

INCREASING CONCEPTUAL LEARNING  
IN SCIENCE THROUGH WRITING

by

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## ABSTRACT

This project sought to discover whether write-to-learn activities increased conceptual change in students' understanding of science content. Students were involved in seven different writing activities aimed at learning and remembering science content. Students also wrote reflections after inquiry activities to help them connect the activity to the content learned in the classroom. During Chapter 1: Introduction to Living Things, students did not receive write-to-learn activities. Chapters 2: Viruses, Bacteria, Protists, and Fungi and Chapter 3: Introduction to Animals, students did receive write-to-learn activities. From the Introduction to Living Things chapter to the Introduction to Animals chapter, there was a 14% increase in test score medians. Students' confidence in their writing and memory skills improved.

## INTRODUCTION AND BACKGROUND

I have been teaching at Sidney Middle School (SMS) for four years. During that time, I have noticed that the majority of my science students struggle with writing. They associate writing with only having to complete writing assignments in language arts class. I wanted to see how incorporating more writing in the science classroom affected their conceptual learning. I also perceived that students view science inquiry as something that is just for fun. My goal was for students to write a reflection after inquiry activities and then they would be able to make connections with the content they were learning in the lessons.

Sidney Middle School is located in Sidney, Montana and accommodates approximately 322 students. Since Sidney is an oil boomtown it brings in many new students because their parents get new jobs in the oil field. Students will also move to other oil towns throughout the year, which causes constant changes in enrollment. The middle school is comprised mainly of Caucasian students (270) students, with the remaining students being Hispanic (26), American Indian (4), Asian (2), and African American (2) (Student Enrollment Summary Report, 2016).

Sidney Middle School has high expectations that students are respectful, responsible, and safe in order to be a learner. This expectation is a result of the Montana Behavior Institute (MBI). We were awarded the platinum award from MBI two years in a row now because the students at SMS demonstrate these expectations. Our students are very respectful to incoming students, as well as to adults. When new students come in from other schools they feel safe at Sidney Middle School and are taken aback by the kindness from all around.

Each year teachers in the middle school consistently make comments about student writing and how students do not write at a middle school level. As a whole district we have been focusing on more writing in the classroom for all subject areas. I chose this project to focus on writing and my choice was greatly influenced by my observations in my classroom. The climate of my class is a structured yet fun a learning environment that is engaging and safe. I provide a mixture of written notes, interactive notebook activities, reading and answering questions in our interactive textbook, hands-on-inquiry, and research.

The primary question for this project was, *Will writing-to-learn activities in a science notebook enhance conceptual learning in science?* The subquestion was, *Will students be able to connect science inquiry activities more confidently to science content by using writing-to-learn activities?*

### CONCEPTUAL FRAMEWORK

In education, writing is one of the most important skills across all content areas, including science. The first section of this framework will discuss scientific literature and review studies that support writing-to-learn science. The second part will discuss how notebooks are used as tools to support the writing-to-learn process. The third part will discuss ways to assess student writing and how it aids in student growth.

When students are able to take information they learned and write it down on paper they generate conceptual change. The writing-to-learn strategy aids in this conceptual change by allowing students to reflect on what they already know and to connect that to new knowledge learned. Mason and Boscolo (2000) investigated fourth grade elementary students to determine how they viewed writing during science class. The aim of the study

was to encourage students to view science writing as an important way to reflect, analyze, and compare ideas. These researchers also sought to see if students would generate new ideas based on their writing. The study included an experimental group that completed writing tasks during the lesson on plants and photosynthesis and a control group did not write during the lesson. Both groups were given a pre-questionnaire and a post-questionnaire. Overall, students in the experimental group used higher order thinking in answering their post-questionnaire questions than the students who did not incorporate writing during the lessons. An analysis of variance (ANOVA) was used to measure the means and standard deviations of the oral and written portions in the prequestionnaire and postquestionnaire. The children in the experimental group had two major learning outcomes: a better understanding about plants and an understanding that writing is often used in science (Mason & Boscolo, 2000).

Tucknott and Yore (1999) investigated the effect writing-to-learn had on conceptual learning and the correlation between writing and increased science understanding. Their study emphasized that writing-to-learn should not focus on proper grammar, correct spelling, and standard English. Writing-to-learn is more concerned with assisting students in discovering science knowledge. This study involved fourth grade students learning about simple machines, inventors, and inventions. They were given various writing tasks during the inquiry lesson. These writing tasks included, “answering open-ended questions, note-taking and summarizing, explanatory paragraph writing, drawing diagrams and labeling with sentence explanations” (Tucknott and Yore, 1999, p.13). The students gained 43.9% between pretest and posttest.

Towndrow and Ling (2008) focused on reflective journal writing to promote discovery during inquiry processes. They conducted a small-scale study focused on proper use of laboratory equipment, how to use a Bunsen burner, and the nature of matter. A class of seventh grade girls were involved in this study for five weeks, the students had to write reflections for five minutes after every lesson. The prompts provided were, “1. Questions I have about today’s lesson, 2. Something I have learned today, and 3. Some thought provoking incident in class today” (Towndrow and Ling, 2008, p.280). As a result, student confidence in asking questions increased, as did their thoughts about science in general. In addition, their understanding that the science process is an ongoing endeavor was heightened.

Reading and writing are important tools for students to use to help them gain new knowledge, but are often not used enough to promote science learning and to connect ideas. (Balgopal, Wallace, and Dahlberg, 2012). Although this study involves college students it still illustrates that writing in science allows students to grow as scientists. The students were assigned various articles to read about ecology. Over the course of the study, they wrote three essays, which were coded one of four ways. Superficial writers were unable to make connection to the reading or ecology concepts being discussed. Subjective writers were able to make connections with the ecological concepts, but could not use evidence to support the concepts. Objective writers were able to communicate their understandings, and authentic writers could easily make connects with concepts discussed in class and the readings (Balgopal, Wallace, and Dahlberg, 2012). By the last essay, close to half of the

students were coded as “authentic” writers and were making connections with knowledge they gained from lessons.

Klein (2000) was interested in observing how writing contributes to learning and how different writing strategies affect the cognitive process in learning. The participants of this study were fourth, sixth, and eighth graders. The students participated in two science experiments: one that included buoyancy and the other that involved using a balance beam. The students were randomly chosen for the experiment and were given a pretest, posttest, and a post-writing task. During the experiment, the students were interviewed about what was happening in the experiment. All students in this study made gains in their explanatory writing skills, which showed students had a better understanding of what they are learning.

Marcarelli (2010) discusses the importance of implementing writing in the science classroom. “First and foremost, writing that goes beyond factual comprehension questions and engages students in manipulating content, increases and deepens students’ learning” (p. 112). Having students write can allow them to dig deeper in their understanding and to use and practice communications skills. Having students use a notebook, as real scientists do, provides them with the experience of being a scientist. Students can “think aloud” in their notebooks and apply content with inquiry activities and real life situations.

Science educators are being challenged by National Standards to combine observing, inferring, and hypothesizing with thinking skills such as scientific knowledge, scientific reasoning, and critical thinking to infer a deeper understanding of science (Bybee, 1997). A study was done to see if students who were obtaining their education degree would be persuaded to use notebooks in their classroom based on the results they saw in their

experience. A requirement of this study was that the pre-service teachers had to keep a science notebook. The pre-service teachers kept notes about experiments, which included elements such as: predictions, observations, data and data analysis, conclusions, and communication of their conclusions. The notebooks included writing in the form of reflections, as well as diagrams and drawings. Initially, most of the pre-service teachers viewed this as something they had to do for the class; however, by the end of the course they found that they were enjoying their notebooks, and they were also applying what they learned. One of the pre-service teachers commented, “By the end of the semester, I was drawing more conclusions because throughout the activities I tended to think of the results and procedures more thoroughly through all the experience I was gaining” (Morrison, 2008, p.17).

