT iS RNA?

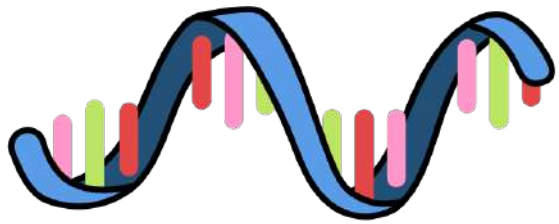
RNA: An Overview

- **RNA** as a **Nucleic Acid**
  - What is RNA?
    - RNA stands for **Ribonucleic Acid.**
      - **Single** Strand of **Nucleotides**
  - Made of a sugar called **ribose**, a **phosphate** group, and **bases** (Adenine, **Uracil**, Cytosine, Guanine).Types of RNA:
    - **mRNA** (**Messenger** RNA)
    - **tRNA** (**Transfer** RNA)
    - **rRNA** (**Ribosomal** RNA)

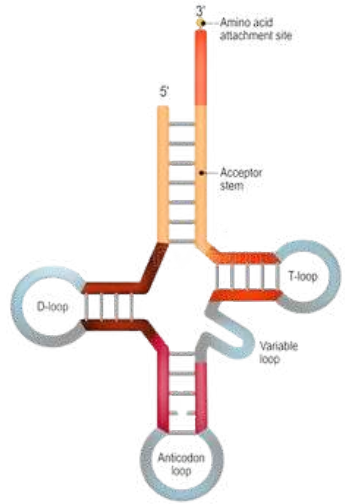


RNA Structure

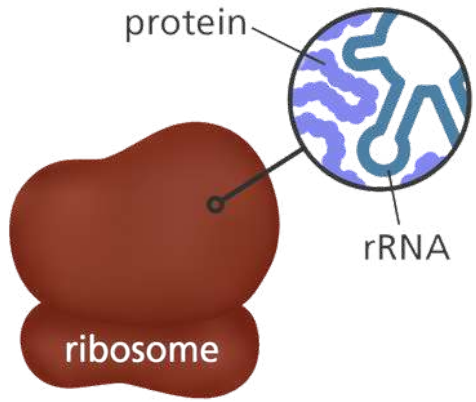
- **mRNA** (Messenger RNA)
  - Looks like: A **single** strand.
  - **Job**: Carries **messages** from **DNA** to the **ribosome**.



- **tRNA (Transfer RNA)**
  - Looks like: A cloverleaf shape with an **anticodon**.
  - Job: Brings **amino acids** to the **ribosome** to build **proteins**.



- **rRNA (Ribosomal RNA)**
  - Looks like: Part of the **ribosome**.
  - Job: Helps make **proteins** by combining with **proteins** to form ribosomes.

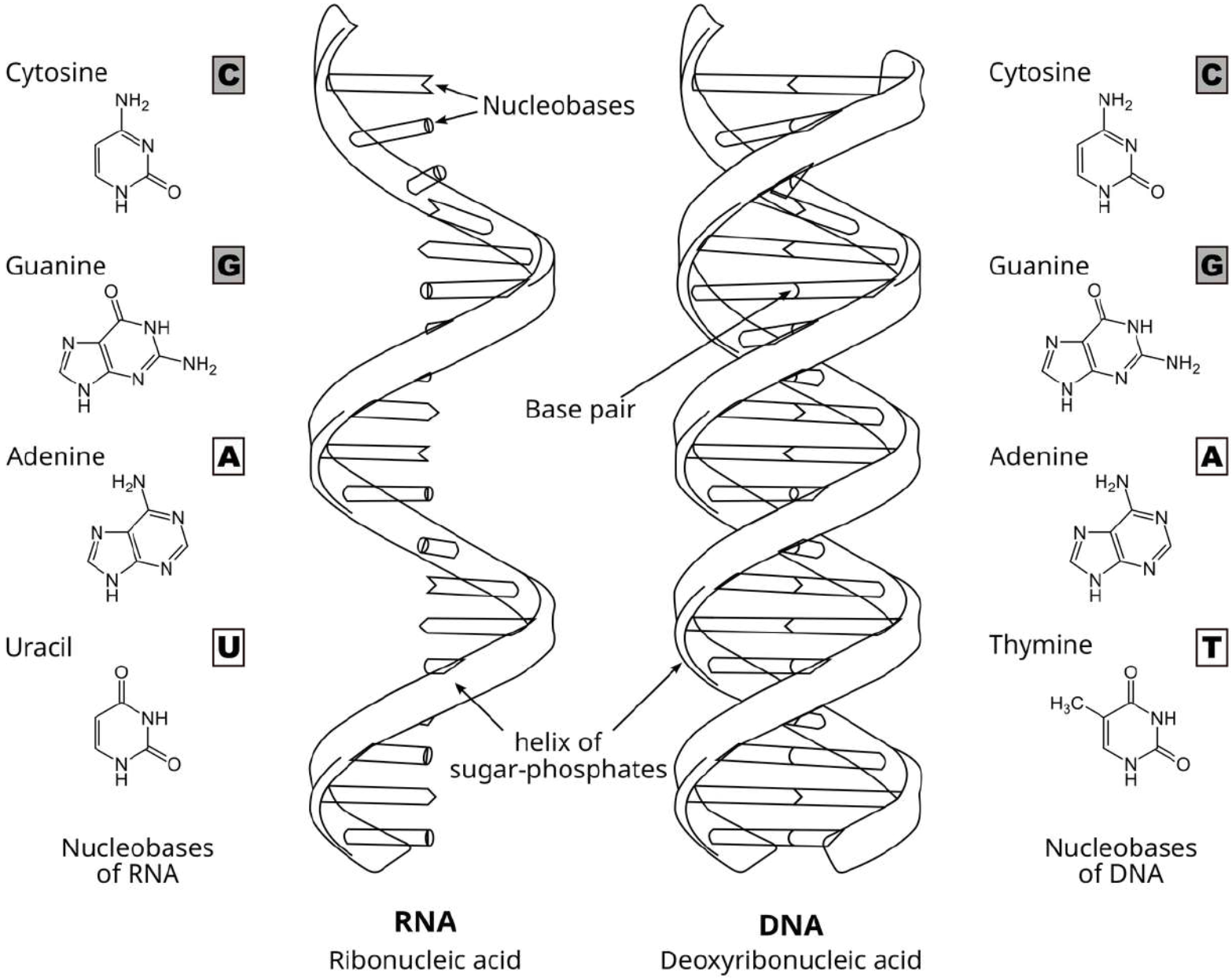


- How are Dexter and Denise (DNA) and Rani (RNA) different in their shapes and jobs in Cellville?
- Why does Rani (RNA) use uracil (U) instead of thymine (T)?
- What does Maya, the messenger, do to help make proteins? How is her job like and different from Dexter and Denise's job?
- What does Rosa, the ribosome supervisor, do to make sure proteins are made correctly in Cellville?
- How do Maya, Rosa, and Tessa work together to make proteins in Cellville? How does this teamwork show how DNA and RNA help each other?

DNA vS RNA

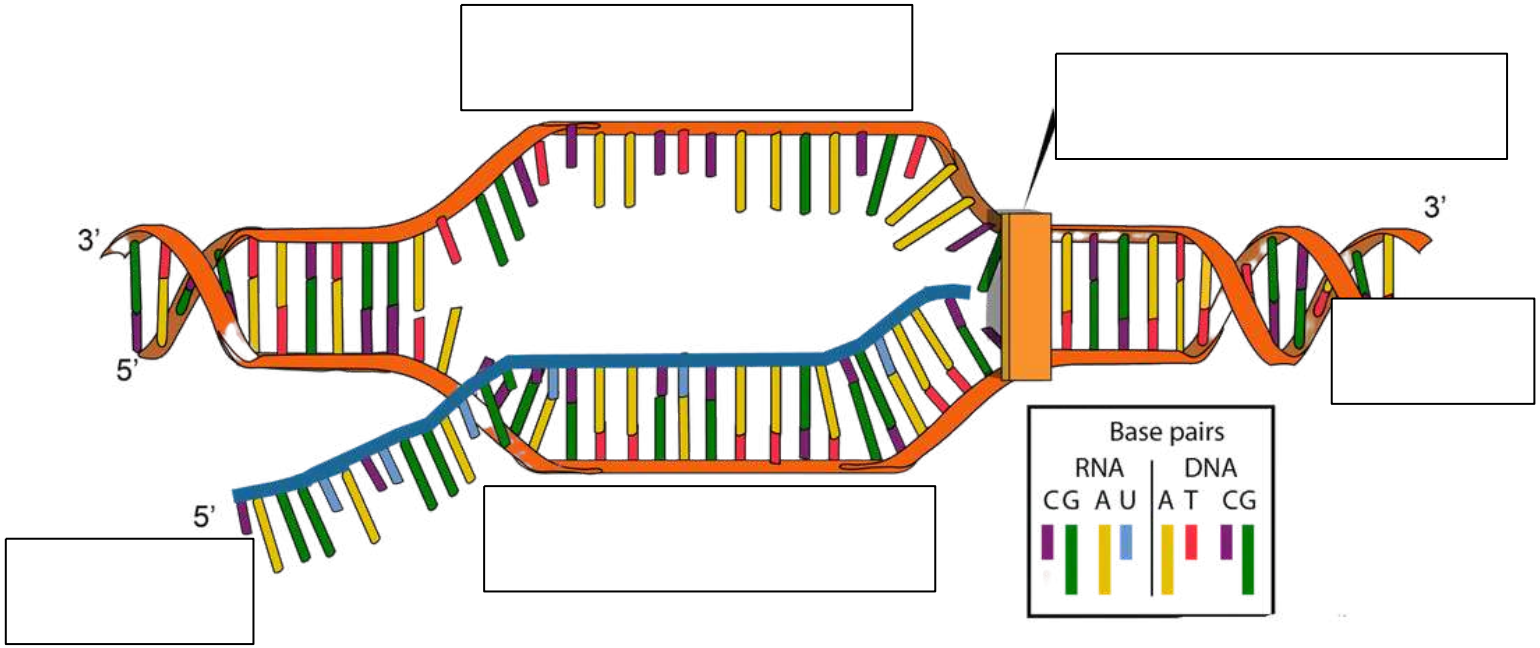
- Comparing DNA and RNA
  - Structure
    - **DNA**: **Double** helix (two strands) with bases **A, T, C, G.**
    - **RNA**: **Single** strand with bases **A, U, C, G.**
  - Function
    - **DNA**: **Stores genetic** information.
    - **RNA**: Helps make **proteins** by carrying **messages** and bringing **amino acids.**

