Excerpt from Climate Change Report: "The Basics of Climate Change"

The document you are assigned to read is an excerpt from a larger report on climate change. The report was prepared in 2014 by the National Academy of Sciences, widely regarded as a group of the most distinguished scientists in the US, and the Royal Society, a similar group from the UK. As you read the report excerpt, take notes related to:

- what climate change is;
- the causes of climate change; and
- likely impacts of climate change.

Greenhouse gases affect temperatures on earth by_____

_____

_____

Evidence linking human activity with increased greenhouse gases includes_____

_____

_____

General notes related to *temperature changes*, *impacts of climate change*, and *evidence*:

_____

_____

_____

_____

_____

_____

Where does carbon come from and where does it go?

PART A: INTIAL MODEL

In the box below, draw your ideas for all of the sources where carbon might come from and where it might go. Consider both above and below ground and if the flow is carbon is connected.

In your drawing:

- Include what you think are the very most important things that might happen to carbon
- Include actions and/or changes that carbon might go through. This might include joining other elements (such as oxygen) or breaking apart from other elements (such as hydrogen)
- If helpful, use words and/or numbers to express your ideas about carbon

Before you start drawing, think first about these ideas, and identify *how* carbon might be undergoing actions and/or changes, and *why* carbon is part of or undergoing actions or changes. Include these ideas in your illustration. When you are done, use your illustration to answer the questions on the next page.

Use your drawing to answer these questions:

A. **How** and **why** do you think this is how carbon moves?

B. **How** do you know?

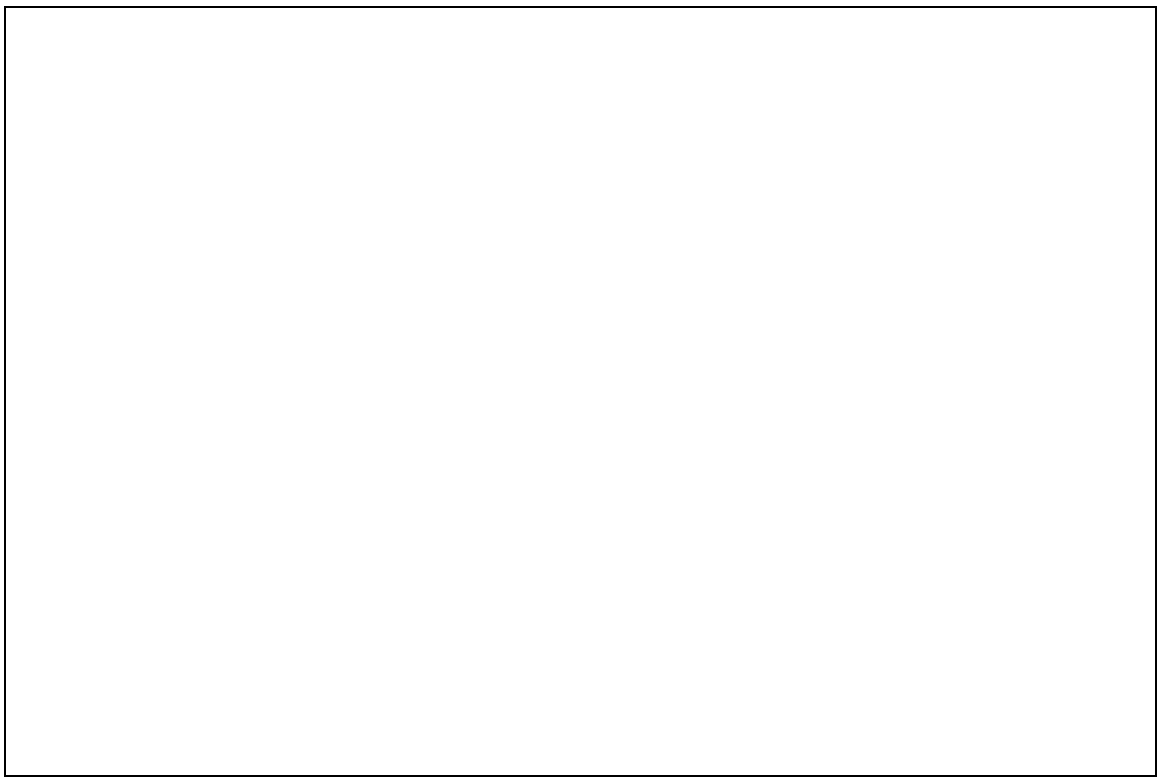
PART B: Model Evaluation and Revision

- On a scale of 1 to 5 (1 is the lowest, 5 is the highest) how well does my model explain carbon movement?