In order for students to continue to experience achievement in their writing as well as in science content or inquiry, feedback from peers and/or the teacher are important. A common way for students to improve their writing is through self-assessment. Another way to assess students and give feedback is through peer review. By self-assessing and peer reviewing, students are able to learn from their mistakes and write more precisely (Butler and Nesbit, 2008).

Teachers should focus on giving feedback to students about their understanding of the content rather than their completion of the writing activity. Along with written feedback from teachers, Butler and Nesbit recommended that students also receive verbal feedback in the form of a conference. Once the student received feedback, they are given the opportunity to go back into their science notebook and make corrections. The process of making

corrections allows students to gain conceptual understanding, and improve their writing skills (Butler and Nesbit, 2008).

The review and analysis of the literature supported implementing writing-to-learn activities in the science classroom can greatly improve conceptual learning. At the same time, students use science notebooks as tools to help guide their understanding in science by using these writing-to-learn strategies to communicate as scientists do in the real world. In order for this conceptual change to take place students are given feedback in various ways to better understand science content and the inquiry process.

#### METHODOLOGY

The purpose of this classroom research project was to implement write-to-learn activities in science with the intent of increasing conceptual change and to connect learned content with inquiry activities. During my research, I investigated how other researchers used various ways to implement write-to-learn activities and assess student's conceptual change in science. In my project, I used similar techniques to collect data. This investigation was conducted from October 2016 to January 2017.

The participants of my capstone research project included 60 students from 4 sections of my 7<sup>th</sup> grade life science classes. The participants had varied educational levels and writing skills. None of the students had Individual Learning Plans in this group, although there were eleven students who received extra assistance outside of science class. All students received the same instruction without any modifications. The research methodology for this project received an exemption by Montana State University's

Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

Before starting the intervention, I described to the students what my project entailed and how they would be helping me out to collect data. Once they knew what I was going to be doing they completed the Science Writing Survey (Appendix B). The Science Writing Survey consisted of nine *yes* or *no* questions. Students were encouraged to explain why they chose either *yes* or *no*. This survey was analyzed by comparing responses from Presurvey to the Postsurvey, which took place after the intervention and by comparing the number of changes between the *yes* and *no* questions along with any written comments.

The intervention took place while covering three chapters from the student textbook, *Pearson Interactive Science: The Diversity of Life* (Pearson, 2011). The first portion of the intervention was over Chapter 1: Introduction to Living Things. During this chapter students were taught four lessons: “What is Life,” “Classifying Life,” “Domains and Kingdoms,” and “Evolution and Classification” (Pearson, 2011, p. T6). Commonly, for each lesson, students wrote notes in their Interactive Science Notebook, completed a review worksheet, and took a quiz over the lesson. During the lessons, “What is Life” and “Domains and Kingdoms” students participated in an activity, but did minimal writing in the activities. The activity in the “What is Life” lesson had the students go around to 15 different items and decide if they were living, nonliving, and dead based on the characteristics of life. When finished with the activity we discussed the outcome and why the items were classified the way they were. For the “Domains and Kingdoms” activity, students were given pictures of five different organisms and they were to place them in the correct Kingdom and list if the organism was

multicellular or unicellular, autotroph or heterotroph, and prokaryotic or eukaryotic. The students did not do any other supplemental write-to-learn activities during this chapter. Once finished with the chapter, students were given the Introduction to Living Things Posttest, which was identical to the Pretest.

The interventions for the chapters on Viruses, Bacteria, Protists, and Fungi and the Introduction to Animals were implemented similar to the chapter on the Introduction to Living Things, except write-to-learn activities were used to supplement after lessons and inquiry activities. Examples of write-to-learn activities that were used during these chapters were prompts to help guide students in their reflective thinking (Towndrow and Ling, 2008). During the Idea Exchange (snowball) students wrote down a concept or came up with a question from the lesson, then exchanged their paper with another student to respond with a comment or an answer. The students continued to exchange ideas and concepts until they were no longer able to. Opening and closing activities were also used, which asked students a question or two at the beginning or the end of the lesson about the content covered. Once students answered the questions I would look over them and we would discuss the concepts further, if they were not understanding, then I would pass their papers back and have them re-write what was discussed with better understanding. Some other write-to-learn activities used were concepts maps, note taking, writing vocabulary, and short answer study guides for Viruses, Bacteria, Protists, and Fungi and the Introduction to Animal's chapter Posttests.

Along with lessons on Viruses, Bacteria, Protists, and Fungi and the Introduction to Animal's chapters, I integrated lab and inquiry activities to help students understand the concepts learned in the lesson. This portion of the project was to help answer my sub

question, *Will students be able to connect science inquiry activities more confidently to science content by using writing-to-learn activities?* In the Viruses, Bacteria, Protists, and Fungi chapter, students participated in two inquiry activities. The first activity was an epidemic simulation, where one student was “infected” with a cold virus and students exchanged their saliva with three other people. For this activity, I used sodium hydroxide solution as the cold virus and the rest of the students were given water in their test tubes. Once the students exchanged with three people, thymol blue indicator solution revealed who got infected. The students then had to trace back to see who the first infected person was. The second activity I had students do was choose a location in the school to collect a sample to grow bacteria. The students first predicted where in the school would have the most bacteria. The bacteria were incubated overnight and students then counted the number of colonies that grew. In each class, we combined the number of colonies for each location and students made bar graphs to represent the data.

In the Introduction to Animal’s chapter, students did two more inquiry activities to supplement the content-learned-in-class lessons about animal body plans and an introduction to invertebrates. The first activity had students make a model using modeling clay to represent the organization of animal bodies. First, they made cells. Then, they combined the cells to make tissue. Next, they combined the tissue to make organs. Finally, they made different organs to place in their imaginary animal drawing. The second activity was an open inquiry project where students got to design an experiment using earth-worms. They imagined that they were earth-worm researchers trying to determine a desirable environment for an earth-worm. Students designed, observed, interpreted their data, and

made inferences. Once they were finished, they wrote a summary about what they learned, what they still wanted to know, and how this project connected to what we are talking about in class.

At the end of each inquiry activity students answered prompts to reflect on the activity and connect it to the content-learned-in-class lessons (Appendix C). Han et al. (2014) used similar prompts in their study and had great success. The answers to their questions were then reviewed to see if students made connections to the content they are learning in class lessons during each chapter. Along with the prompts ten students, five boys and five girls were randomly chosen for an interview after each inquiry activity, which were recorded and conducted one on one (Appendix D). The interview responses from the four inquiry activities were combined and analyzed to see if students felt like the writing activities after the inquiry activities helped them connect the content to the activity.

To assess students' conceptual learning for each chapter, I administered Viruses, Bacteria, Protists, and Fungi Pretest and Posttest, as well as Introduction to Animals Pretest and Posttest (Appendix E, Appendix F). Along with the Introduction to Living Things Pretest and Posttest (Appendix G), these tests were analyzed using a paired *t*-test and normalized gain. According to Hake (1999), a *low* normalized gain is 0.3 or below, a *medium* gain is between a 0.3 and 0.7, and a *high* normalized gain is above a 0.7. I graphed the Pretests and Posttests in a box and whisker plot to compare the median scores of all three chapter tests. Student writing examples from the Introduction to Living Things Pretest and Posttest were compared to examples from the Introduction to Animals Pretest and Posttest to determine if there was conceptual change.

