**Argumentative Writing in Science**

Using Controversial Topics

Many topics taught in science classes can be used to construct an argumentative essay. Students can write based on information from the text book or they can be given additional resources to read and use as evidence. A small selection of possible topics is presented below.

Chemistry

* Undersea manganese modules should/should not be mined.
* The use of helium for recreation purposes should/should not be banned.
* Water bottles that contain bisphenol A (BPA) should/should not be banned.
* Fluoride should/should not be added to Hawaii’s water supply.
* Chemicals that cause air pollution should/should not be regulated.
* Greenhouse gas chemicals should/should not be regulated.
* As ocean water becomes more acidic it will/will not effect the health of our reef ecosystems.
* Companies should/should not have to prove their chemicals are harmless before manufacturing.
* Plastic polymers should/should not be banned.

Physics

* The United States should/should not build a new larger particle accelerator.
* The State of Hawai`i should/should not build a new telescope on Mauna Kea.
* People should/should not only buy electric cars.
* The State of Hawai`i should/should not build a nuclear power plant.
* The United States should/should not develop nuclear fusion reactors.
* The United States should/should not store nuclear waste at a central location.
* Radiation from cell phones / blue tooth devices is/is not dangerous.

Biology

* Farmers should/should not be allowed to use human antibiotics in animal.
* Scientist should/should not clone animals.
* Scientist should/should not clone humans.
* Adults should/should not get a genetic test that reports their entire DNA.
* Parents should/should not be able to get a genic test that reports the entire DNA of their fetus.
* Killing sharks should/should not be banned in Hawai`i.
* Chocolate is/is not good for you.
* Countries should/should not be allowed to make and use DDT.
* Vaccines do/do not cause autism.

Earth Science

* Global climate change is/is not caused by human actions.
* Global climate change does/does not cause more severe storms / sea level rise.
* Genetically Modified Organisms are/are not safe for human consumption.
* The United States should/should not send people to Mars.

**Argumentative Writing in Science:** Using Controversial Topics

A few templates

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| In the topic of \_\_\_\_\_, one controversial issue has been \_\_\_\_\_\_\_\_\_. On one hand, some argue that \_\_\_\_\_\_\_\_\_. In \_\_\_\_\_ X states that \_\_\_\_\_\_. This implies that \_\_\_\_\_. On the other hand, \_\_\_\_\_\_\_\_\_ contends \_\_\_\_\_\_\_\_\_. From this perspective \_\_\_\_\_. My own view is \_\_\_\_\_\_\_\_\_ because \_\_\_\_\_\_. This is important because  |

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|  In recent discussion of \_\_\_\_\_, a controversial issue has been whether \_\_\_\_\_\_. On one hand, \_\_\_\_\_ argues \_\_\_\_\_. In \_\_\_\_\_, X maintains that, “\_\_\_\_\_.” From this perspective, \_\_\_\_\_. On the other hand, however, \_\_\_\_\_ argues that \_\_\_\_\_. In the words of Y, one of this view’s main proponents, “\_\_\_\_\_.” According to this view, \_\_\_\_\_. In sum, then, the issue is whether \_\_\_\_\_ or \_\_\_\_\_.My own view is that \_\_\_\_\_. For example, \_\_\_\_\_. Although some might object that \_\_\_\_\_, I would reply that \_\_\_\_\_. Ultimately what is at stake here is \_\_\_\_\_. |

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| In the discussions of X, one controversial issue has been \_\_\_\_\_. On one hand , \_\_\_\_\_ argues \_\_\_\_\_. On the other hand, \_\_\_\_\_ contends \_\_\_\_\_. Some argue that \_\_\_\_\_\_\_\_\_. From this perspective \_\_\_\_\_. In \_\_\_\_\_ X states that \_\_\_\_\_\_. This lead to the conclusion that \_\_\_\_\_.On the other hand, \_\_\_\_\_\_\_\_\_ contends \_\_\_\_\_\_\_\_\_. According to this view, \_\_\_\_\_. In \_\_\_\_\_ Y, states, “\_\_\_\_\_.” This implies that \_\_\_\_\_. In sum, then, the issue is whether \_\_\_\_\_ or \_\_\_\_\_.My own view is \_\_\_\_\_\_\_\_\_ because \_\_\_\_\_\_. In addition there is the issue of \_\_\_\_\_\_. This discussion of \_\_\_\_\_ is in fact addressing the larger matter of \_\_\_\_\_\_\_\_. |

**Argumentative Writing in Science**

Using Experimental Data

The data collected in an experiment can be used as the evidence for constructing an argumentative essay. Students can write the conclusion of a lab report in an argumentative format using the CERCC format described below.

