

Bay Area Scientists in Schools Presentation Plan

Lesson Name: A Whole New World of DNA and Proteins: 7th Grade Version

Presenters: _____

Grade Level: 7th **Standards Connection(s):** Life Science: 1.c the nucleus is the repository for genetic information in plant and animal cells. 2.e Students know DNA (deoxyribonucleic acid) is the genetic material of living organisms and is located in the chromosomes of each cell.

Next Generation Science Standards

- MS-LS1-1.** Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
- MS-LS1-2.** Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
- MS-LS1-3.** Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.</p> <p>Develop and use a model to describe phenomena. (MS-LS1-2) Develop a model to describe unobservable mechanisms. (MS-LS1-7)</p> <p>Planning and Carrying Out Investigations Planning and carrying out investigations in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.</p> <p>Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation. (MS-LS1-1)</p> <p>Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods.</p>	<p>LS1.A: Structure and Function All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). (MS-LS1-1)</p> <p>Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. (MS-LS1-2)</p> <p>In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. (MS-LS1-3)</p>	<p>Cause and Effect</p> <ul style="list-style-type: none"> • Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS1-8) <p>Scale, Proportion, and Quantity</p> <ul style="list-style-type: none"> • Phenomena that can be observed at one scale may not be observable at another scale. (MS-LS1-1) <p>Systems and System Models</p> <ul style="list-style-type: none"> • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. (MS-LS1-3) <p>Structure and Function</p> <ul style="list-style-type: none"> • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function. (MS-LS1-2) <p><i>Connections to Engineering, Technology and Applications of Science</i></p> <p>Interdependence of Science, Engineering, and Technology</p> <ul style="list-style-type: none"> • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-LS1-1)
<p><i>Common Core State Standards Connections:</i></p>		

ELA/Literacy -

RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. *(MS-LS1-5),(MS-LS1-6)*

RI.6.8 Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. *(MS-LS1-3)*

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. *(MS-LS1-1)*

WHST.6-8.8 Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. *(MS-LS1-8)*

Mathematics -

6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *(MS-LS1-1),(MS-LS1-2),(MS-LS1-3)*

Objective:

Introduce students to the concept of DNA and proteins. By the end of the lesson, students should understand the Central Dogma of Biology and be able to do base pair matching and amino acid coding. Students will also learn some basic lab techniques, such as using a pipette, in the DNA extraction activity.

Vocabulary to introduce:

- Translation
- Transcription
- DNA
- RNA
- Amino Acid
- Restriction enzymes

Timeline:

Introduction (5 min)

Activities Modules (35~40 min - 18 min each, 2 min for switching)

Wrap-up (2 min)

* Cool Scientist (5 min) (at the end of class depending on time)

Introduction:

Goal:

Introduce Biology-House Analogy

Instruction:

One person will start off the lesson with an introduction by showing the slides.

Script:

(Slide 1) Hi everyone, we're graduate students in the department of bioengineering at UC Berkeley. Today, we're going to talk about a whole new world of tiny molecules in the body called DNA and proteins.

How many of you have heard of DNA? **should be yes?

How many have heard of proteins? **should be yes?

(Slide 2) Great, you guys are off to a great start! We're going to start by introducing a simple analogy to help show the relationship between some of these new terms.

(Slide 3) To start, we will assume people are like houses.

(Slide 4) So, in each house, we have many rooms, like living room, bedroom, and kitchen. Similarly, people are made up of many, many little rooms, called CELLS.

Leading question: HOW MANY CELLS DO YOU THINK YOUR BODIES HAVE? *Around 100 trillion!

(Slide 5) Each of the rooms in the house is filled with many things to build it, decorate it, and make it functional. For example, we have bricks for the walls, tables and chairs to use, etc. In the cell, there are many proteins in the cells for structure and function.

Leading question: WHAT THINGS DO PROTEINS BUILD IN OUR BODY? *Heart, brain, etc

(Slide 6) Now, when we're building the houses, how do the builders know how to build the house, like where to put each room and what materials to use? We need a blueprint! In the cell, the cellular blueprint is the DNA.

Today, we're going to split 2 activity modules. In the first module, we will learn how to use the DNA blueprint to build proteins. In the 2nd module, we will do a hands-on lab to extract some DNA from bananas.

****Split class into 2 groups****

Activity Module 1 - Central Dogma of Biology (Amy, Dave, and Elaine)

Goal:

Introduce Central Dogma of Biology, base pairing, and restriction enzymes

Outline:

- **Base pairs (2 minutes)**
- **Restriction enzymes (3 minutes)**
- **Central dogma of biology (4 minutes)**
- **Instructions on activity (4 minutes)**
- **Activity (7 minutes)**

Script:

For the first part of this module, we're going to talk about some important concepts about making proteins from DNA. Please fill in the blanks on the worksheet as we go.