The Science Writing Survey was completed a second time after the intervention to see if students changed their responses to any of the questions about writing helping them learn science content. Finally, the Science Writing Survey also has a question to address whether students felt writing after inquiry activities helped them connect the content to the activity. Along with the Science Writing Survey, I also randomly interviewed 15 students at the end of my intervention using Post-Intervention Interview Questions (Appendix H). The interviews were given in groups of five students and recorded. I used student responses to help summarize their thoughts about writing in science and if they felt like it helped them learn. My data collecting instruments used in this intervention are summarized in Table 1.

Table 1  
*Data Triangulation Matrix*

Focus Questions	Data Source 1	Data Source 2	Data Source 3	Data Source 4
<i>Primary Question:</i> 1. Will writing-to-learn activities in a science notebook enhance conceptual learning in science?	Science Writing Survey	Chapters Pretests and Posttests	Student Writing Samples	Post-Intervention Interview Questions
<i>Sub-Question:</i> 1. Will students be able to connect science inquiry activities more confidently to science content by using writing-to-learn activities?	Science Writing Survey	Post Inquiry Prompt Questions	Post-Inquiry Interview Questions	Post - Intervention Interview Questions

## DATA AND ANALYSIS

To answer my primary question, *Will writing-to-learn activities in a science notebook enhance conceptual learning in science?*, students were given the Science Writing Survey (Appendix B) at the beginning and end of my intervention. The results of The Science Writing Survey indicated changes in students' perceptions of writing. When asked if they liked writing, 5% of the students changed their response from *no* to *yes* as a result of the intervention ( $N=60$ ). Between the Presurvey and Postsurvey, 17% of the students changed their answer from *no* to *yes*, that writing in science would help them learn. One student stated, "Writing will help you learn science because you write to understand stuff and do reflections and you write in experiments." Students were asked to circle all the writing activities that helped them the best and 82% of the students felt like writing notes helped them learn and remember the information the best. Idea exchange was also helpful for students, which was chosen by 72% of the students. The least helpful activity, chosen only by 17% of the students was Prompt Writing. The results are shown in Table 2.

Table 2

*Write-to-Learn Writing Activities that Helped Students Remember Science Content*

Write-to-Learn Activity	Number of students who found the activity helpful
1. Writing Notes	49
2. Idea Exchange (Snowball)	43
3. Writing Definitions	36
4. Reflection Paragraphs	24
5. Open/Exit Slips	19
6. Concept Diagrams	16
7. Prompt Writing	10

Before and after the first chapter of my intervention, the Introduction to Living Things Pretest and Posttest were given to 60 students. Many students doubled their posttest score, resulting in a *medium* normalized gain score of .51. The *t*-test results indicate a significance in the mean difference of  $p= 2.87E-31$ , indicating a significance at a 95% confidence level. There was a 36% increase in the mean scores between the Introduction to Living Things Pretest and Posttest.

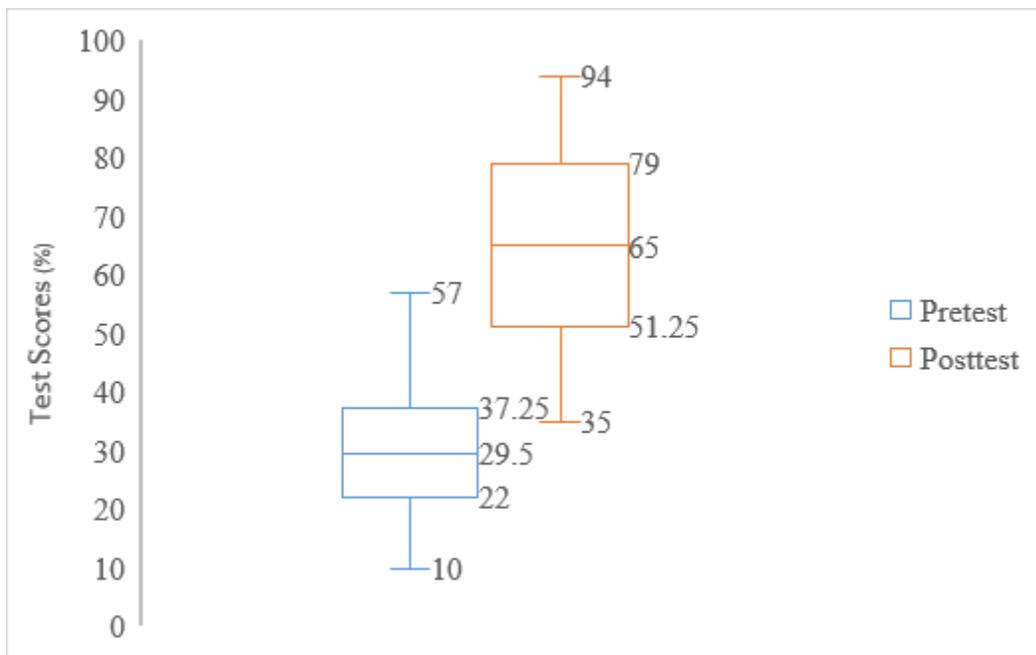


Figure 1. Introduction to Living Things pretest and posttest Score Distribution, ( $N=60$ ).

During the chapters on Viruses, Bacteria, Protists, and Fungi and Introduction to Animals, students were given write-to-learn activities, which were done mostly in their science notebook. Students were given pretests and posttests to measure their conceptual learning. The results indicated a 42% increase in mean scores between Viruses, Bacteria, Protists, and Fungi Pretest and Posttest and a 48% increase in means scores for Introduction to Animals. The *t*-test results indicated a significance in the mean difference of  $p=3.07E-27$

for the Viruses, Bacteria, Protists, and Fungi chapter and  $p=1.14E-36$  for Introduction to Animals, both indicating a significance at a 95% confidence level. The normalized gains were calculated at .56 with a *medium* gain for Viruses, Bacteria, Protists, and Fungi, and .71 for Introduction to Animals, which was a *high* gain.