DNA vS RNA


Cytosine
C
Guanine
G
Adenine
A
Uracil
U
Nucleobases of RNA
Nucleobases
Base pair
helix of sugar-phosphates
RNA
Ribonucleic acid
DNA
Deoxyribonucleic acid
Cytosine
C
Guanine
G
Adenine
A
Thymine
T
Nucleobases of DNA

TRANSCRIPTION

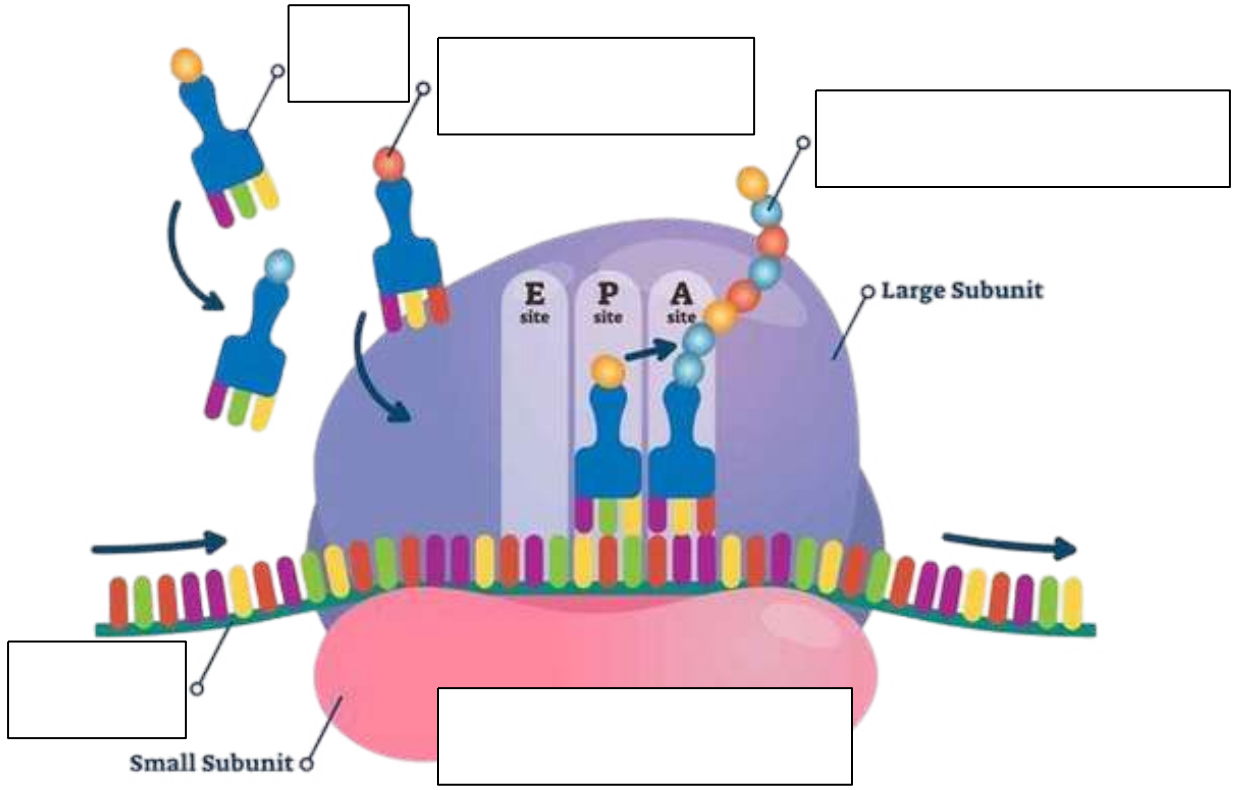
- **Purpose of Transcription**
  - **Transcription** means copying **instructions** from **DNA** to **RNA.**
  - **Process of Transcription**
    - **Steps:**
      - **RNA polymerase** binds to **DNA**.
      - **RNA polymerase** reads DNA and **makes RNA.**
      - RNA is **released** and **carries** the **message** to the **ribosome.**



- Who are Dexter and Denise in the city of Cellville, and what do they do?
- What is transcription in biology, and how is it similar to transcription in music?
- Who is Polly (RNA Polymerase), and what does she do with Dexter and Denise's DNA?
- What are the RNA letters, and how do they pair with the DNA letters when Polly is making Maya (mRNA)?
- What happens to Maya (mRNA) before she leaves the nucleus, and where does she go next?

TRANSLATION

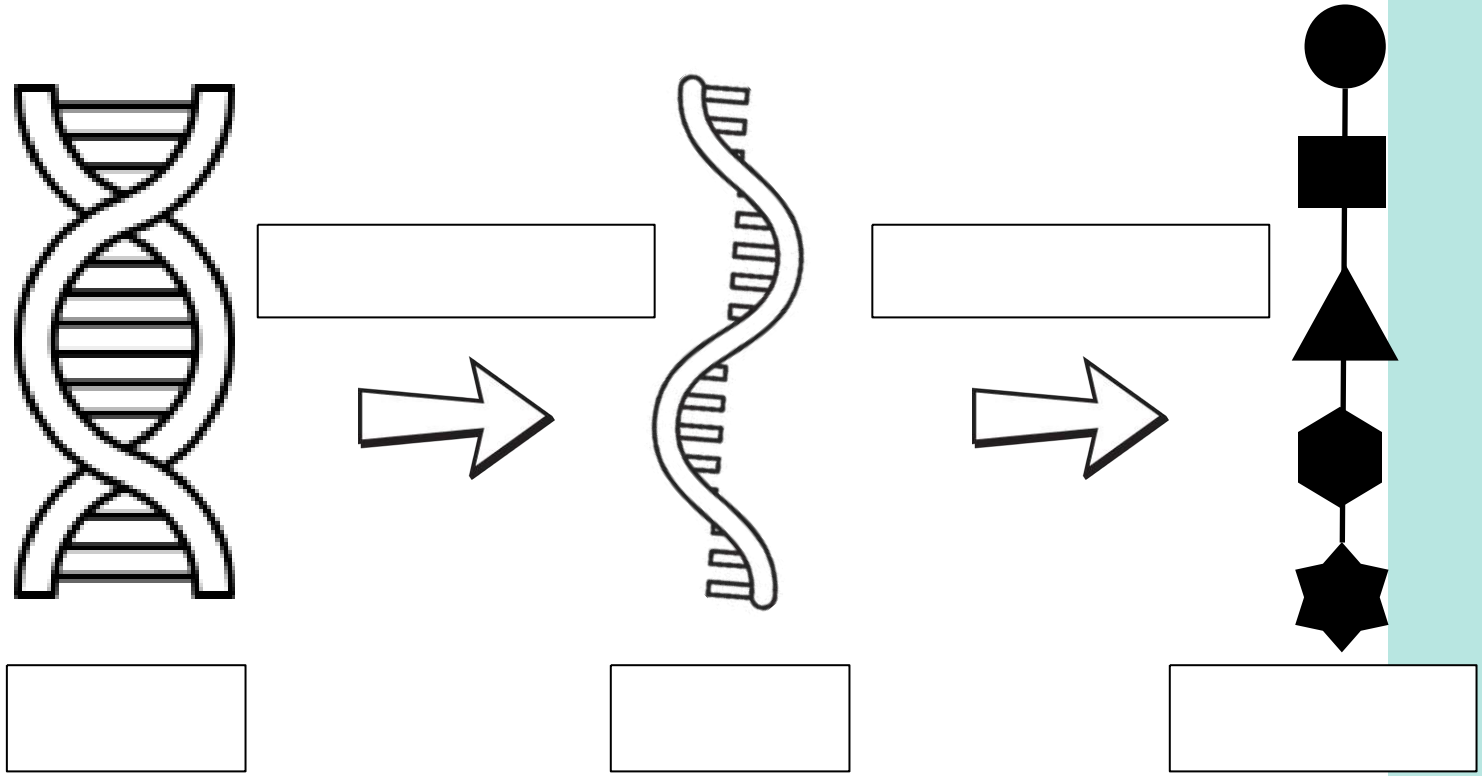
- Purpose of Translation
  - **Translation** means reading the **RNA** instructions to make a **protein**.
  - Process of Translation
    - Steps:
      - **mRNA** attaches to the **ribosome**.
      - **Start codon** (AUG) begins **translation**.
      - **tRNA** brings **amino acids** to the **ribosome**.
      - **Codons** on **mRNA** match with **anticodons** on **tRNA**.
      - **Amino acids** link to form a **protein**.
      - **Stop codon** ends **translation**, and the **protein** is released.