**Claim:** The claim is a testable statement that answers the experimental question. This paragraph is concise, 1-2 sentences. It relates directly to the experimental question, and focus only on the most important features of the experiment.

**Evidence:** The evidence is data or observations from the experimentthat supports the claim. the Evidence must be relevant, sufficient and accurate. Relevant means that the data relates to and supports the claim. Sufficient means there must be multiple data points that support the claim. Accurate means correct in all details and free from error or defect, including correct units.

**Reasoning:** The reasoning explains howthe evidence supports the claim by connecting it to scientific background knowledge or a scientific theory. It shows why data counts as evidence. If more than one piece of evidence is provided each piece of evidence has its own reasoning section.

**Counterclaim** (Rebuttal): The counter claim describes an alternative answer to the experimental question. It then provides evidence and reasoning for why the alternative explanation is incorrect and why the original claim is still the most valid explanation of the data. Alternative explanations may include: other scientific theories, physical or chemical properties (variables) not accounted for in the procedure, or experimental errors that were significant enough to affect the data.

**Conclusion**: The conclusion summarizes all the evidence and reasoning to reinforce the claim as the best answer to the experimental question. It also incorporates background knowledge, makes connections to science concepts studied in class, and describes how these concepts relate to real life events.

**Rubric for Argumentative Writing in Science:** Using Experimental Data

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| --- | --- | --- | --- | --- |
|  | **1** | **2** | **3** | **4** |
| **Claim** * A testable statement that answers the experimental question.
* Concise statement, 1-2 sentences.
* Relates directly to the question
* Focuses on only the most important features of the experiment
 | The claim shows that the student does not understand the concept / content of the lab. The claim does not respond to the purpose of the lab.The claim is so vague or incomplete that the answer is not clear or reasonable.  | The claim shows that the student has a partial understanding of the concept / content of the lab. The claim relates to the purpose of the lab.The claim is only partially correct or accurate but incomplete claim. | The claim shows that the student has a thorough understanding of the concept / content of the lab. The claim correlates to the purpose of the lab presents complete and original thoughts.The claim is accurate and complete claim. | The claim shows that the student has a deep understanding of the concept / content of the lab. The claim responds directly to the experimental question or prompt The claim establishes a perceptive or insightful idea  |
| **Evidence** * Uses data from the experimentthat supports the claim.
* Data is:

Relevant: connects to claimSufficient: multiple data sources Accurate: correct in all details, correct units. | Data is not relevant, or is incorrect, random or illogical. | Data is relevant but insufficient or incomplete. Units are missing.Data shows little or no depth of thought, or is just mentioned / listed. | Data is relevant to the claim. It is specific, logical, related to the claim and focused on the purpose of the labData is sufficient to support claim. Multiple data sources are used and the connection between the data are stated. | Data is relevant to the claim. The data thoroughly proves a relationship between the evidence. Data shows a deep understanding of the complexity of the topic. Multiple data sources are used and the connection between the data are stated. |
| **Reasoning** * Shows why data counts as evidence.
* Explains howthe evidence supports claim by connecting it to scientific background knowledge or a scientific theory.
 | Reasoning does not link evidence to the claim.  | Reasoning links the claim and evidence. Repeats the evidence and/or includes some scientific principles, but not sufficient. Reasoning included more than one piece of evidence. | Provides reasoning that links evidence to claim. Includes appropriate and sufficient scientific principles. Each piece of evidence has its own reasoning. | Reasoning clearly links evidence to claim and insightfully explains the connection the evidence and claim.Each piece of evidence has its own reasoning. |
| **Counterclaim*** Describes an alternative answer to experimental question.
* Provides evidence / reasoning why alternative explanation is incorrect and original claim is most valid.
 | Does not recognize that an alternative explanation exists Does not provide relevant counter evidence Poor reasoning in making a rebuttal. | Recognizes alternative explanations Provides relevant but insufficient counter evidence Good reasoning in making a rebuttal. | Recognizes alternative explanations Provides relevant and sufficient counter evidence Clear reasoning when making rebuttals. | Recognizes alternative explanations Provides highly effective counter evidence Compelling reasoning when making rebuttals. |
| **Conclusion*** Summarizes evidence and reasoning to reinforce claim as the best answer to the experimental question.
* Incorporates background knowledge, makes connections to science concepts studied in class, and describes how these concepts relate to real life events.
 | Conclusion does not adequately explain the connection between the evidence / reasoning and concept / content. Conclusion is hard to follow because ideas do not connect together, are unreasonable, vague, generic, or unrelated to the experimental question. | Conclusion partially explains connection between the evidence / reasoning and concept / content.Conclusion is slightly difficult to follow because some ideas are vague or relationship to the experimental question is unclear.Some evidence is ignored.  | Conclusion adequately explains the connection between the evidence / reasoning and concept / content. Conclusion makes sense and is easy to follow. It connects evidence back to the experimental question and claim. Each piece of evidence is included.Clear application to real world. | Conclusion clearly and insightfully explains the connection between the evidence / reasoning and concept / content.Conclusion smoothly guides the reader from one point to the next. It includes intricate and interesting connections of evidence to the claim. Thoroughly explains each piece of evidence. Shows a deep understanding of concept and connections to real world. |