- Why did you give your model the rating that you did?

- In what ways should your model be revised to explain carbon movement? List those below:

In the box below, draw a new illustration that incorporates your revisions for where does carbon come from and where it goes:



A. **How** and **why** do you now think this is how carbon moves?

B. **How** do you now know?

PART C: Final Model

Using your models from Part A and Part B along with your new understanding of carbon movement, draw your ideas for all of the sources where carbon might come from and where it might go in the box below. Consider both above and below ground and if the flow is carbon is connected. (Refer to Part A as a reminder of what things to include in your model.)

Please answer the prompt on the next page.

Large systems, like the carbon cycle, have feedback loops. These feedback loops maintain a balance or homeostasis in the system. If variables are changed in the carbon cycle, the feedback loop might be disrupted which then disrupts homeostasis. Discuss your understanding of how the carbon cycle works when all variables are balanced and how changing certain variables might affect other parts of the carbon cycle and the overall system on Earth.

Hbio Fish & Elodea Lab
Name:_____Hr:_____

In this experiment 4 sets of jars were set up, each with a solution to indicate change in pH.

Carbon dioxide dissolves in (and reacts with) water, forming carbonic acid, H_2CO_3. Carbonic acid then immediately dissociates into a hydrogen ion and a bicarbonate ion. The reaction occurring in solution is:

$$CO_2(g) + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+(aq) + HCO_3^-(aq)$$

The free hydrogen ions (H^+) lower the pH of the solution, making it more acidic. The degree to which the pH change is proportional to the amount of carbon dioxide that dissolves in the water. In other words, as more carbon dioxide dissolves in water, the pH of the solution will continue to decrease. If carbon dioxide is removed from the solution, the pH will increase. A pH indicator such as BTB can therefore indicate the relative amount of carbon dioxide dissolved in water based on the color of the solution.

The solution is yellower if the pH goes down (less than 7, more acidic). The solution will become bluer if the pH increases (gets more basic).

The jars contain the following:

Jars in the *Light*	Contents	Jars in the *Dark*	Contents
1	Sprig of *Elodea*	5	Sprig of *Elodea*
2	Fish	6	Fish
3	Fish & *Elodea*	7	Fish & *Elodea*
4	Nothing	8	Nothing

Data Collection:

The Effect of Light and Types of Organisms on the Relative Color and CO_2 Concentration in BTB over 24 Hours

	Light			Dark			
Jar #	Contents	Color	CO_2 Conc.	Jar #	Contents	Color	CO_2 Conc.
1	*Elodea*			5			
2				6			
3				7			
4				8			

Please place the jar numbers where they appropriately go on the scale below:

Yellowest (most CO_2) CO_2)

Bluest (least

Initial Analysis:

Create a model that explains what is happening in each of the jars. You may use text books and online resources to help you develop your explanation. You may want to consider the following questions to guide your thinking.

1. Which jar was the most yellow? Why do you think this jar was more yellow than the others?

2. Which jar was the most blue? Why do you think this jar was bluer than the others?

3. Compare and contrast Jars 3 and 7. What might be some reasons for any differences you see?

4. Why did we have two jars with nothing in them? What purpose did these jars serve?

5. How do you think this experiment relates to what we've learned about the Carbon Cycle so far? Make as many connections as possible.

HONORS BIOLOGY

Know Your Sources of Information

Consider your sources as you collect information regarding any difficult issues, especially issues that involve science.

With modern technologies, it is possible to find information on virtually any topic, but the quality and usefulness of the information to which you have access will vary. It is critical that you pay attention to where information is coming from, who is behind the information (their credibility, expertise, biases, etc.), and what you can and/or should do with that information. There is no single method for documenting the credibility and reliability of information and information sources, but here are some suggested questions to explore in your analysis of any information source. Keep in mind that not all of these questions will be pertinent for all information sources.

1. Who is (or what organization or company) presenting the information?

2. What is the purpose of the publication?

3. What expertise and/or relevant experience does the author (or organization or company) have?

4. What biases does the author (or organization or company) have and how might those biases affect the presentation of information?

5. Does the information presented seem to be accurately reported? Are the claims made in the presentation supported? Do any facts or analyses seem to be distorted?