- Who are Dexter and Denise in Cellville, and what important task do they have?
- What is the role of Polly, the RNA Polymerase, in making Maya, the messenger RNA (mRNA)?
- What does Maya (mRNA) do after she leaves the nucleus and reaches the ribosome?
- Who is Tessa, the transfer RNA (tRNA), and how does she help build the protein?
- What happens when Maya (mRNA) reaches the stop codon UAA at the end of the translation process?

What is DNA's Role?

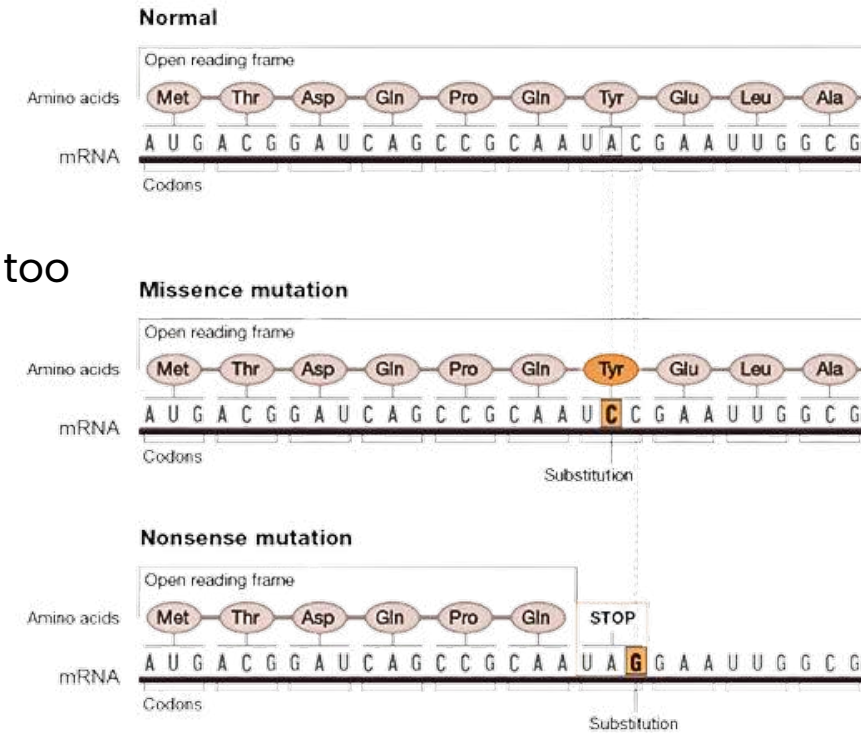
- Role of DNA in Protein Synthesis
  - **DNA** provides the **instructions** to make **proteins**.
  - **Proteins** are made using the **instructions** copied to **RNA**.
  - DNA -> mRNA -> Protein (**Central Dogma** of Molecular Biology)



MUTATIONS - CHANGES IN DNA

Types of DNA **Mutations** - any change in DNA

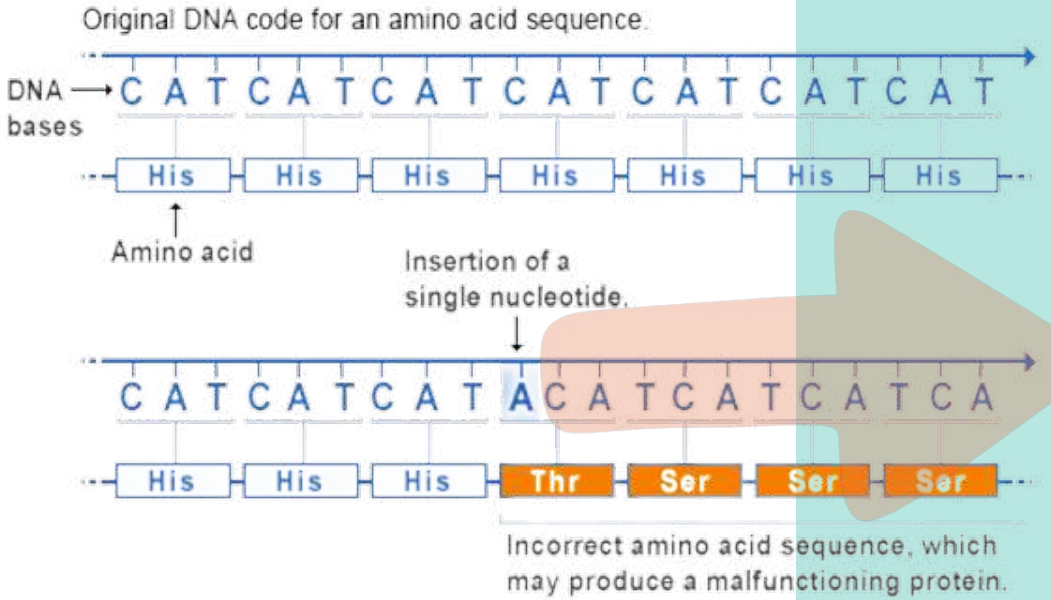
- **Point Mutations**
  - **Substitution**: One base is swapped for another.
    - **Missense** Mutation: Changes one amino acid.
    - Example: **Original**: **AAT ACA GGG**
      - **mRNA**- UUA UGU CCC
      - **Protein**: Leu-Cys-Pro
      - **Mutation**: AAT **G**CA GGG
        - **mRNA: UUA CGU CCC**
        - **Protein**: **Leu-Arg-Pro**
    - **Nonsense** Mutation: Creates a stop codon too early.
      - **Mutation**: ATT ACA GGG
        - **mRNA**: **UAA UGU CCC**
        - **Protein**: **STOP** - **premature stop**
    - **Silent** Mutation: No change in amino acid.
      - **Mutation**: AAT ACG GGG
        - **mRNA**: **UUA UGC CCC**
        - **Protein**: **Leu-Cys-Pro**



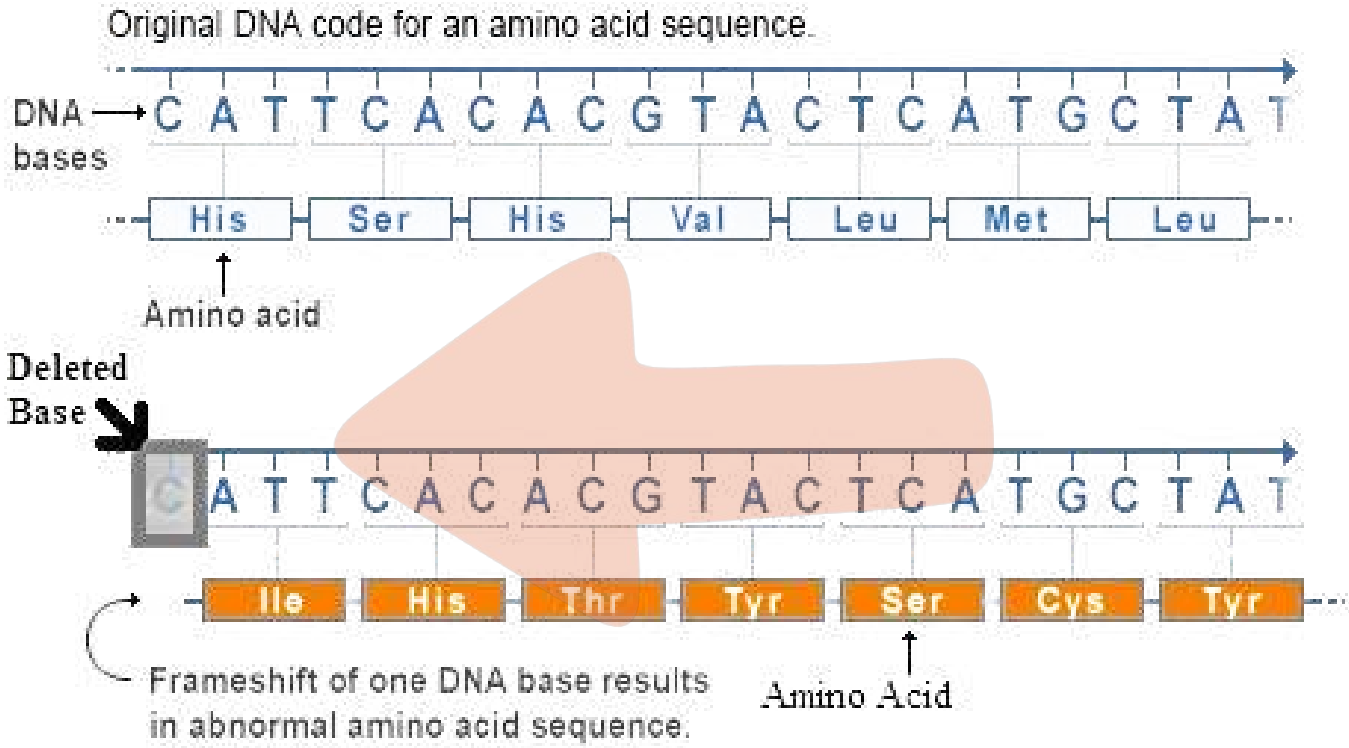
- What are mutations and why are they important?
- What are some types of mutations mentioned in the video?
- How can mutations affect an organism?
- What is a substitution mutation, and what effect can it have?
- What is a frameshift mutation, and why is it more severe than a substitution mutation?