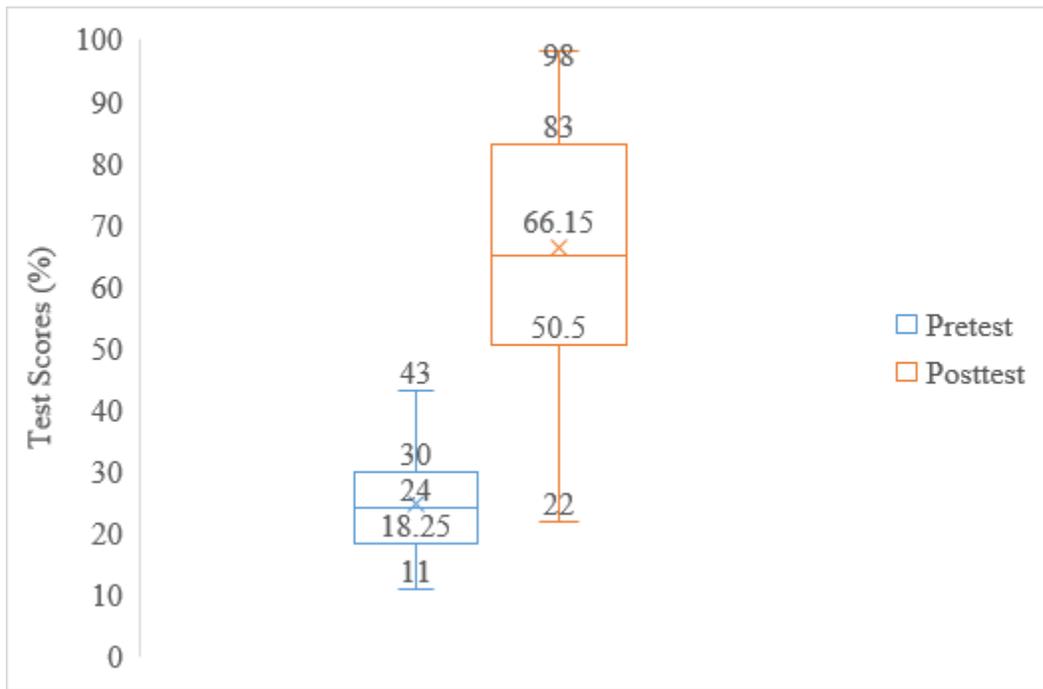
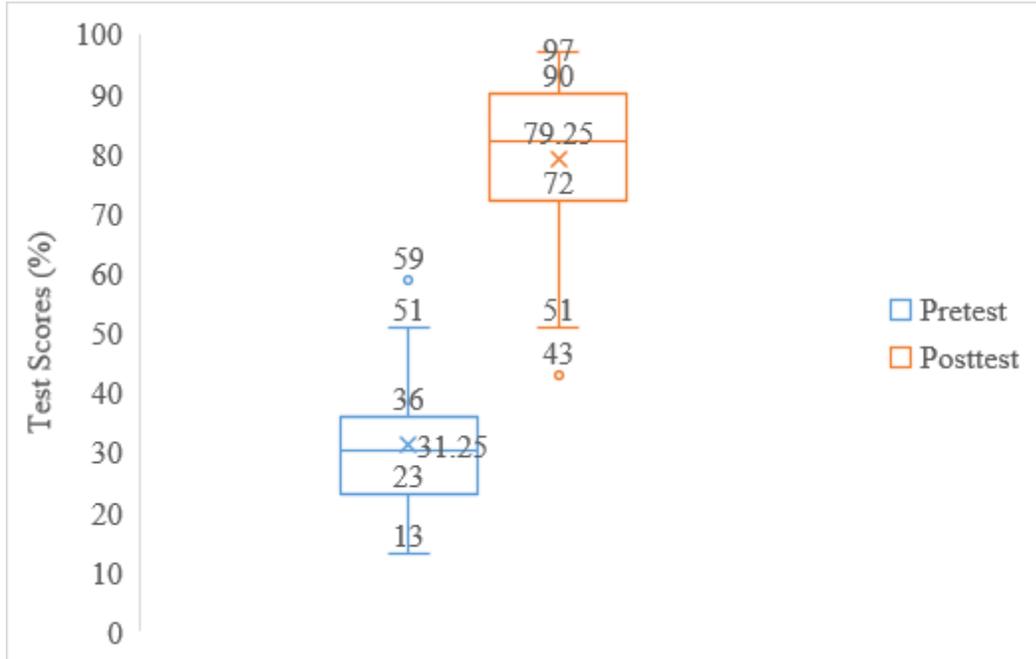


Figure 2. Viruses, Bacteria, Protists, and Fungi pretest and posttest Score Distribution with write-to-learn activities, ( $N=60$ ).



*Figure 3.* Introduction to Animals pretest and posttest Score Distribution with write-to-learn activities, ( $N=60$ ).

The examples of student essay responses in Figures 4-7 show that from Pretest to Posttest their writing became not only longer but more detailed. The details in the posttests were based on information the students learned in class. These writing examples show conceptual increases from the Introduction to Living Things chapter, Pretest and Posttest, to the Introduction of Animal's chapter, Pretest and Posttest, for both students. The amount of writing increased as well as the proper answer for the essay questions.

Pre

17

40. Based on the information in the table, which two organisms would you say have the most similar evolutionary history? Explain.

Essay

Gray wolf, and coyote, everything is the same with their family, class, etc.

41. Computers use energy and respond to certain stimuli, such as commands from the user. Why, then, are computers not considered living things?

Computers do not have living cells therefore they are not alive.

Post

40. Based on the information in the table, which two organisms would you say have the most similar evolutionary history? Explain.

The grey wolf and coyote are the closest. They are part of the same kingdom, phylum, class, order, and genus but different species.

Essay (At least 5 sentences)- Make sure you use examples.

41. Computers use energy and respond to certain stimuli, such as commands from the user. Why, then, are computers not considered living things?

Computers are not considered alive for many reasons. It doesn't have the four basic needs of a living thing. It doesn't need food, water, living space, or use homeostasis. Computers do not have living cells. Computers can't reproduce. These are just a few examples.

Figure 4. Student 1: Introduction to Living Things pretest and posttest essay responses.

Essay

Pre

32. What is an endotherm? How do sweating, fur, and feathers affect the body temperatures of endotherms?

2

P

Essay

Post

32. What is an endotherm? How do sweating, fur, and feathers affect the body temperatures of endotherms?

An endotherm is very different from an ectotherm. Endotherms control and regulate internal conditions, while ectotherms change body temperature with the environment. Sweating allows endotherms to cool off when it gets too hot. Fur and feathers keep endotherms warm when it gets cold outside. But ectotherms don't have any of these. There are many differences between endo and ectotherms.

Figure 5. Student 1 Introduction to Animals pretest and posttest essay responses.

Pre

40. Based on the information in the table, which two organisms would you say have the most similar evolutionary history? Explain. *A tiger and that panthera tigris*

## Essay

41. Computers use energy and respond to certain stimuli, such as commands from the user. Why, then, are computers not considered living things?

*No, because they are electrical and have cords*

POST

40. Based on the information in the table, which two organisms would you say have the most similar evolutionary history? Explain.

*The grey wolf and a coyote. They are all the same besides the species.*

## Essay (At least 5 sentences)- Make sure you use examples.

41. Computers use energy and respond to certain stimuli, such as commands from the user. Why, then, are computers not considered living things?

*2 Computers are not living things because they are electrical. Computers only react to stimuli when the user does something. The computer is also not living because when people say "it's dead," they are referring to the battery. It just needs to be charged. The computer is not a living thing because it is electrical and does not have all of the characteristics of a living thing. like what?*

Figure 6. Student 2 Introduction to Living Things pretest and posttest essay responses.

pre

Essay

32. What is an endotherm? How do sweating, fur, and feathers affect the body temperatures of endotherms?

Furs keep endotherms warm, as well as feathers. They effect the body temperature because it keeps them warm so they would have a higher body temperature.

-2

Post

Essay

32. What is an endotherm? How do sweating, fur, and feathers affect the body temperatures of endotherms?

An endotherm has its skeleton on the inside of its body.

When you run or get hot, sweating cools you down by putting out sweat out of the sweat glands. Fur keeps you warm, kind of like a blanket, some blankets are made out of fur. Feathers have a couple purposes, feathers can keep you warm just like fur. But feathers also help birds fly, by having air when the bird is propelling forward, the air goes right under, and over the feathers, like when you put olive oil on your skin and pour water over it, the water will fall right off of your skin.

Figure 7. Student 2 Introduction to Animals pretest and posttest essay responses.

In parallel with my primary question, I also collected data on my subquestion, *Will students be able to connect science inquiry activities more confidently to science content by using writing-to-learn activities?* On the Science Writing Survey, students were asked, “Does writing after a lab activity help you connect what you learn in class to what we did in the activity?” On the Presurvey, 33% of the students stated that writing after the lab did not help them connect what they learned. On the Postsurvey, 78% of the students said writing helped them, 6% of the students said, “kind of”, and 15% of the students said it did not help them. When asked how writing helped them connect the lab to content learned, one student said, “Yes, because then I know why we did the activity and HOW it connects to what we are learning.” A student that answered, “kind of” stated, “It's not really yes, or no. It all depends on the situation the lesson is.” A student who did not feel like writing helped them said, “Why write about what you just did?”