Base pairs (2 minutes)

(Slide 8) DNA looks like a spiral staircase. Each DNA is made of 2 strands that are paired together. DNA is made of 4 building blocks, called A,C,T, and G. These 4 building blocks like to be in pairs. A always pairs with

T and C always pairs with G! One easy way to remember this is that the straight, pointy letters are always paired, and the round, curvy letters are always paired.

(Slide 9-14) Let's do a sample problem now. Say we have this DNA strand, what does the complementary strand look like? So, for the first letter A, what is its pair? T ****go through rest of the strand****

(Slide 15-20) Now, we'll give you a minute to work on question 1 ****Check answers after****
****If there's no time, work on it together****

Restriction enzymes (3 minutes)

(Slide 21) Now that we know how DNA is paired, why do we need to know this? Sometimes, scientists want to cut the DNA up to do cool stuff! Scientists use something called "restriction enzymes" to cut up the DNA. Restriction enzymes are like special scissors for DNA!

(Slide 22) When restriction enzymes cut DNA, they can only cut specific sequences. For example, this restriction enzyme can only cut TAT. After cutting, the ends sticking out are called sticky ends! When these sticky ends come together with their matching sticky ends, they will stick together and make a new piece of DNA!

(Slide 23) Now we're going to do a practice question. Can anyone find where this restriction enzyme will cut? Draw this on your worksheet and raise your hand when you found ACG!!!

Central dogma of biology (4 minutes)

(Slide 25) now we know a little bit about DNA, does anyone know how proteins are made from DNA? **** no!** The way this is done is called the central dogma of biology and we will show you how it's done!

(Slide 26) Like we said before, DNA is like a blueprint! Where do you think DNA is located in the cell? **** the nucleus!** Yes, the nucleus is kind of like a library where the DNA blueprint is kept. The DNA blueprint must stay in the library.

(Slide 27) Where do you think the proteins are being made? (maybe they will know ribosomes, if not, tell them). Since DNA can only stay in the nucleus, we need a messenger to bring the code out of the nucleus. The RNA is kind of like a messenger that copies the DNA blueprint; this process is called transcription!

(Slide 28) The RNA then comes out of the nucleus, which is like the messenger coming out of the library with the copied code!

(Slide 29) RNA, now outside the nucleus, uses the copied code to make protein. This process is called translation!

(Slide 30) To summarize, the DNA code is copied by the messenger RNA in the transcription process. Then, the messenger RNA comes out of the cell and uses the code to build proteins in the translation process. The process of DNA to RNA to Proteins is the Central Dogma of Biology.

(Slide 31) Now we know that in cells, proteins are made using the DNA code. The proteins build up the structure of the cells and many cells together form the person. This is just like how blueprints are used to build up rooms that make up houses.

Instructions on activity (4 minutes)

(Slide 32) Next, how exactly do we make protein from DNA? We have this strand of DNA. Does anyone know how to make a protein? **no... We will show you!

(Slide 33) going from DNA to RNA follows this chart. It is very similar to complementary strands, except instead of T's, we now have U's.

(Slide 34-35) This is the RNA strand that you get from the DNA based on the chart we just showed you. We will do a practice problem before our activity.

(Slide 36) So how do we get from RNA to proteins? There is this intermediate step that is called amino acids. Amino acids are building blocks of protein. We can see from this chart that there are 23 amino acids, and we will show you how to read this chart.

(Slide 37-40) When we have the RNA strands, we first group it into groups of 3. When you read this chart, you go from the center of the chart outward. For our RNA strand, we have GAC for our first amino acid. So we first go to the G quadrant, and then go outward to find A. After that, we find where C is, and we land and the amino acid D. With the second triplet, can someone tell me what AAU makes? ** N!

(Slide 41) The three amino acids D, N and A come together to make a protein!

(Slide 42) Now, we are going to do a decoding activity to practice this!

(Slide 43) You will each get a worksheet with 5 rows.

(Slide 44) First, I want you to pick a 5-letter word and write it in row 1.

(Slide 45) Then, using the amino acid chart (on page 2 of your worksheet), figure out the RNA sequence that can be used to make each amino acid letter and write it in row 2.

(Slide 46) Next, write the corresponding DNA base pair in row 3. Remember, RNA uses AUCG while DNA uses ATCG.

(Slide 47) Afterwards, cut at the dotted line and give me the bottom half. I will pass out the codes to your classmates.