FRAMESHIFT

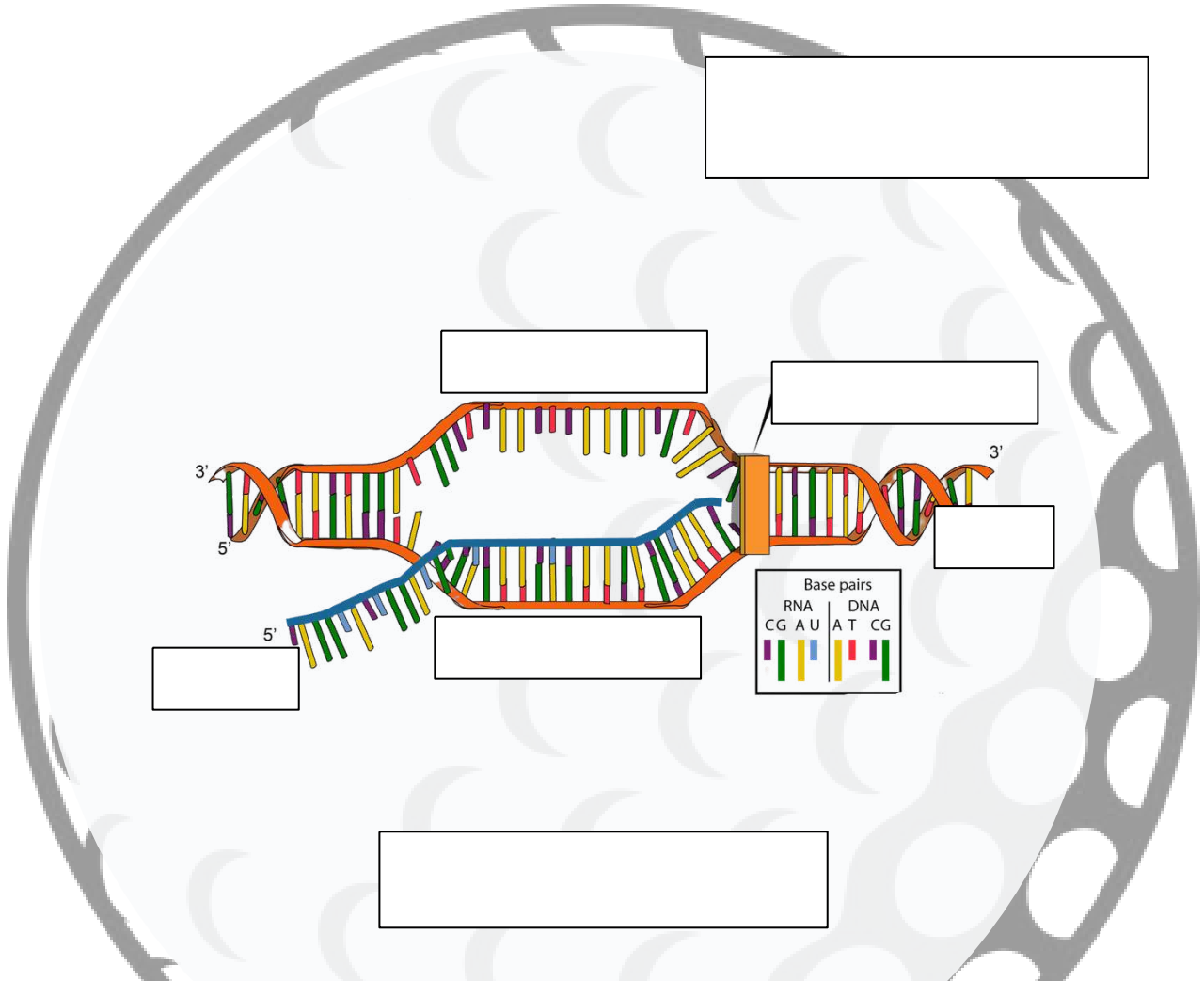
- **Insertion** Mutations
  - **Adding** one or **more bases**.
  - Can cause a **frameshift**, changing the **reading** frame.
    - Example: **Original Strand - AAT ACA GGG CAT**
    - **mRNA: UUA UGU CCC GUA**
    - **Protein: Leu-Cys-Pro-Val**
- **Mutation:** AAT ACA **C**GG GCA T…
  - **mRNA: UUA UGU GCC CGU A…**
  - **Protein: Leu-Cys-Ala-Arg-…**



- **Deletion** Mutations
  - **Removing** one or more bases.
  - Can cause a **frameshift**, changing the reading frame.
  - **Mutation**: AAT ACG GGC AT…
    - **mRNA: UUA UGC CCG UA…**
    - **Protein: Leu-Cys-Pro-…**



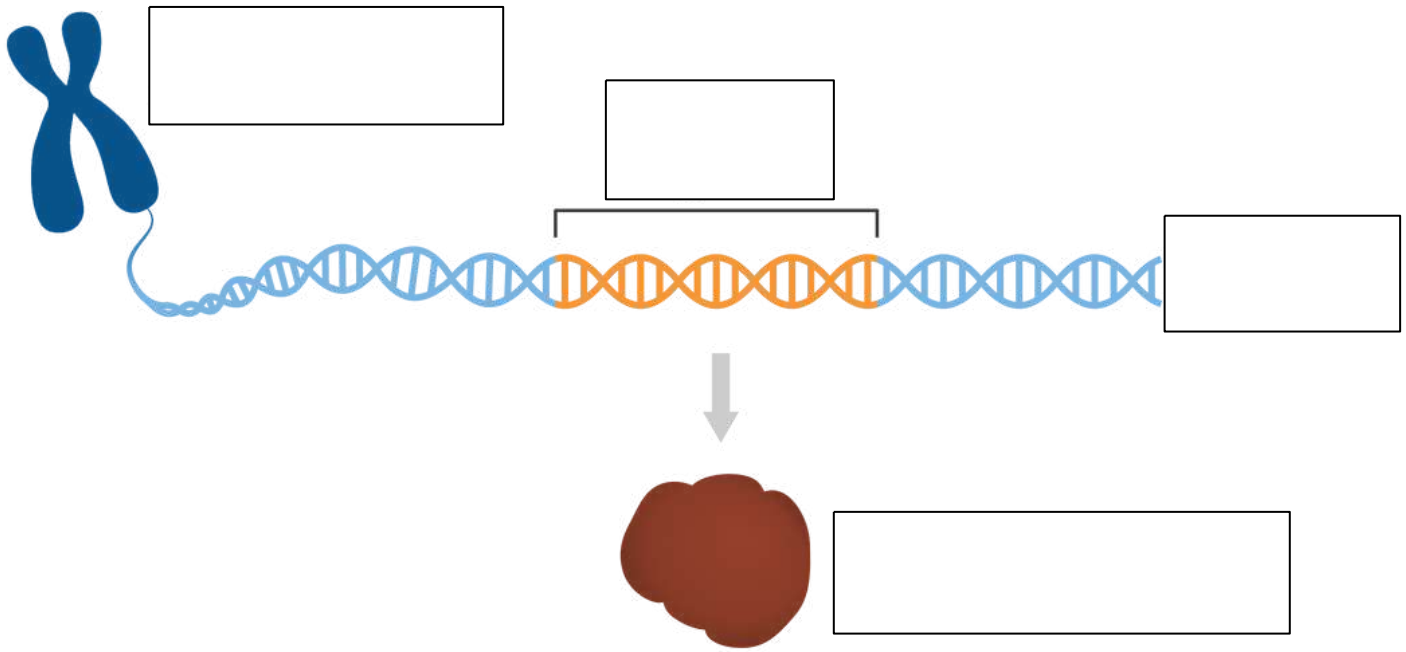
- What is a mutation, and how can it change the DNA sequence?
- Can you explain the difference between a substitution mutation and a frameshift mutation?
- What are the three types of point mutations Zoe mentioned, and what does each type do to a protein?
- How do missense, nonsense, and silent mutations differ in their effects on proteins?
- What causes mutations to occur, and how does the body usually fix them?