After each lab activity, I used the Post-Inquiry Interview Questions (Appendix G) to interview five girls and five boys. A total of 15 boys and 15 girls were interviewed throughout the intervention. The majority of the students interviewed enjoyed the activities and felt that the activities helped them connect their understanding of content to the activity. Out of the 30 students interviewed, 2% of the students did not feel like writing after the activity helped them connect the content they learned in class to the activity. The rest of the students felt a positive impact on their understanding. What one student said about writing after the lab was, “It made me think more about the lab instead of just saying oh yeah we just did this. It puts it [information learned] back in my brain to process it even more”.

## INTERPRETATION AND CONCLUSION

The analysis of my project data allowed me to claim that write-to-learn activities aide in an increase of conceptual learning. Although there could be other variables that may have affected the results, the quantitative data shows nothing but increases in learning outcomes and the qualitative data indicates positive student feelings. The medians of all three posttests increased for each test. There was a 14% increase in the medians from the Introduction to Living Things Posttest to the Introduction to Animals Posttest. The largest increase in the median occurred from the Viruses, Bacteria, Protists, and Fungi Posttest to the Introduction to Animals Posttest, which was a 13% increase. Write-to-learn activities were being used during these chapters, which indicates they helped students learn the content for these two tests.

The Introduction to Animal's Posttest had the highest median overall, which I think could be due to a couple of reasons. During this chapter, students knew my expectations for the write-to-learn activities since we had been doing them for at least a month before we started the Introduction to Animals. Students' writing was noticeably more detailed from the Viruses, Bacteria, Protists, and Fungi chapter to the Introduction to Animals chapter. I measured this based on the amount of writing students did. On average, students wrote one or two sentences to answer a question in write-to-learn activities during the Viruses, Bacteria, Protists, and Fungi chapter. By the end of the intervention, students on average wrote three or more sentences during the activities. The amount of writing also depended on what writing activity they were doing. I also compared the answers to their Pretest and Posttest essay questions. Again, on average students wrote a sentence or two in the Pretest

essay question and wrote at least five sentences in their Posttest essay question. I think doing writing activities contributed to the increase in detail along with understanding and learning the content. On the Post-Intervention Interview, the students were asked if they felt like they became better writers after doing the activities. Out of the 15 students, 87% of the students said they felt like they became better writers. One interviewee said, “Yes because I give more detail and say what we learned.” I also think the content taught about animals was more intriguing to students than the previous chapters which were about what is life, viruses, bacteria, protists, and fungi. The Introduction to Animal’s Pretest median was slightly higher than the Introduction to Living Things chapter and Viruses, Bacteria, Protists, and Fungi chapter Pretests, which could be because they had more previous knowledge on animals.

As write-to-learn activities were incorporated and students used them more often, students felt like this helped them remember content better. Out of the 15 students interviewed at the end of the intervention, 93% of them said that they found it helpful to write down ideas and concepts after they learned them. One student said, “yes, because it helps you remember what you learned and you can look at it when you need to know something.”

My sub-question was also supported by valuable qualitative data. Students felt strongly that writing reflections after a lab on how the lab connected to what they were learning in class was helpful. Out of 15 students, 86% expressed in the Post-Intervention Interview that they felt like the lab activities helped them connect what they were learning in class. Those students also felt like the writing activities helped them connect the lab to

content learned in class. One student said they were able to connect what they learned in class with the lab, “because the labs made more understandable because visual activities help me learn easier.” The same student said writing activities helped them with connections because, “[writing activities] made it even easier to understand and remember.”

### VALUE

The construction and implementation of this project has had an impact on me as a teacher and on the students involved. I always knew that writing played a crucial role in the learning process, but I never saw it as something that needed to be high on the priority list until this project. The students in this study experienced the benefits writing provides them in the learning process. They realized how important it is to help them remember and understand information. This realization was stated by many students in the interviews and post science survey.

This project has changed me as a teacher by giving me more experience with writing in science and realizing the importance. I gained knowledge about action research in the classroom and it brought me enthusiasm to continue doing more research projects such as this one. The project taught me that testing out different ways to improve yourself as a teacher can be difficult but rewarding at the same time. I was lucky enough that this project showed me positive results and that I need to continue to use write-to-learn activities in my lesson plans. I also realized that if my results weren't what I was hoping for they would also be beneficial to my improvement as a teacher.

After observing the impact writing has on conceptual learning, I will continue to implement write-to-learn activities. I would like to continue collecting data to see if test

scores continued to increase and if student writing would progress. Along with the seven write-to-learn activities listed in Table 2, I would like to research and incorporate more write-to-learn activities. I want these activities to allow students to use deeper understanding. I would start with simpler write-to-learn activities at the beginning of the year and progress into having students use higher order thinking skills in their writing as they make improvements. I think students would gain incredible understanding and scientific knowledge throughout the year.

Another way I would like to further this project is to see how big of an impact using science notebooks play in this process. Students used notebooks throughout the entire project, but I would like to focus on the correlation between writing in science notebooks and student progress both intellectually and their opinion about how using the notebooks helped them.

Overall, this project has given me great insight on writing in science and a new way to incorporate writing in science classrooms. I felt students enjoyed these quick write-to-learn activities. They were able to realize whether they understood the information or not by how easy or hard it was to complete the writing activity, which aided in their conceptual change. I feel the outcome of this project was a success for me as a teacher as well as the students.

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APPENDICES

APPENDIX A  
IRB APPROVAL



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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Montana State University
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MEMORANDUM

TO: Jenna Noble and John Graves

FROM: Mark Quinn [Handwritten signature]

DATE: September 6, 2016

RE: "Increase of Conceptual Change in Science through Writing" [JN090616-EX]

The above research, described in your submission of September 6, 2016, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- X (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
X (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
(b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
(b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
(b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
(b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B  
SCIENCE WRITING SURVEY

## SCIENCE WRITING SURVEY

\*This survey is completely voluntary and in no way will affect your grade in this class or student standing. \*

1. Do you enjoy writing?      Yes    No
2. What is a reflection?
  
3. Will writing help you learn science?      Yes    No
4. Explain why you chose your answer in question 3.
  
5. Is writing used in science?    Yes    No
6. If you answered **YES** to question 5, explain how.
  
7. Which write-to-learn activity/s help you learn science the most?

**Circle all that apply**

- |                                |                         |
|--------------------------------|-------------------------|
| a. Idea Exchange               | e. Writing Definitions  |
| b. Concept Map                 | f. Prompt Writing       |
| c. Journal Writing in Notebook | g. Exit Slip or closing |
| d. Observation Report          | h. Prompt Writing       |

8. Does writing after a lab help you connect what you learn in class to what we did in the lab?

Yes    No

9. Explain why you chose your answer in question 8.

APPENDIX C  
POST-INQUIRY PROMPT QUESTIONS



APPENDIX D  
POST-INQUIRY INTERVIEW QUESTIONS

1. What was this lab about?
2. How did this lab connect to what we are learning in science class?
3. What were you confused about in this lab?
4. Did this lab help you understand what we are learning in science?
5. Do you have any questions about how the content in class relates to this lab?
6. How did writing after the lab help you connect what we learned in class to this lab?
7. Do you have anything you want to comment about?