6. Does the presentation leave important information out? Does the presentation offer information that is unnecessary (particularly if the extra information distorts the message)?

Competition between Woody & Herbaceous Plants
Questions

1. Refer to your model of soil moisture for prairies. Which kinds of plants, woody plants or herbaceous plants (grasses and forbs), will do better under drought conditions? Why?

2. Climate models make complex predictions about the link between rising temperatures and changes in precipitation. In some places like the Arctic, rising global temperatures will likely increase precipitation. Places like Northern Africa will probably receive less precipitation. In other places, like the Midwest including Missouri, climate change is NOT predicted to change the amount of precipitation; however, it probably will change the frequency and intensity of precipitation events. That is, the same overall amount of precipitation will probably fall, but it will come in stronger storms separated by longer periods without rain. If this prediction for precipitation in Missouri is correct, which kinds of plants, woody plants or herbaceous plants (grasses and forbs), will likely do better? Why?

3. We are not sure about how climate change may be affecting Tucker Prairie; this is why Dr. Holdo is actively conducting research. Research, conducted in other natural areas, helps to inform what we think is likely taking place. Read the abstract of the article by Kulmatsi & Bard (on the back of this handout; the full article from *Nature Climate Change* is available online: http://restem4.wix.com/learning-resources). Explain the main findings from this study.

Kulmatiski, A., & Beard, K. H. (2013). Woody plant encroachment facilitated by increases precipitation intensity. *Nature Climate Change, 3,* 833-837.

Global circulation models and empirical evidence suggest that precipitation events are likely to become more extreme across much of the globe[1, 2]. As most plant roots are in shallow soils[3, 4, 5], small but pervasive changes in precipitation intensity could be expected to cause large-scale shifts in plant growth, yet experimental tests of the effects of precipitation intensity are lacking[6, 7, 8, 9]. Here we show that, without changing the total amount of precipitation, small experimental increases in precipitation intensity can push soil water deeper into the soil, increase aboveground woody plant growth and decrease aboveground grass growth in a savannah system. These responses seemed to reflect the ability of woody plants to increase their rooting depths and competitively suppress grass growth. In many parts of the world, woody plant abundance has multiplied in the past 50–100 years, causing changes in fire, forage value, biodiversity and carbon cycling[10]. Factors such as fire, grazing and atmospheric CO_2 concentrations have become dominant explanations for this woody encroachment and semi-arid structure in general[10, 11, 12]. Our results suggest that niche partitioning is also an important factor in tree–grass coexistence and that the woody plant encroachment observed over the past century may continue in the future should precipitation intensity increase.

Tracking Soil Moisture

Side A

Complete each statement by adding an arrow to indicate how increases in a water process influences soil moisture.