MUTATION EFFECT

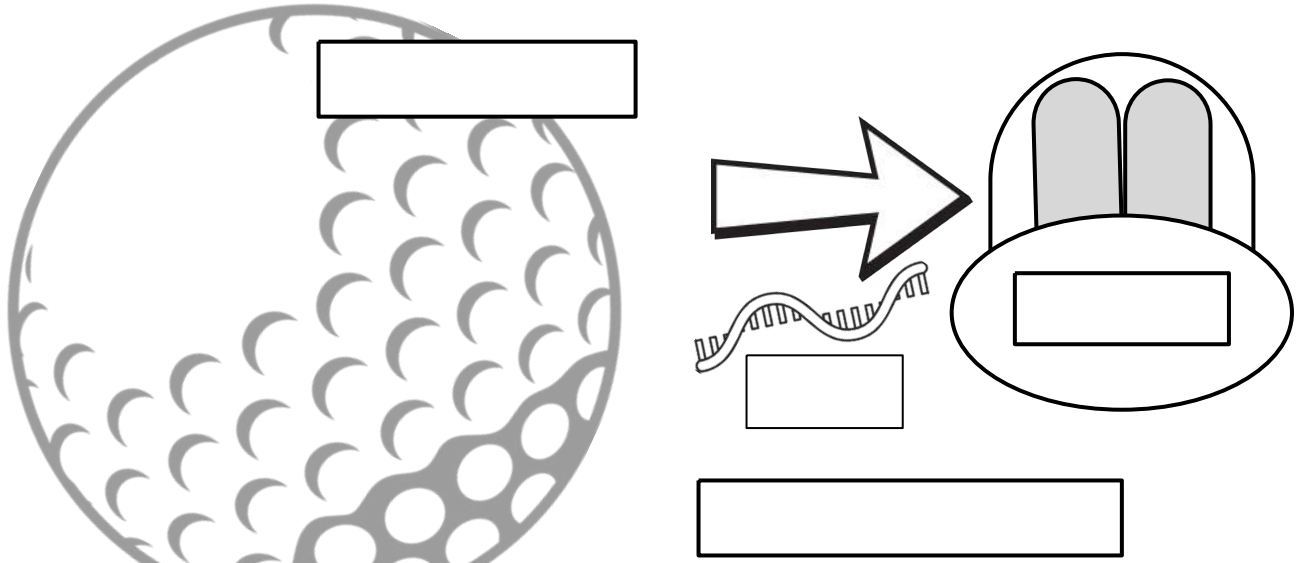
Effects of DNA Mutations

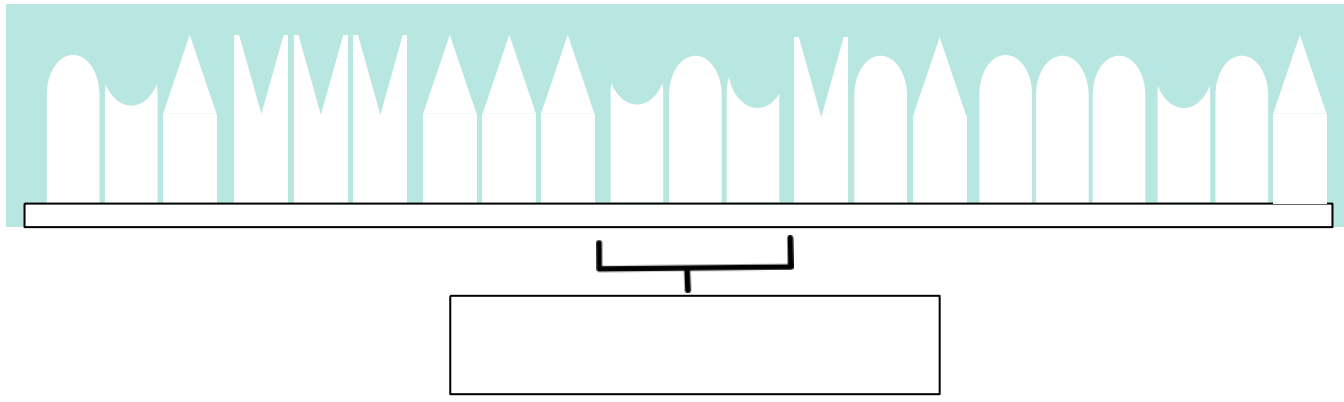
- Impact on **Genes**
- What is a Gene?
  - A **gene** is a section of **DNA** that contains **instructions** for making a specific **protein**.
- Gene **Expression**
  - Gene expression is the process by which the **information** in a **gene** is **used** to make a **protein**.
  - Changes the **instructions** for making proteins.
    - Can cause **genetic** disorders or **diseases**.
- Impact on P**rotein Synthesis**
  - Changes in **mRNA** lead to different **proteins**.
    - Can produce **nonfunctional** or **harmful** proteins.
    - Examples:
      - **Sickle Cell Anemia** (point mutation)
      - **Cystic Fibrosis** (deletion mutation)