APPENDIX E

VIRUSES, BACTERIA, PROTISTS, AND FUNGI PRETEST AND POSTTEST

## Chapter 2 Viruses, Bacteria, Protists, Fungi

### Multiple Choice

*Identify the choice that best completes the statement or answers the question.*

1. The genetic material of a virus is found in its
  - a. coat.
  - b. core.
  - c. coat and core.
  - d. nucleus.
2. A virus's proteins are important because they
  - a. contain genetic material.
  - b. make new virus particles.
  - c. provide energy for the virus.
  - d. help the virus attach to its host.
3. Which shape describes some bacterial cells?
  - a. cube-shaped
  - b. bullet-shaped
  - c. spiral
  - d. robotlike
4. What process results in genetically different bacteria?
  - a. binary fission
  - b. respiration
  - c. conjugation
  - d. asexual reproduction
5. Viruses are considered to be nonliving because they
  - a. cannot multiply.
  - b. use energy to grow.
  - c. are smaller than bacteria.
  - d. do not show all the characteristics of life.
6. What characteristic do all algae share?
  - a. They are autotrophs.
  - b. They are unicellular.
  - c. They are multicellular.
  - d. They live in colonies.
7. Like animals, animal-like protists are
  - a. autotrophs.
  - b. heterotrophs.
  - c. unicellular.
  - d. prokaryotes.

8. Club fungi are named for
  - a. their food source.
  - b. their movement.
  - c. where they live.
  - d. the appearance of their reproductive structures.
9. How are fungus-like protists similar to fungi?
  - a. They are unable to move.
  - b. They are autotrophs.
  - c. They use spores to reproduce.
  - d. They do not have cell walls.
10. What characteristic of viruses makes them useful in gene therapy?
  - a. their ability to enter cells
  - b. their ability to remain inactive for a long time
  - c. their inability to multiply in cells
  - d. their inability to take over the functions of host cells
11. Binary fission is the bacterial process of
  - a. asexual reproduction.
  - b. obtaining food.
  - c. producing energy.
  - d. forming endospores.
12. Which structures allow sarcodines such as amoebas to move?
  - a. cilia
  - b. contractile vacuoles
  - c. flagella
  - d. pseudopods
13. What bacteria-killing fungus did Fleming isolate in his 1928 experiment?
  - a. ringworm
  - b. corn smut
  - c. wheat rust
  - d. *Penicillium*
14. Heterotrophic bacteria obtain food by
  - a. capturing the sun's energy.
  - b. using the energy from chemicals in their environment.
  - c. consuming autotrophs and other heterotrophs.
  - d. helping autotrophs make food.

**Modified True/False**

*Indicate whether the statement is true or false. If false, change the identified word or phrase to make the statement true.*

15. Binary fission occurs when a bacterium transfers some of its genetic material to another bacterium. \_\_\_\_\_

16. One reason that viruses are considered to be nonliving is that they are not made of proteins.

17. All fungi are autotrophs. \_\_\_\_\_

18. Fungi absorb food through hyphae that grow into a food source. \_\_\_\_\_

19. Animal-like protists are commonly called algae. \_\_\_\_\_

### **Completion**

*Complete each statement.*

20. Bacteria are called \_\_\_\_\_ because their genetic material is not contained in nuclei.

21. A virus's \_\_\_\_\_ contains the instructions for making new viruses.

22. Autotrophic bacteria either use the sun's energy to make food or break down \_\_\_\_\_ in their environment.

23. In \_\_\_\_\_ reproduction in fungi, the hyphae of two organisms join, exchange genetic material, and then produce spores.

24. All fungus-like protists are able to \_\_\_\_\_ at some point in their lives.

25. A virus can multiply only when it is inside a living \_\_\_\_\_.

26. The shape of the \_\_\_\_\_ on a virus's coat allows the virus to attach to certain cells.

27. Bacterial cells contain structures called \_\_\_\_\_, which are chemical factories where proteins are produced.

28. Some bacteria move by using a long, whip-like structure called a(n) \_\_\_\_\_.

29. Fungi break down food by releasing \_\_\_\_\_ from the tips of their hyphae.

30. The bodies of multicellular fungi are made up of branching, threadlike tubes called \_\_\_\_\_.

31. The fungus *Penicillium* produces a(n) \_\_\_\_\_ that saves peoples' lives by

killing bacteria.

32. Wine is made by allowing yeast cells to turn the sugar in grapes into carbon dioxide and

\_\_\_\_\_.

33. Dinoflagellates and diatoms are examples of plantlike protists, which are commonly called

\_\_\_\_\_.

34. An amoeba moves and feeds by forming temporary bulges of the cell membrane called

\_\_\_\_\_.

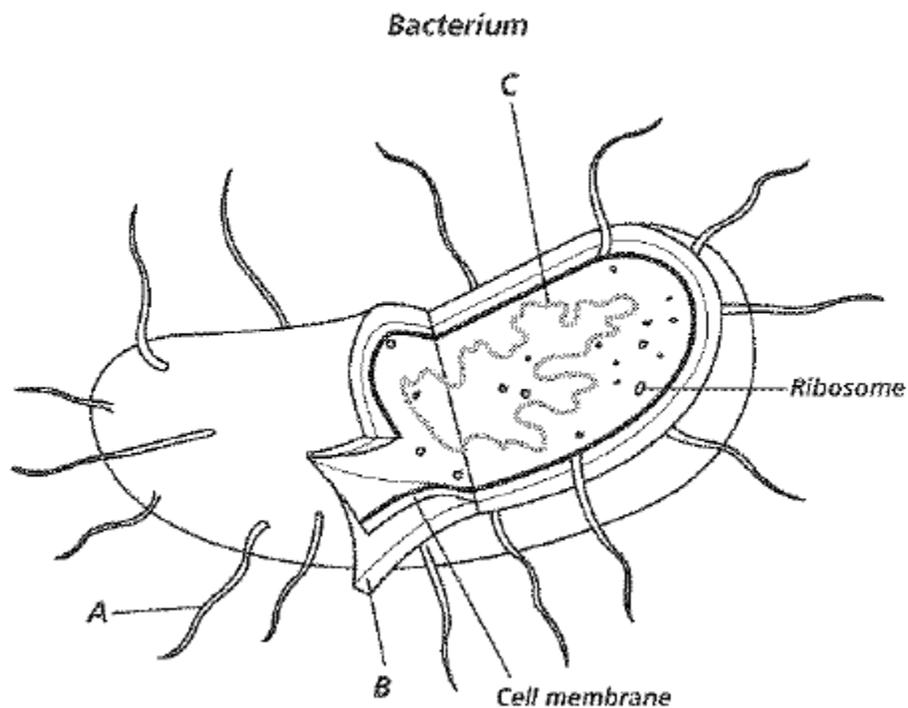
35. Fungi that break down the chemicals of living host organisms are examples of

\_\_\_\_\_.

36. The antibiotic \_\_\_\_\_ resulted from the work of Alexander Fleming, who

noticed that bacteria did not grow near a spot of mold in a petri dish.