↑ Precipitation → _____ Soil Moisture

↑ Infiltration → _____ Soil Moisture

↑ Runoff → _____ Soil Moisture

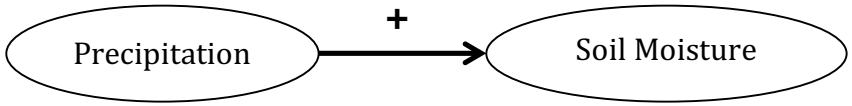
↑ Evaporation → _____ Soil Moisture

↑ Transpiration → _____ Soil Moisture

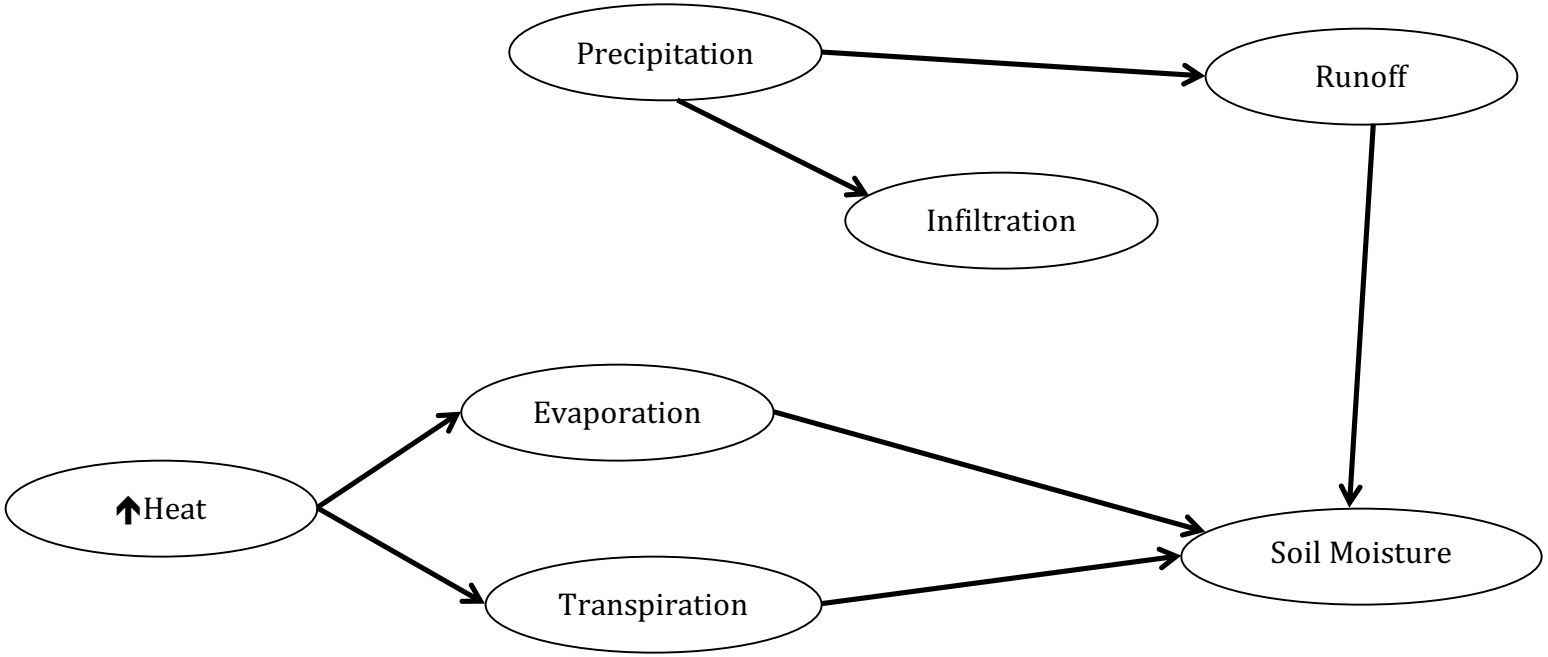
Tracking Soil Moisture

Side B

Add a "+" or a "-" to every arrow linking the processes and measures as a means of indicating how one process impacts another. For example …



…because precipitation will lead to an increase (+) in soil moisture.



Honors Biology Name:

Indicator Species Follow Up

1. *In small groups, share information regarding the species you researched. See the definitions below to help describe your species to your classmates.*

Niche: the role of the organism in its environment (could be general or specific; ex: how it contributes, position in the food chain, etc.)
Habitat: the specific place where an organism lives

Name of Organism: Niche: Habitat: Potential climate change effects:	Name of Organism: Niche: Habitat: Potential climate change effects:	Name of Organism: Niche: Habitat: Potential climate change effects:
Name of Organism: Niche: Habitat: Potential climate change effects:	Name of Organism: Niche: Habitat: Potential climate change effects:	Name of Organism: Niche: Habitat: Potential climate change effects:

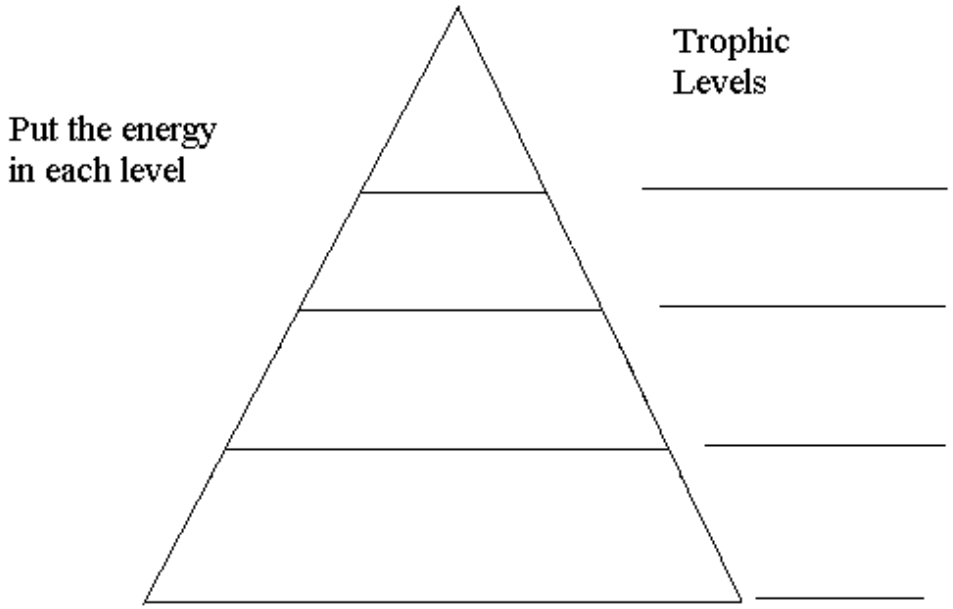
2. *Next, using the six indicator species along with their predators and prey and organisms you saw/know live in Tucker Prairie, create a food web that outlines the flow of energy within this ecosystem.*