(Slide 48) Your partner will find the RNA complementary strand.

(Slide 49) Then use the amino acid chart to decode the protein message.

Activity (7 min)

- Each student will be given a sheet with Protein->RNA->DNA->RNA->Protein. They fill out the first three rows, cut off the DNA->RNA->Protein portion
- We will shuffle the cut-outs off, and then hand them out to everyone and they can solve for the proteins

Follow up questions

- What does a double stranded DNA look like?

Wrap up Questions (back-up)

- How many proteins do you think your cells can make?
 - Why do you need RNA in the process of making proteins? Why can't you make proteins straight off of DNA?
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Activity Module 2 - DNA Extraction (Britta and Yunsuk)

Logistics:

Total time/section: 18 minutes

Total number of sections: 8 classes * 2 sections/class = 16 sections

Expecting 10-15 students per section (=total 240 students)

Materials:

- 250 * 2mL transparent EP tubes
- 250 coffee stirrers
- 15 bananas
- 4 plates for bananas
- ice in big ice box (to last for the whole day)
- 2 styrofoam boxes (to hold 50mL conical tubes of ethanol)
- 3 tube racks (2 for students, 1 for demo)
- 1L ethanol
- 1L salt water (1L H₂O + 10mL salt)
- 1 bottle of dish soap
- 3 * 50mL tubes - for ethanol
- 3 * 50mL tubes - for salt water
- 3 * 50mL tubes - for soap
- 20 * 50mL tubes - for demo
- 7 * 1000p pipettes
- 2 boxes of pipette tips
- eye droppers - for soap
- vortexer
- extension cord
- 7 VWA markers
- yarn

Actual numbers for the extraction:

	<i>Demo</i>	<i>Individual</i>
<i>Banana</i>	<i>1cm³</i>	<i>size of lady bug</i>
<i>Salt water</i>	<i>15 mL</i>	<i>500 uL</i>
<i>Soap</i>	<i>2 drops</i>	<i>1 drop</i>

<i>Ethanol</i>	<i>15 mL</i>	<i>500 μL</i>
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Before lesson:

- Prepare salt water, soap, and ethanol in 50mL tubes; place salt water and soap in tube rack and ethanol in styrofoam box with ice.
- Prepare bananas on plates.
- Have yarn cut out in pieces of ~2.5 ft.
- Set all pipettes to 500 μ L.

Outline for lesson:

Introduction (2 min)

- DNA is a long molecule found in the nucleus of the cell.
- DNA contains all the codes for proteins.
- Every organism has DNA, including humans, animals, plants, and... bananas!
- Let's extract DNA from bananas.

Activity (15 min)

- Instructions will be given while one instructor is doing a demonstration using a larger scale 50mL tube.
- The other volunteers help the students with adding solutions and any other difficulties they may be having.
- Basic steps of DNA extraction:
 - Add banana to EP tube
 - Squish banana using coffee stirrer
 - Add 500 μ L salt water using a pipette and vortex
 - Add 1 drop of soap and vortex
 - Add 500 μ L ethanol and hold still
 - Observe DNA clumping together and rising to the top

Wrap Up (2 min)

- Banana has DNA. Do you think strawberry has DNA?
 - Ans. yes
- Give me other examples.
 - Ans. (could be anything really; the point is to get across to the students that every living organism has DNA).
- We extracted DNA from bananas and learned some important laboratory techniques; pipetting, vortexing, labeling.

< Instructions > + Script in green:

Intro: Hi, my name is _____ and I will be explaining to you about a cool laboratory technique to "see" DNA. We have volunteers to help you in the process as you follow along. I will let them introduce themselves.

Okay, so, DNA is a long molecule found in the nucleus of the cell that contains all the codes for proteins. Every living organism has DNA. For example, I have DNA in my body and you have DNA in your body. What other living organisms can you think of? Animals, plants... and bananas! Today we brought bananas from which we

are going to extract DNA and observe it with our own eyes. We are going to ask you to carefully listen to our instructions and to cooperate with us so this activity will be safe and fun!

To volunteers: "Would you please prepare the bananas on the tables? Thank you."

1. Have volunteers prepare ½ banana on each plate and place on table. Also place vortexer on table.

So I will demo with this big tube, and you guys will have your own experiments in your own little tubes called eppendorf tubes, or EP tubes in short.

Now I want each of you guys to take one EP tube and one coffee stirrer.

2. Hand out EP tubes and coffee stirrers. Take one each and pass along.

Okay, so first of all, I want you to use your coffee stirrer to cut a small piece of banana, about the size of a lady bug, and put it in your EP tube. I am going to use a bigger piece in my big tube so that you can see it better.