**Science Writing Templates and Transition Words**

**Introduction**

* A number of scientists have recently discovered \_\_\_\_\_.
* The theory of \_\_\_\_\_\_ states that \_\_\_\_\_\_.
* In discussions of X, one controversial issue has been \_\_\_\_\_\_\_\_\_. On one hand, \_\_\_\_\_\_\_\_\_ argues \_\_\_\_\_\_\_\_\_. On the other hand, \_\_\_\_\_\_\_\_\_ contends \_\_\_\_\_\_\_\_\_. Others even maintain \_\_\_\_\_\_\_\_\_.
* Experiments showing \_\_\_ and \_\_\_\_ have led scientists to propose \_\_\_\_\_.
* X’s work leads to the question of \_\_\_\_\_. Therefore \_\_\_\_\_ was investigated.

**Establishing why your claims matter:**

* X is important because \_\_\_\_\_\_\_.
* Ultimately, what is at stake here is \_\_\_\_\_\_\_\_.
* My discussion of X is in fact addressing the larger matter of \_\_\_\_\_\_\_\_.
* Although X may seem of concern to only a small group of \_\_\_\_\_\_, it should in fact concern anyone who cares about \_\_\_\_\_\_\_\_\_\_\_.

**When citing sources or using quotes:**

* X observes that \_\_\_\_\_\_\_\_\_.
* X reports that \_\_\_\_\_\_\_\_\_.
* X states, “\_\_\_\_\_\_\_\_\_.”
* According to X, “\_\_\_\_\_\_\_\_\_.”
* In her book, \_\_\_\_\_\_\_\_, X maintains that “\_\_\_\_\_\_\_\_\_.”

**Analysis**

* The trend in the data shows that\_\_\_\_\_\_\_\_\_.
* In trial one the \_\_\_\_\_\_\_\_ was \_\_\_\_\_\_\_\_.
* The average of the data shows \_\_\_\_\_\_\_\_\_.
* The \_\_\_\_\_\_\_\_ was \_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_ was \_\_\_\_\_\_\_\_ giving a difference of \_\_\_\_\_\_\_\_\_\_\_.

**Error Analysis**

* The difference between \_\_\_\_\_ and \_\_\_\_\_ is probably due to \_\_\_\_\_.
* One explanation of \_\_\_\_\_ is that \_\_\_\_\_. An alternative explanation is \_\_\_\_\_.
* Some may argue that this experimental design fails to account for \_\_\_\_\_\_.
* An error observed during the experiment was \_\_\_\_\_\_\_\_.
* An error observed in the data was \_\_\_\_\_\_\_\_\_\_\_.
* This may be a measurement error due to the imprecise measurement of the \_\_\_\_\_\_\_\_.
* This may be a human error due to \_\_\_\_\_\_\_\_.
* This error probably *did/did not* affect the data because \_\_\_\_\_\_\_\_.

**Claim**

* This experiment shows that \_\_\_\_\_\_.
* The data suggest/hint/imply \_\_\_\_\_.
* Our results show/demonstrate \_\_\_\_\_\_.
* Our data supports/confirm/verify the work of X by showing that \_\_\_\_\_.