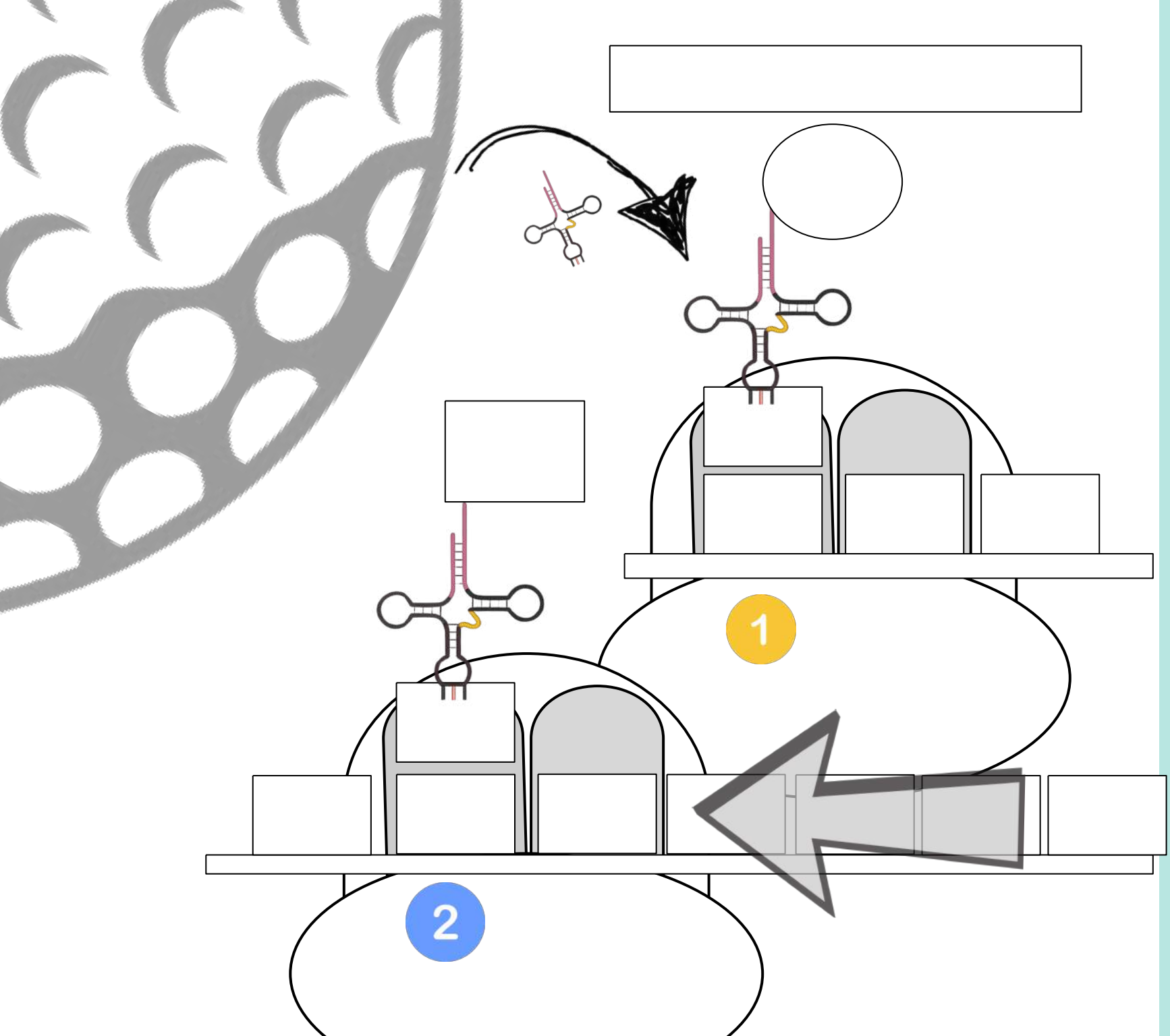


DNA Template Strand: T A C G G G C C T A T A G T C T T T A T C

mRNA



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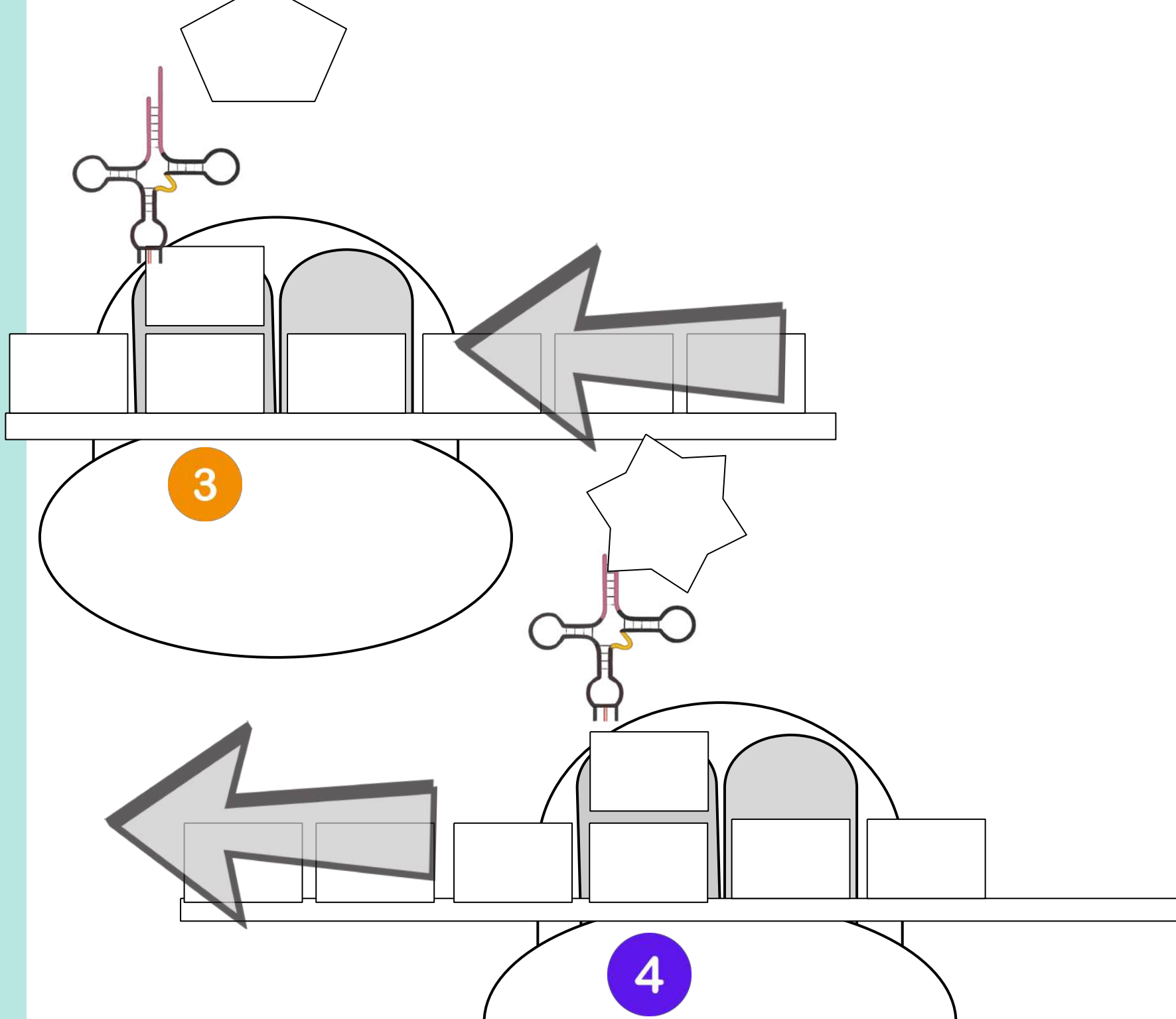
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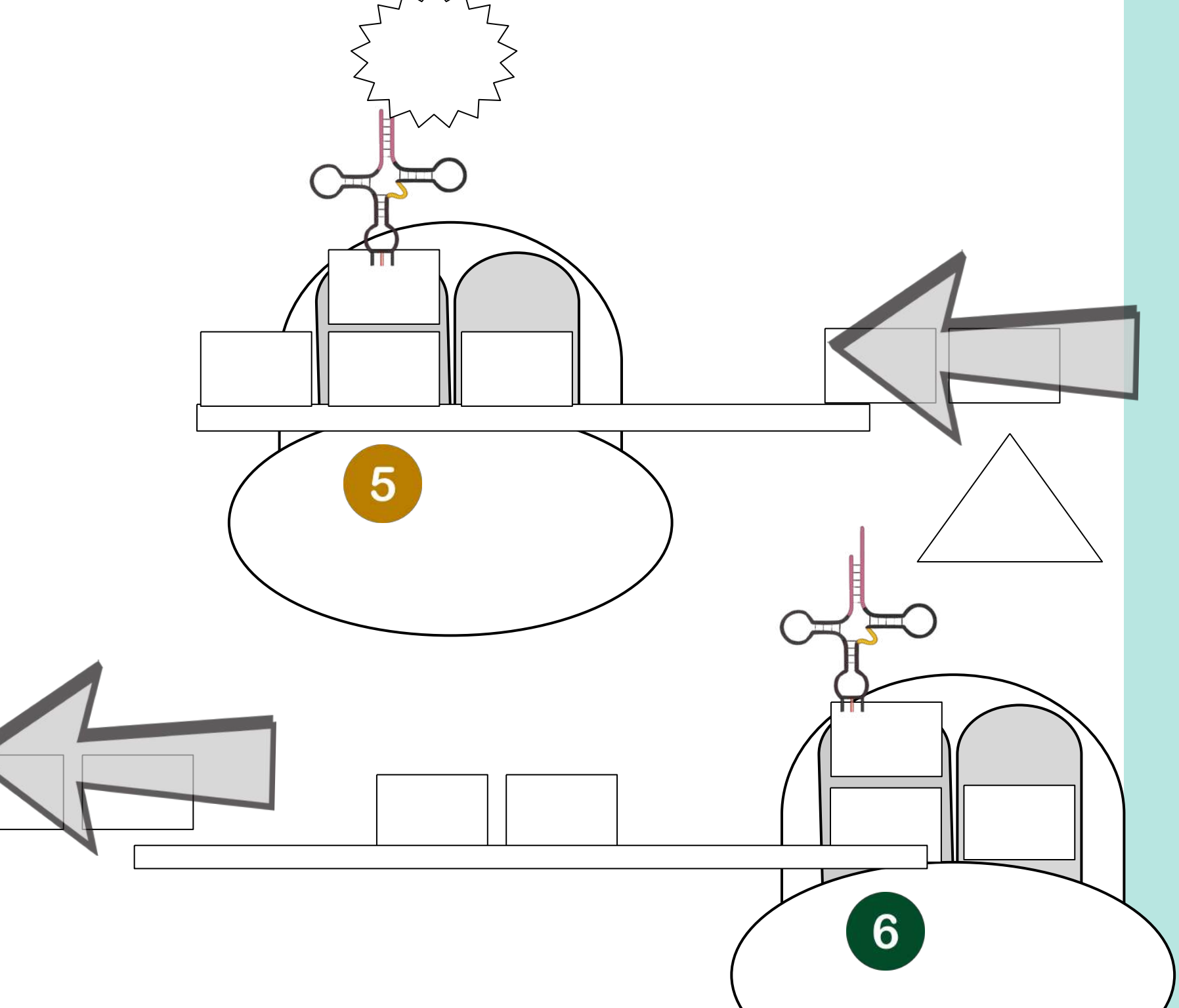
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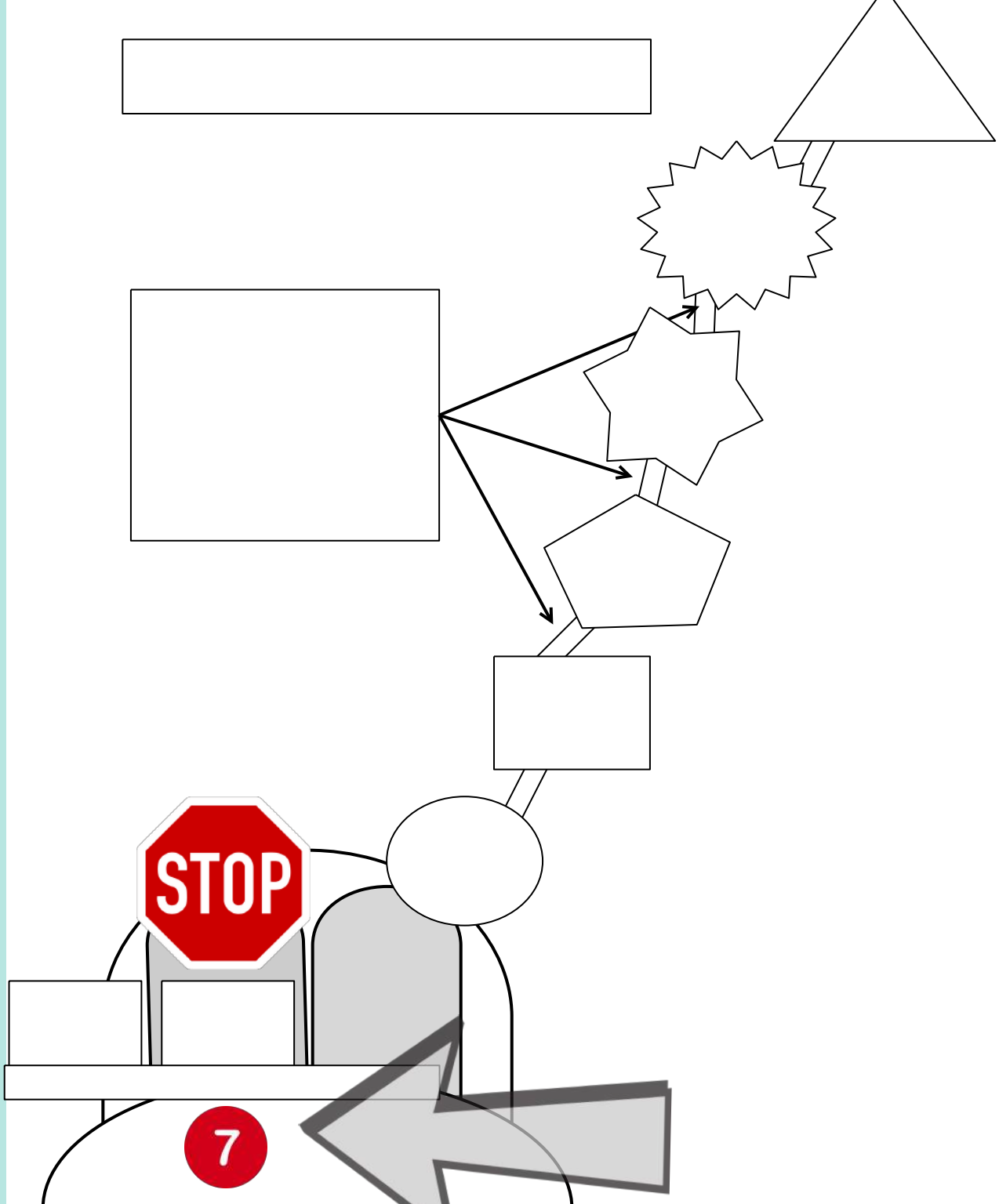
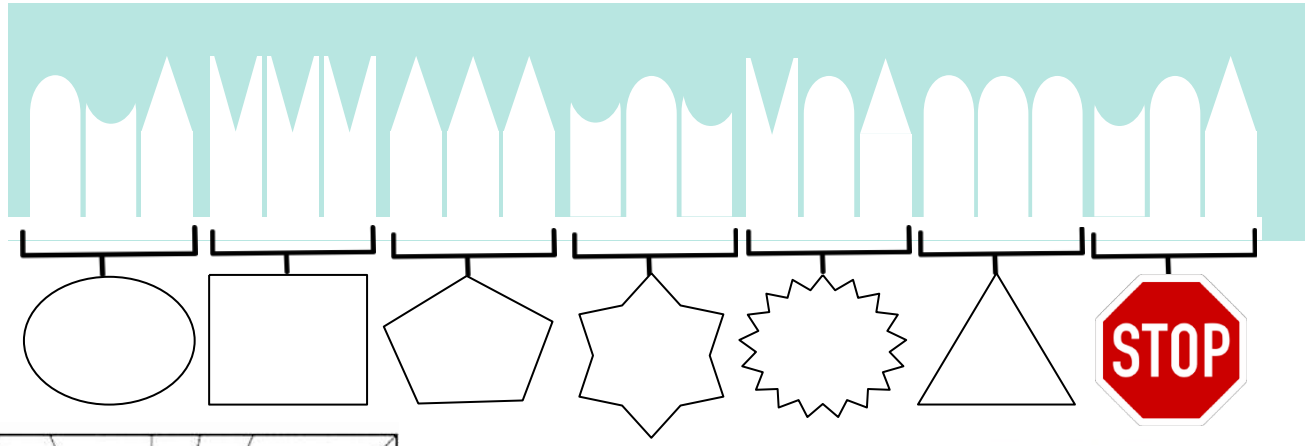
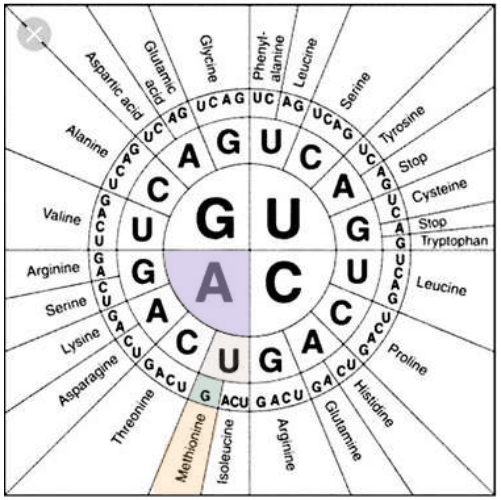
6