3. *Go back to your food web and label, color code, symbolize, etc. the following individuals:*
    - Producer- autotrophs, organisms that can make their own energy
    - Consumer- heterotrophs, organisms that must intake their energy
        - Primary consumer- eats producers
        - Secondary consumer- eats primary consumers

    - Tertiary consumer- eats secondary consumer
    - NOTE: organisms can be at multiple tropic levels
- Herbivore- consumers that only each plants
- Carnivore- consumers that only eat other animals
- Omnivore- consumers that eat both plant/animals
- Decomposer- organisms that break down dead organic matter (recycle nutrients back to soil)

4. *Outline one food chain (include a producer, primary, secondary, and tertiary consumer) below.*

5. *Use your food chain to create an energy pyramid that shows the amount of available energy at different trophic levels. Assume that 1,000,000 kcal of energy from the sun fuels this food chain. Only 1% of this energy gets stored in the producers. Only 10% of the energy at one trophic level is available to the next level, while the rest is "lost" as heat energy (think about what you know about cellular respiration).*



Honors Biology **Name:**
Model Evaluation

Using the Visual Model strand from the rubric, evaluate each model.

	4	3	2	1
Visual Model	Clearly shows specific, relevant, thoughtful, and accurate cause/effect relationships that predict changes in the organism's population.	Shows specific, relevant, and accurate cause/effect relationships that predict changes in the organism's population.	Attempts to show cause/effect relationships that predict changes in the organism's population, but is limited and/or general; may lack relevance and/or accuracy.	Attempts to show cause/effect relationships that predict changes in the organism's population, but is confusing or incomplete.

1. Model 1 Score _____
   a. Defend your score by explaining how the criteria from the rubric are met by the model.

   b. What could be added/modified about this model to make it more effective? What have you learned about creating an effective visual model from this example?

2. Model 2 Score _____
   c. Defend your score by explaining how the criteria from the rubric are met by the model.

   d. What could be added/modified about this model to make it more effective? What have you learned about creating an effective visual model from this example?

3. Model 3 Score _____
    e. Defend your score by explaining how the criteria from the rubric are met by the model.

    f. What could be added/modified about this model to make it more effective? What have you learned about creating an effective visual model from this example?

Ecology Unit Final Project

Project Description. In this project, you will use ideas and modeling skills that you've learned through your exploration of Tucker Prairie to make sense of the likely impacts of climate change on an organism from another part of the world. Your project work will have four phases:

I. Select an organism that is being affected by (or likely will be affected by) climate change. We recommend that you select one of the nine organisms featured on http://restem4.wix.com/learning-resources#!ecology-unit-final-project/c1wfv (this link is accessible on the *Climate Change Learning Resources* page. If you would like to use an organism that is not on the list but you know is being affected by climate change, talk to your teacher.

II. Conduct research on your selected organism (there are links available for the recommended organisms that highlight much of the information you will need to find). Through your research, you need to collect information about your organism's
    - Natural history and niche (What habitat does it require? How does it acquire energy? What other species does it interact with? What abiotic factors are important for its success?)
    - Status of the species (secure, threatened, endangered, etc.)
    - Ways in which climate change may be impacting the organism (or localized populations of the organism).

NOTE: The kind of information that you will be collecting about your selected organism is very similar to the information you accessed when looking at Tucker Prairie Indicator Species (e.g., Henslow's sparrow, armadillo, Meades Milkweed, etc.)