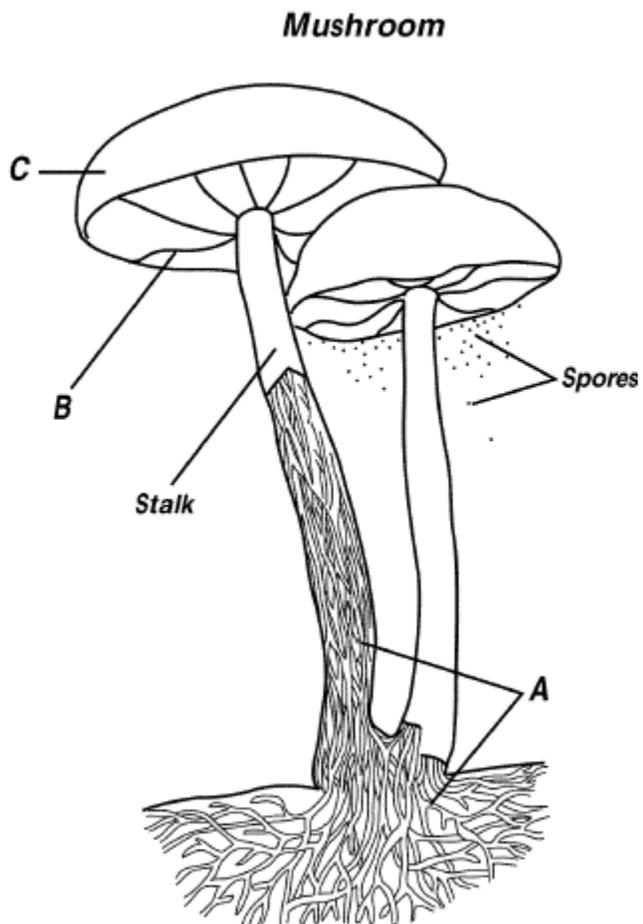
**Short Answer (At Least 2 Sentences)**



37. Describe the function of the ribosomes in a bacterium.

38. How does the diagram show that bacterial cells are different from the cells of eukaryotes?

39. If the bacterium shown in the diagram had almost completed binary fission, how would you expect the cell to look? Explain your answer.



40. List two ways that the organism in the diagram can be helpful to humans.

1.

2.

**Essay (At Least 5 Sentences)**

41. Why is it a good idea to wash your hands after you shake hands with people who have colds?

**Bonus Question**

Describe how a vaccine works and prevents you from getting a virus.

APPENDIX F

INTRODUCTION TO ANIMALS PRETEST AND POSTTEST

Name: \_\_\_\_\_ Period: \_\_\_\_\_

### Chapter 3 Introduction to Animals

#### Multiple Choice

*Identify the choice that best completes the statement or answers the question.*

1. Major functions of animals include obtaining food and oxygen, keeping internal conditions stable, movement, and
  - a. adaptation.
  - b. reproduction.
  - c. classification.
  - d. fertilization.
2. An animal that has a backbone is called a(n)
  - a. cnidarian.
  - b. predator.
  - c. vertebrate.
  - d. invertebrate.
3. Which of the following is a characteristic shared by all animals?
  - a. Their bodies have many cells.
  - b. They eat plants.
  - c. They reproduce asexually.
  - d. They have skeletons.
4. Which of these animals has radial symmetry?
  - a. a sea anemone
  - b. a butterfly
  - c. a rabbit
  - d. a fish
5. What does the backbone surround and protect in a vertebrate?
  - a. the heart and lungs
  - b. vertebrae
  - c. the spinal cord
  - d. the gill slits
6. When the temperature of the environment changes, the body temperature of a reptile
  - a. changes.
  - b. stays the same.
  - c. always increases.
  - d. always decreases.
7. What is a characteristic of many invertebrate groups?
  - a. gills
  - b. feathers
  - c. spinal cord
  - d. exoskeleton

8. At some point in their lives, all chordates have a flexible supporting rod in their backs called a
- notochord.
  - gill.
  - nerve cord.
  - backbone.
9. If an animal is an ectotherm, it has
- a skeleton on the outside of its body.
  - a skeleton on the inside of its body.
  - a body that regulates its own internal temperature.
  - a body that does not produce much internal heat.
10. An animal has bilateral symmetry if
- no lines can be drawn to divide the animal into halves that are mirror images.
  - many lines can be drawn to divide the animal into halves that are mirror images.
  - one line can be drawn to divide the animal into halves that are mirror images.
  - any line through the center of the animal divides it into halves that are mirror images.
11. Which of the following is a characteristic of animals with radial symmetry?
- They have no distinct head or tail ends.
  - They must move quickly to catch prey.
  - They move faster on land than in water.
  - They have sense organs at the front of their bodies.
12. Most members of the phylum Chordata have
- radial symmetry.
  - backbones.
  - exoskeletons.
  - feathers.
13. An animal whose body temperature does not change much, even when the temperature of the environment changes, is called
- a temperature regulator.
  - a cold-blooded animal.
  - an endotherm.
  - an ectotherm.

**Modified True/False**

*Indicate whether the statement is true or false. If false, change the identified word or phrase to make the statement true.*

14. Most animals are invertebrates. \_\_\_\_\_
15. A type of worm with many linked sections is a flatworm. \_\_\_\_\_
16. Animals must maintain a stable environment within their bodies to survive.  
\_\_\_\_\_

17. If only one line can divide an object into mirror-image halves, the object is said to have radial symmetry. \_\_\_\_\_

### Completion

*Complete each statement.*

18. Animals in the mammal group called \_\_\_\_\_ allow their young to develop in a pouch on their mother's body.

19. Mammals and \_\_\_\_\_ are the two groups of vertebrates that are endotherms.

20. Classifying animals involves comparing their \_\_\_\_\_, a chemical that controls an organism's inherited characteristics.

21. An animal may have radial symmetry, bilateral symmetry, or \_\_\_\_\_ symmetry.

22. Tissues combine to form a(n) \_\_\_\_\_ that performs a specific job for an organism.

23. Jellyfishes are examples of animals with \_\_\_\_\_ symmetry.

24. \_\_\_\_\_ is the group of invertebrates that take food into a central body cavity.

25. Mammals that lay eggs are called \_\_\_\_\_.

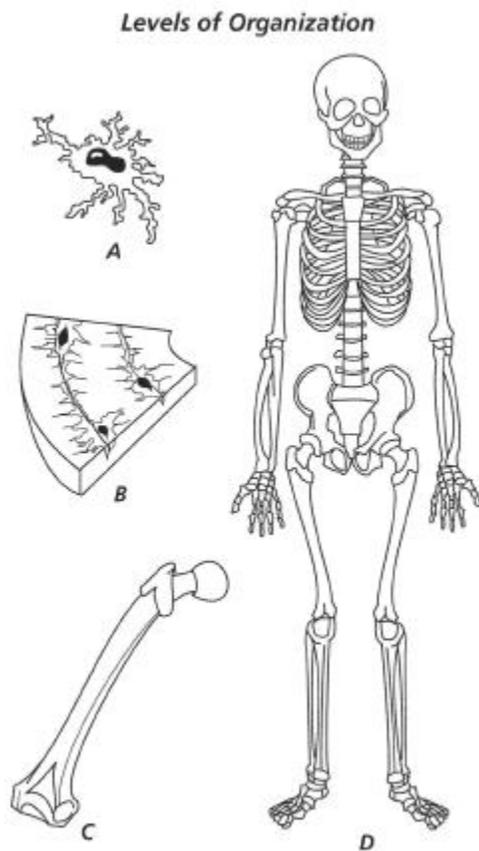
### Short Answer

<i>Animal A</i>	<i>Animal B</i>	<i>Animal C</i>
Cannot fly	Can fly	Can fly
Lays eggs	Lays eggs	Does not lay eggs
Has a four-chambered heart	Has feathers	Has hair
Has webbed feet	Has webbed feet	Has webbed fingers
Has a bill	Has a bill	Has teeth

26. Is animal B a bird or a mammal? Explain your reasoning.

27. In which of the animals in the table do the females produce milk?

28. Decide whether mammal A is a monotreme, a marsupial, or a placental mammal. Explain your reasoning.



29. What level of organization is represented by A? What is the relationship between that level and the level represented by B?