**Evidence**

* We measured \_\_\_\_\_ (sample size) subjects, and the average response was \_\_\_\_\_ (mean with units) and with a range of \_\_\_\_\_ (lower value) to \_\_\_\_\_ (upper value).
* The data from trial one shows \_\_\_\_\_\_\_\_\_\_ because \_\_\_\_\_\_\_\_\_\_
* The data from trial one shows \_\_\_\_\_\_\_\_\_\_ however \_\_\_\_\_\_\_\_\_\_

**Reasoning**

* This supports the claim because \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Counter Claim**

* Some of the data appears to contradict the claim because \_\_\_\_\_\_\_.
* Some data seems to show \_\_\_\_\_\_\_ however \_\_\_\_\_\_\_\_\_.
* While it is true that\_\_\_\_\_, it does not necessary follow that \_\_\_\_\_\_.

**Conclusion**

* This experiment demonstrates that \_\_\_\_\_\_ because \_\_\_\_\_\_\_\_\_.
* The results of this experiment agree with other scientific studies that have found \_\_\_\_\_\_\_\_.
* In conclusion, this experiment proves \_\_\_\_\_.
* This experiment is related to \_\_\_\_\_\_\_.
* Understanding this concept is important because it relates to \_\_\_\_\_\_\_\_.
* This concept impacts us every day when we \_\_\_\_\_\_\_\_.
* Further work in this are a may lead to the development of \_\_\_\_\_.
* These results provide an illustration of \_\_\_\_\_.
* Ultimately what is at stake here is \_\_\_\_\_.
* These finding have important implications for the broader domain of \_\_\_\_\_.
* If we are right about \_\_\_\_\_, then major consequences follow for \_\_\_\_\_.
* These conclusions/This discovery will have significant applications in \_\_\_\_\_ as well as in \_\_\_\_\_.

**Commonly Used Transitions**

|  |  |  |  |
| --- | --- | --- | --- |
| Cause and EffectAccordinglyAs a resultConsequentlyHenceIt follows, thenSinceSoThenThereforeThus | ConclusionAs a resultConsequentlyHenceIn conclusion, thenIn shortIn sum, thenIt follows, thenSoThe upshot of all this is thatThereforeThusTo sum upTo summarize | ContrastAlthoughButBy contrastConverselyDespite the fact thatEven thoughHoweverIn contrastNeverthelessNonethelessOn the contraryOn the other handRegardlessWhereasWhileYet | ElaborationActuallyBy extensionIn shortThat isIn other wordsTo put it in another wayTo put it bluntlyTo put it succinctlyUltimately |
| AdditionAlsoAndBesidesFurthermoreIn additionIn factIndeedMoreoverSo too | ExampleAfter allAs an illustrationConsiderFor exampleFor instanceSpecificallyTo take a case in point | ComparisonAlong the same linesIn the same wayLikewiseSimilarly | ConcessionAdmittedlyAlthough it is true thatGrantedI concede thatOf courseNaturallyTo be sure |

Adapted from Graff, Gerald, and Cathy Birkenstein. They Say, I Say: The Moves That Matter In Academic Writing. New York: W. W. Norton & Company, 2006.

**Argumentative Writing in Science:** Using Experimental Data

EXAMPLE:Lab Report Directions

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| **Conservation of Mass Lab Report**Format* **Title Page** with title, student names, period and date.
* Entire report is **typed**, including data table and graph.
* Font is Ariel or Times New Roman, 10 or 12 point. Not all caps, bold or italic. Aligned on the left.
* Each section should have a heading in bold.
* All parts of the report use **complete sentences** and **proper spelling and grammar.**

**Introduction** Write the introduction in the Informational format. * Define the law of conservation of mass and explain what the law of conservation of mass tells you about what happens during a chemical reaction
* Write the balanced chemical equation of this reaction, and explain how you can tell it is balanced.
* Explain how this experiment should prove the law of conservation of mass.
* Explain how the law of conservation of mass relates to our planet; think of air, water, food or trash.

**Experiment*** **Materials**: List all the materials used in the experiment. List the quantity of materials used.
* **Method**:
	+ Describe in detail how you did the experiment. How did you create a closed system? How did you mix the chemicals in the closed system? How and when did you measure the mass?
* State the number of **trials**.
* **Safety**: Write at least three safety rules related to the procedure.