III. Create a visual model to describe what is happening or likely will happen to this organism with ongoing climatic changes. This model will be a diagram that you create to help explain and predict how your organism may be impacted by climate change over time. Your model may be hand drawn or created using software (e.g., Powerpoint, Word, Notability, etc.)

IV. Write an explanation of your model and include an APA reference list (in-text citations needed, as well).

Project Criteria: Your project will have two related products: a visual model and a written explanation of your model. Criteria for these two products are presented below. A sample model and written explanation, related to Henslow's sparrow in tall grass prairies, are available on the *Climate Change Learning Resources* page.

Criteria for the visual model: Your model should…

1. Show how the organism's population trend may change over time.
2. Show the key factor(s) for your organism's population. Key factors may include habitat loss, changes in reproductive seasons or growing seasons, changes in the availability of other species, competition from an invasive species, etc.
3. Show climate change-related causal influences. Climate change is predicted to alter many aspects of climate and weather such as temperature, rainfall patterns, severity of weather systems, sea levels, etc. Your model should indicate which of these influences are significant for your organism and how the influence is affecting your organism.
4. Highlight ways that your organism is connected to other species. These interactions may be related to sources of habitat, competition, predation, food sources, etc.

Criteria for the written explanation: Your explanation should…

1. Introduction that includes:
    a. A brief description of your organism's habitat and niche.
    b. Thesis-- Predict (claim + reasoning) what will happen to your organism over time if Earth's climate continues to change at its current rate.
2. Describe and analyze the interactions and processes represented in your model to support your thesis/prediction. Include the following:
    a. Attention to the key factors for your organism's population and the climate change-related causal influences
    b. Interactions between your organism and other species and how changes in one population affects the others
3. Include in-text citations and a reference list with APA citations.

Category	4	3	2	1
Thesis Statement	Thesis statement fully addresses the prompt by making a precise claim and provides controlled and thoughtful reasoning for the claim.	Thesis statement fully addresses the prompt by making a claim and provides logical reasoning for the claim.	Thesis statement fully addresses the prompt by making a claim and provides reasoning that may be too narrow, superficial, and/or vague.	Thesis statement responds partially to the prompt with a claim that is vague, incomplete, or lacks reasoning.
Description	Smoothly and thoroughly integrates specific, relevant, and accurate evidence, creating a strong foundation for the argument.	Integrates specific, relevant, and accurate evidence, creating a foundation for the argument.	Integrates limited and/or general evidence; may lack relevance and/or accuracy; creating a weak foundation for the argument.	Attempts to integrate evidence, but is insufficient in creating a foundation for the argument.
Analysis	Clearly and efficiently breaks down and elaborates on meaning and significance of each piece of evidence.	Breaks down and elaborates on meaning and significance of each piece of evidence.	Breaks down evidence but provides limited meaning and significance.	Breaks down evidence in a confusing or incomplete manner.
Synthesis	Clearly connects the evidence and analysis to the thesis to develop the implications and significance.	Connects the evidence and analysis to the thesis to develop the implications and significance.	Attempts to connect the evidence and analysis to the thesis to develop the implications and significance.	Attempts to connect the evidence and analysis to the thesis but there is little development of implications and significance.
Visual Model	Clearly shows specific, relevant, thoughtful, and accurate cause/effect relationships that predict changes in the organism's population.	Shows specific, relevant, and accurate cause/effect relationships that predict changes in the organism's population.	Attempts to show cause/effect relationships that predict changes in the organism's population, but is limited and/or general; may lack relevance and/or accuracy.	Attempts to show cause/effect relationships that predict changes in the organism's population, but is confusing or incomplete.
Communication	Language skills are superior. Demonstrates professionalism and fluency, and is engaging to the audience.	Language skills are average. Demonstrates average professionalism and fluency, and I am engaging to the audience.	Language skills are inconsistent. Attempts to be professional and fluent, but I may not consistently engage the audience.	Language skills are lacking. Demonstrates a deficiency in being professional and fluent, and I am largely disengaging to the audience.
Research	Multiple creditable sources utilized throughout the piece. Correct APA format is observed.	Multiple creditable sources utilized; however, strong reliance on one source throughout the piece. Mostly correct APA format is observed.	Few sources are referenced, but they are not creditable or utilized throughout the piece. Incorrect APA format is observed.	Sources utilized throughout the piece are not referenced or are not creditable, and poor APA format is observed.