30. Structure C is a thighbone. Identify and define the level of organization represented by C.

31. Identify and define the level of organization represented by structure D.

**Essay**

32. What is an endotherm? How do sweating, fur, and feathers affect the body temperatures of endotherm

APPENDIX G

INTRODUCTION TO LIVING THINGS PRETEST AND POSTTEST

## Chapter 1 Test

### Multiple Choice

*Identify the choice that best completes the statement or answers the question.*

1. One characteristic used to place organisms into kingdoms is
  - a. how they move.
  - b. where they live.
  - c. their ability to make food.
  - d. their ability to reproduce.
2. Which group of organisms includes only multicellular heterotrophs?
  - a. protists
  - b. bacteria
  - c. plants
  - d. animals
3. Which is the broadest classification level?
  - a. family
  - b. domain
  - c. phylum
  - d. species
4. What is one way in which scientists get information about the evolutionary history of species?
  - a. by comparing organisms' body structures
  - b. by observing where organisms live
  - c. by observing what organisms eat
  - d. by studying how organisms move
5. An organism's scientific name consists of
  - a. its class name and its family name.
  - b. its kingdom name and its phylum name.
  - c. its genus name and its species name.
  - d. its phylum name and its species name.
6. A plant grows toward the light. The plant's action is an example of
  - a. reproduction.
  - b. a response.
  - c. a stimulus.
  - d. development.
7. Spontaneous generation is a mistaken idea because living things
  - a. exhibit binomial nomenclature.
  - b. are produced only by living things.
  - c. do not reproduce.
  - d. maintain homeostasis.

8. What contribution of Charles Darwin had a major impact on classification?
  - a. binomial nomenclature
  - b. taxonomy
  - c. seven levels of classification
  - d. his theory of evolution
9. Which kingdoms include both unicellular and multicellular organisms?
  - a. fungi and plants
  - b. fungi and protists
  - c. protists and animals
  - d. protists and plants
10. The experiments of Redi and Pasteur helped to demonstrate that
  - a. species gradually change over time.
  - b. living things do not arise from nonliving material.
  - c. organisms can be placed in groups based on their similarities.
  - d. the chemicals of life could have arisen on early Earth.
11. Which is the most abundant chemical found in living cells?
  - a. water
  - b. carbohydrates
  - c. proteins
  - d. nucleic acids
12. The more classification levels that two organisms share,
  - a. the closer together on Earth they live.
  - b. the easier it is to tell them apart.
  - c. the more characteristics they have in common.
  - d. the more distantly related they are.
13. Which classification level is broader than the kingdom level?
  - a. order
  - b. class
  - c. family
  - d. domain
14. Taxonomic keys can be used to help determine the
  - a. size of organisms.
  - b. needs of organisms.
  - c. identity of organisms.
  - d. behavior of organisms.
15. Which domain(s) include(s) only prokaryotes?
  - a. Bacteria and Archaea
  - b. Bacteria only
  - c. Archaea only
  - d. Eukarya only
16. The gradual change in species over time is called
  - a. adaptation.
  - b. natural selection.

- c. evolution.
- d. classification.

**Modified True/False**

*Indicate whether the statement is true or false. If false, change the identified word or phrase to make the statement true.*

- \_\_\_\_\_ 17. A horse is a(n) heterotroph. \_\_\_\_\_
18. The scientific study of how organisms are classified is called binomial nomenclature.  
\_\_\_\_\_
- \_\_\_\_\_ 19. Alligators and crocodiles are classified in the same order and therefore probably have  
different evolutionary histories. \_\_\_\_\_
- \_\_\_\_\_ 20. Mushrooms, molds, and mildew are members of the fungi kingdom. \_\_\_\_\_
- \_\_\_\_\_ 21. Archaea and Bacteria are two domains of eukaryotes. \_\_\_\_\_

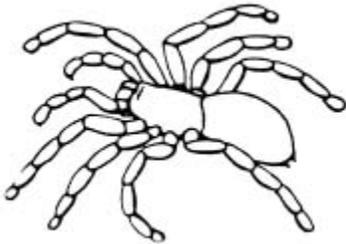
**Completion**

*Complete each statement.*

22. Organisms that make their own food are called \_\_\_\_\_.
23. A(n) \_\_\_\_\_ consists of paired statements about the characteristics of different organisms.
24. The bones in the wing of a bat are similar to the bones in the flipper of a whale. This information suggests that bats and whales have a similar \_\_\_\_\_ history.
25. The first word in an organism's scientific name is its \_\_\_\_\_.
26. \_\_\_\_\_ developed a naming system that grouped organisms on the basis of their observable features.
27. A(n) \_\_\_\_\_ organism is a living thing that is composed of many cells.
28. An organism's ability to maintain stable internal conditions despite changes in its surroundings is called \_\_\_\_\_.

29. Biologists find \_\_\_\_\_ useful because this scientific study gives them much information about an organism based on its classification.
30. In the modern classification system used by biologists, the broadest level of organization is called a(n) \_\_\_\_\_.
31. Each genus of organisms contains one or more \_\_\_\_\_.
32. Archaea are not classified with \_\_\_\_\_, the other prokaryote domain, because they have different chemical makeups.
33. The modern system of classification is based on the theory of \_\_\_\_\_, which was first proposed by Charles Darwin.
34. The \_\_\_\_\_ kingdom is the only kingdom of eukaryotes that contains both autotrophs and heterotrophs and both unicellular and multicellular organisms.

**Short Answer (At least 2 Sentences)**



35. What information would you need about this organism to help you classify it into a kingdom and domain?
36. Suppose you are using a taxonomic key to identify this organism. What are some physical characteristics of the organism you would need to examine?

37. Which of the organisms in the table is least similar to the others? Explain.

Table of Classification Labels					
Classification Level	Aardwolf	Grey Wolf	Coyote	Lion	Blue Whale
Kingdom	Animalia	Animalia	Animalia	Animalia	Animalia
Phylum	Chordata	Chordata	Chordata	Chordata	Chordata
Class	Mammalia	Mammalia	Mammalia	Mammalia	Mammalia
Order	Carnivora	Carnivora	Carnivora	Carnivora	Cetacea
Family	Hyaenidae	Canidae	Canidae	Felidae	Balaenopteridae
Genus	<i>Proteles</i>	<i>Canis</i>	<i>Canis</i>	<i>Panthera</i>	<i>Balaenoptera</i>
Species	<i>Proteles cristatus</i>	<i>Canis lupus</i>	<i>Canis latrans</i>	<i>Panthera leo</i>	<i>Balaenoptera musculus</i>

38. In what two ways are the organisms in the table similar to organisms in the plant kingdom?

39. Which of the organisms in the table is (are) most similar to a tiger (*Panthera tigris*)? Explain.

40. Based on the information in the table, which two organisms would you say have the most similar evolutionary history? Explain.

**Essay (At least 5 sentences)- Make sure you use examples.**

41. Computers use energy and respond to certain stimuli, such as commands from the user. Why, then, are computers not considered living things?

APPENDIX H  
POST-INTERVENTION INTERVIEW QUESTION

Interview Questions

1. How have we used writing in science class?
2. Did you find it helpful to write ideas and concepts down after you learned them? Why?
3. Were the writing activities easy or hard for you to do? Why?
4. Do you feel like you became better at writing as we practiced more? Explain.
5. Were you able to connect your writing to what you learned in class? Explain.
6. Were you able to connect what we learned in class with the labs we did? Explain.
7. If yes in number 6, do you feel like the writing activities helped you with this connection?