**Results*** **Data Table**: present all the data measured in the experiment. Title clearly states what the table shows, Columns and Rows have headings, Measurements have units

**Analysis*** State the trends in the data and support this statement using multiple data points.
* State experimental errors, these may be problems with the experimental design (only one trial) or errors that occurred during the experiment (accidentally unplugged the hot plate for 5 minutes).
* Discuss the effect that these errors had on the data (a minor error would have little effect, a major error could make the data so unreliable that the experiment should be repeated before any conclusions can be made.)
* Discuss changes that could be made to remove this error.

**Conclusion** (CERCC format)* Make a testable statement that answers the Experimental Question, is related directly to the experimental question, and focused only on the most important features of the experiment. ***(Claim)***
* Describe data or observations from the experimentthat supports the claim. It must be relevant, sufficient and accurate. ***(Evidence)***
* Explain howthe evidence supports the claim by connecting it to scientific background knowledge or a scientific theory. If more than one piece of evidence is provided each piece of evidence has its own reasoning section. ***(Reasoning)***
* Describe an alternative answer to the Experimental Question. Then provide evidence and reasoning for why the alternative explanation is incorrect and why the original claim is still the most valid explanation of the data. Alternative explanations may include other scientific theories, unaccounted for physical or chemical properties or significant experimental errors. ***(Counterclaim)***
* Summarize all the evidence and reasoning to reinforce the claim as the best answer to the experimental question. Incorporate background knowledge, make connections to science concepts studied in class, and describe how these concepts relate to real life events. ***(Conclusion)***
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**Argumentative Writing in Science:** Using Experimental Data

EXAMPLE:Student Lab Report

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| **Results**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Observation | Mass of Reactants | Mass of Products | Difference |
| Trial 1 | Reactants mixed before bag was sealed | 12 g | 10 g | 2 g |
| Trial 2 | Reactants bubbled when mixed | 13 g | 13 g | 0 g |
| Trial 3 | Reactants bubbled when mixed | 14 g | 14.1 g | - 0.1 g |
| Average |  | 13 g | 12.4 g | 0.6 g |

**Analysis**Two of the trials show that the difference between the Mass of Reactants and Mass of Products was almost 0. In Trial 2 Mass of Reactants and the Mass of Products were both13g. In Trial 3 Mass of Reactants was 14g and Mass of Products 14.1g giving a difference of 0.1 gThere were two errors noticed during the experiment. In trial 1 the reactants were mixed before the bag was sealed so some product might have escaped. This may be why the Mass of the Products was 2 grams less than the mass of the Reactants. This trial should not be considered when analyzing the data because of this possible error. This error could have been eliminated by making sure the bag was sealed before the reactants were mixed.The other errors that was noticed was that in the third trial there was 0.1 g more product than reactant. Because of the small difference, this is likely a measurement error due to human error or the calibration of the scales. This error is small enough that it is unlikely to affect the reliability of the data and trial 3 does not need to be excluded from consideration when analyzing the data.**Conclusion** This experiment addresses the experimental question: Does this reaction demonstrate the law of conservation of mass? The law of conservation of mass states that matter is not created or destroyed in a chemical reaction and therefore, the mass before and after the reaction will be the same. The data from this experiment shows that in this reaction mass was conserved so it does demonstrate the law of conservation of mass. ***(Claim)***The data from Trial 2 shows that mass is conserved because the mass of the reactants was 12 g and the mass of the products was 12 g. This data shows that mass did not change during the reaction therefore no matter was created or destroyed. ***(Evidence and Reasoning)***Some of the data appears to contradict the law of conservation of mass. In trial 1 the mass of the products was 12 g and the mass of the reactants was 10 g. It appears that the mass of the products decreased however, it was observed that the reactants were mixed before the bag was sealed. Therefore, the decrease in mass is due to product escaping from the sealed container not that mater was destroyed. In trial 3 the mass of the products was 0.1 g greater than the mass of the products. However this is within the measurement error of the mass balance that was used so it does not indicate that matter was created in the reaction. *(****Counterclaim****)*This experiment did demonstrate that matter is conserved in a reaction because two trials showed that the mass of the reactants and mass of the products was the same, within the margin of error f or our mass balance. This agrees with other scientists’ studies which have proven that matter is not created or destroyed in a chemical reaction. Conservation of mass is important because in nature nothing is created or destroyed. This can be seen in the water cycle when one molecule of water passes through many stages; evaporation, condensation, precipitation, but no molecules are created or destroyed. ***(Conclusion)*** |