3. Open EP tube and put some banana in it (~size of a lady bug).

In order to get DNA out of the banana, we first need to squish up the banana. I want everyone to start mashing the banana in their tubes with the coffee stirrer. (also, mash the banana in the big tube). Right now we are breaking down the banana into individual cells. Make sure the banana in your tube is squished and that there are no big chunks left!

4. Mash banana using coffee stirrer.

Now we are going to use salt water and soap to help break up the cells even further. First I will demonstrate in this big tube.

5. Demo adding salt water, vortexing it, then adding 2 drops of soap and vortexing again

The soap is breaking the cell walls, which can be thought of as breaking the walls of individual rooms in a house. This will allow the DNA to get out of the cells. The salt water helps keep the DNA intact.

Now it is your turn! We will show you how to use these pipettors to get 500 uL of salt water, and then use the vortexer to shake it up!

6. Pipettes should be set to 500uL.
7. Volunteers pass out pipettes. Two people share one.
8. Place tube racks with salt water and soap on table.
9. Volunteers go around and explain how to use pipettes. You push in, immerse the pipetter into 50mL tube, let go, eject into EP tube.
10. Add salt water (500uL) to tube.
11. Stir, close EP tube, vortex for 10 seconds.

Now add one VERY small drop of soap using your eye dropper, and vortex it again!

12. Open EP tubes carefully, add one drop of soap into tube using eye dropper.
13. Stir, close EP tube, vortex for 10 seconds.

The DNA is out of the cells now, but it is very tiny, so we will need to add ethanol, which will clump the DNA together so it's big enough for us to see it! Everyone ready to see some DNA? Okay! I will demonstrate first. (Pour ethanol into tube) The white strings floating into the clear top part is DNA! Can everyone see it? Isn't that cool?!?!

Now each of you can use your expert pipetting skills to add 500 uL of ethanol to your tubes! Do NOT shake the tubes after this step... just wait for the DNA to rise to the top!

14. Place ethanol on table.
15. Open EP tubes carefully, and add ethanol (500uL) to tube.
16. Close EP tube and hold still. Wait for DNA to precipitate! (the mixture should divide into two layers, a clear top layer and a darker mixture in the bottom.)
17. Observe DNA. (it should be seen near the top of the solution, as a white substance.)

Now that we have extracted DNA from a banana, we need to show it off to all our friends and family! by wearing it around on necklaces!

First, we will label the tubes, which is what real scientists do for everything they make in the lab so they remember what it is, who made it, and when they made it! We want you to use these markers to label the tubes with "DNA", your initials, and today's date (10/25). ****Write on board****

18. Use marker to put initials and date on the EP tube. (teach students the importance of labeling.)

Now, take one pieces of yarn, carefully open the EP tube while holding it upright, place the yarn right here, and close the tube back up. Now tie it around your neck and show it off :)

19. Students use yarn to make a necklace with the EP tube of DNA.

Cool, so let us quickly wrap up what we have learned in this section. We extracted DNA from banana! Can anyone explain why we used soap? (to break down the cells) Good! And does anyone remember what we added at the final step to aggregate the DNA? (ethanol) Awesome! Good job guys. Let me also quickly recap some important laboratory techniques we have learned - pipetting, vortexing, and labeling. Did you like pipetting and vortexing? (yes) Awesome! Why is it important to label things? (to remember what and when we made stuff) Nice job, go and show off your DNA to your friends now :)

Conclusion & Wrap-up

(Slide 45-46): central dogma

What are some key vocab words you learned today?

Yes, so to recap, DNA is the main blueprint in our cells which gives instructions for proteins to be made and the RNA acts as a messenger. We also learned that there are cool techniques for extracting this DNA from cells in a banana.

So today we have introduced you to the "whole new world of DNA and Proteins". We hope you enjoyed the lesson and now we will have a couple of scientists come up and describe what they do in their respective labs!

Cool Scientist

Goal:

Introduce the real-life work of 2 scientists (2 min each).

Script:

2 people will be assigned to talk about their research for 2 minutes.