STOP
7





mRNA Codon Chart

First Base	Second Base: U	Second Base: C	Second Base: A	Second Base: G	Third Base
U	Phenylalanine	Serine	Tyrosine	Cysteine	U
	Phenylalanine	Serine	Tyrosine	Cysteine	C
	Leucine	Serine	Stop	Stop	A
	Leucine	Serine	Stop	Tryptophan	G
C	Leucine	Proline	Histidine	Arginine	U
	Leucine	Proline	Histidine	Arginine	C
	Leucine	Proline	Glutamine	Arginine	A
	Leucine	Proline	Glutamine	Arginine	G
A	Isoleucine	Threonine	Asparagine	Serine	U
	Isoleucine	Threonine	Asparagine	Serine	C
	Isoleucine	Threonine	Lysine	Arginine	A
	Methionine	Threonine	Lysine	Arginine	G
G	Valine	Alanine	Aspartic Acid	Glycine	U
	Valine	Alanine	Aspartic Acid	Glycine	C
	Valine	Alanine	Glutamic Acid	Glycine	A
	Valine	Alanine	Glutamic Acid	Glycine	G

SUMMARY

1. What is RNA, and how is it different from DNA?
   - "RNA stands for _____ and is made of a single strand of _____."
   - "Unlike DNA, RNA has the base _____ instead of _____."
   - "RNA's job is to _____, while DNA's job is to _____."
2. What is the purpose of transcription, and what happens during this process?
   - "Transcription is the process of copying _____ from DNA to RNA."
   - "This happens when _____ reads the DNA and makes _____."

- "The RNA then carries the message to _____ so a protein can be made."

3. What happens during translation, and how do codons and tRNA help build proteins?
   - "Translation is the process of reading the _____ to build a _____."
   - "Codons are sets of three bases on _____ that match with _____ on tRNA."
   - "Each tRNA brings an _____ to the ribosome, which links them to form a protein."
4. What are codons, and why are they important for protein synthesis?
   - "Codons are _____ made of three nucleotides on mRNA."
   - "Each codon tells the cell to add a specific _____ to the growing protein."
   - "If a codon is changed by a mutation, it can lead to _____."
5. What are the different types of DNA mutations, and how can they change a protein?
   - "There are three main types of DNA mutations: _____, _____, and _____."
   - "A point mutation changes one base, which can result in _____."
   - "Insertion or deletion mutations can shift the _____ and change the entire protein."
6. How can DNA mutations affect gene function and lead to disease?
   - "A mutation can change the instructions for making a _____."
   - "If the protein doesn't work correctly, it can lead to _____."
   a. "Examples of diseases caused by mutations include _____ and _____."

RESOURCES

FuseSchool – Global Education. (2017, March 9). What is RNA | Genetics | Biology | FuseSchool [Video]. YouTube. https://www.youtube.com/watch?v=Y4p6jhFaru4

Amoeba Sisters. (2019, August 30). DNA vs RNA (Updated) [Video]. YouTube. https://www.youtube.com/watch?v=JQByjprj_mA

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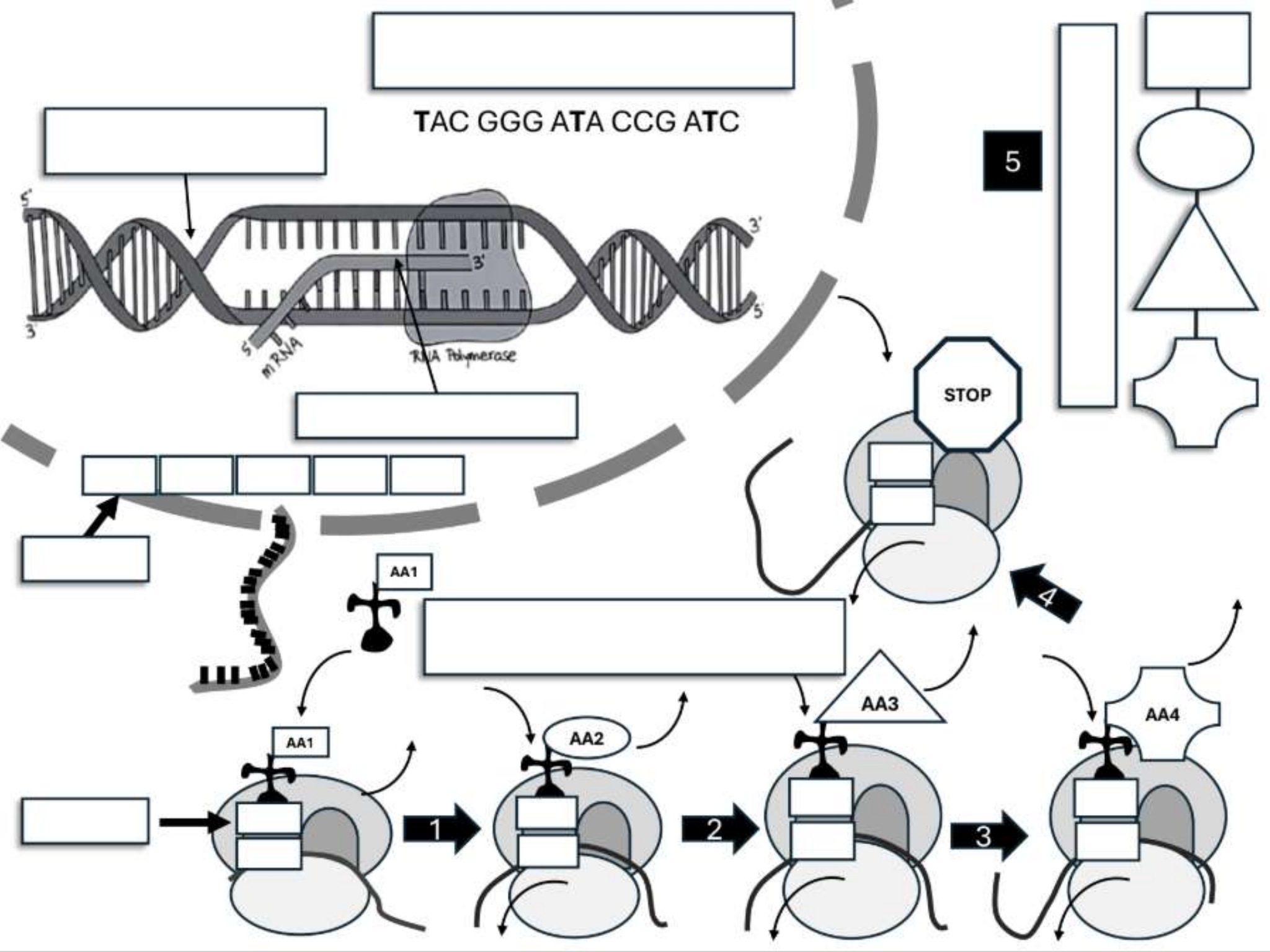
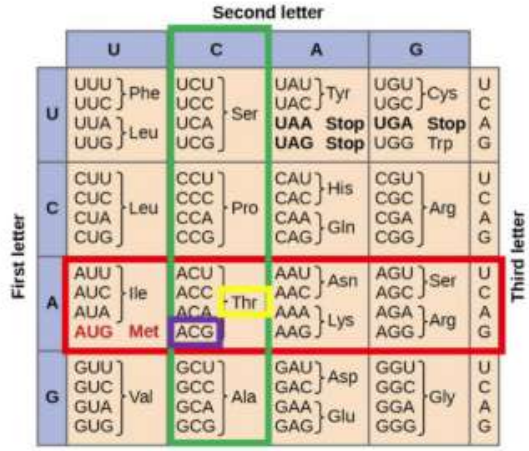
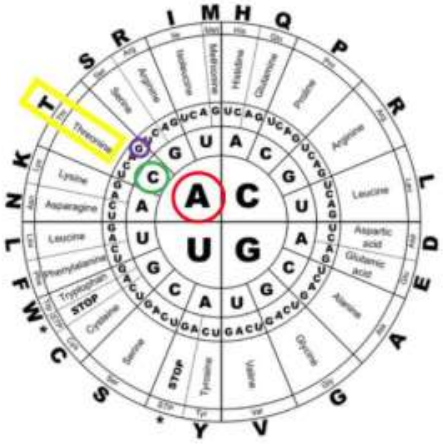
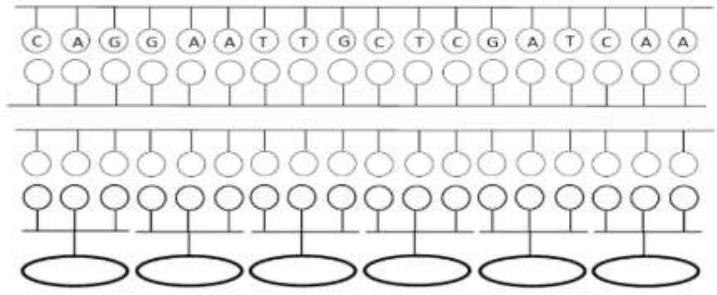
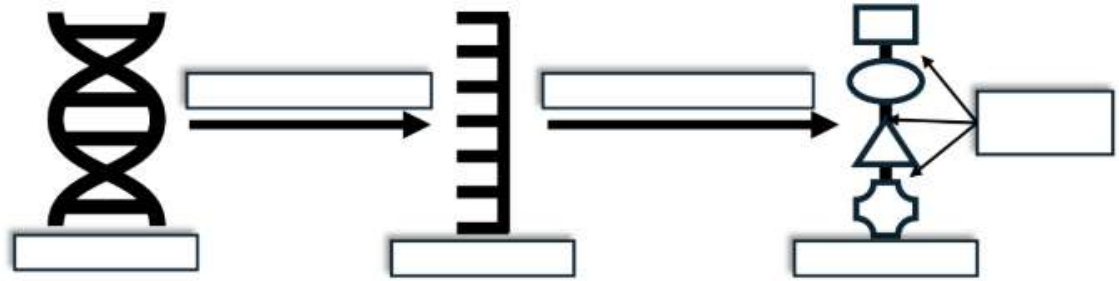

TAC GGG ATA CCG ATC
5
5'
3'
3'
3'
5'
5'
mRNA
RNA Polymerase
STOP
AA1
AA1
AA2
AA3
AA4
1
2
3
4

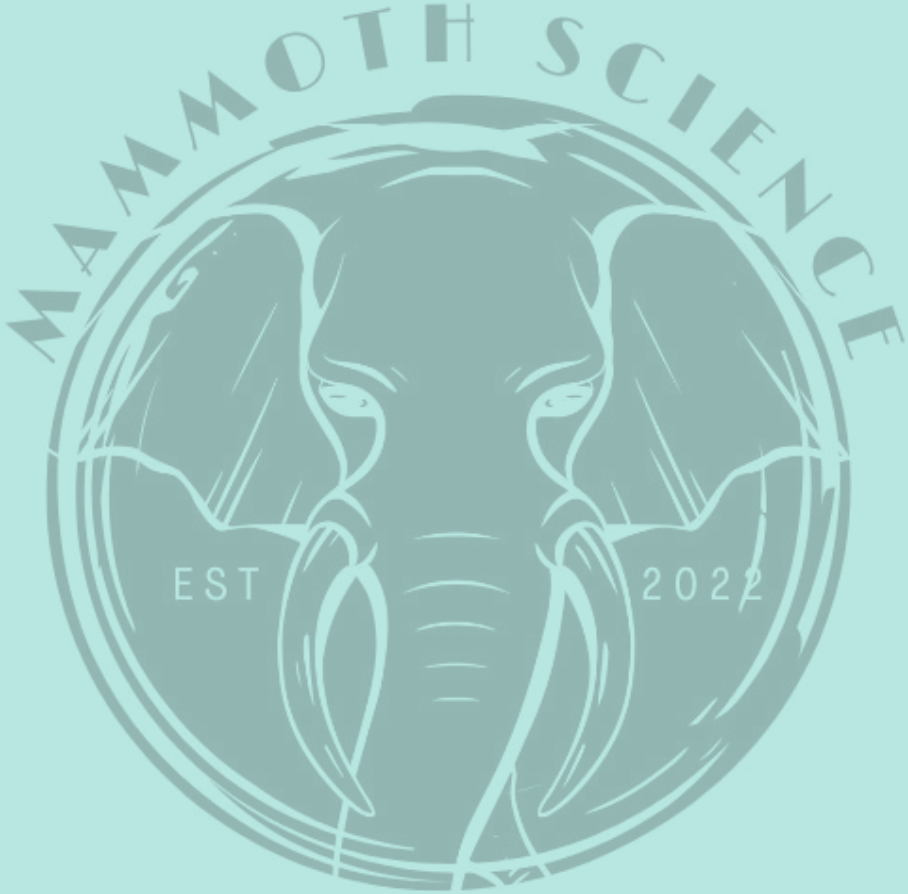




DNA Triplet	mRNA Codon	tRNA Anticodon	Amino Acid
1. TAC	AUG	UAC	Methionine (Met)
2. GGA	CCU	GGA	Proline (Pro)
3. TTC			
4.	UAG		
5. GTC			
6.			Tryptophan (Trp)
7.		GUA	
8.	UUU		



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