1

Amino Acid	—	—	—	—	—	—	—	—
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2

RNA	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
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3

DNA	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
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4

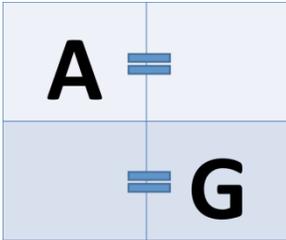
RNA	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
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5

Amino Acid	—	—	—	—	—	—	—	—
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Part 1: DNA Base Pairs

This is how DNA pairs:



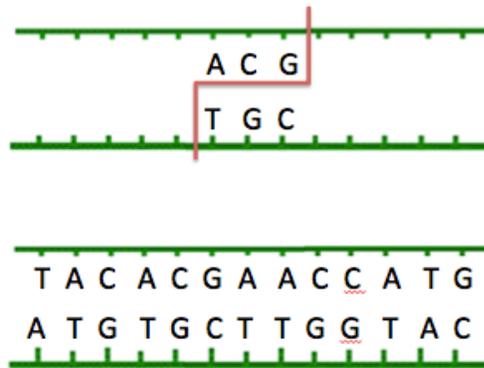
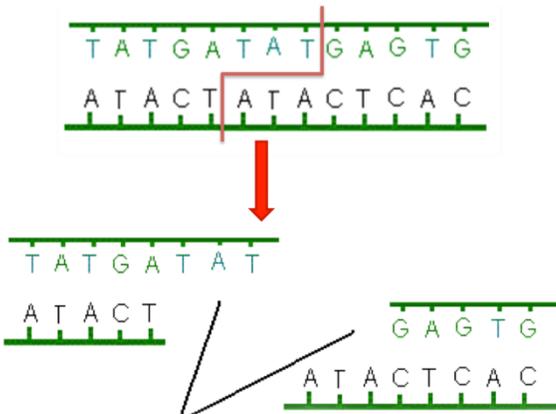
Question 1: Find the strand goes with this strand of DNA!

T	A	T	G	C

Part 2: Restriction Enzymes

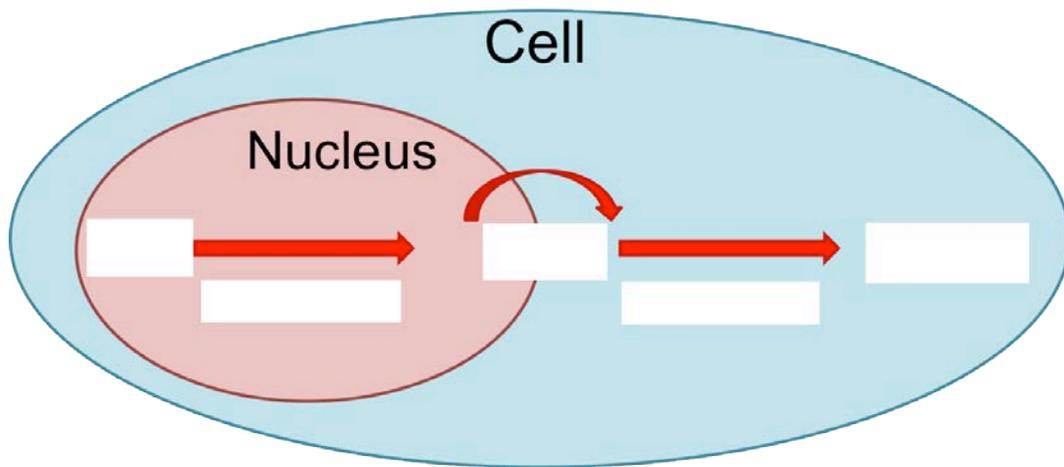
Restriction enzymes are like _____ for DNA!

Question 2: Where will the restriction enzyme cut? Draw it in!



These are called _____.

Part 3: Central Dogma of Biology



Practice Problems (for home)

1. A double-stranded segment of DNA has the following sequence:

**ACAGGCCTGCAGAATCCGATCACGGAATCCGCAGGCCTGTTAGAATCCATG
TGTCCGGACGTCTTAGGCTAGTGCCTTAGGCGTCCGGACAATCTTAGGTAC**

- a. You put some of the DNA in a tube with a restriction enzyme that cuts the following sequence:

**G AATC C
C TTAG G**

Draw a solid line on the DNA sequence above to show all the sites where the restriction enzyme will cut.

- b. You take some more of the uncut DNA, and you put it in a tube with a restriction enzyme that cuts the following sequence:

**AGG CCT
TCC GGA**

Draw a dotted line on the DNA sequence above to show where the restriction enzyme will cut.

2. **BONUS:** Two different double-stranded segments of DNA have the following sequences:

**CTGAGGAATCCACTT ACATGGCGAATCCGC
GACTCCTTAGGTGAA TGTACCGCTTAGGCG**

- a. You put each segment of DNA in a separate tube, and you add the restriction enzyme from Problem 1 to each tube. Draw a solid line on the DNA sequences above to show where the restriction enzyme will cut.
- b. You mix the two tubes from the previous part together and allow the cut DNA to form new DNA segments via their sticky ends. Write the sequences of all the DNA segments you would expect to see in the tube.