

DOES A MIXED APPROACH TO VOCABULARY INSTRUCTION INCREASE  
STUDENT COMPREHENSION IN SEVENTH GRADE LIFE SCIENCE?

by

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## ABSTRACT

In this investigation a mixed approach to vocabulary instruction was implemented within a seventh grade life science classroom. This mixed approach included semantic mapping of unit vocabulary words, morphology and textbook reading strategy lessons, which were utilized instead of my standard curriculum. The results showed no statistical difference in the median of any of the data collection instruments from pre to post-test or between treatment and non-treatment groups. The treatment increased student comprehension of the unit concepts, but no more than the standard curriculum.

## INTRODUCTION AND BACKGROUND

I am a teacher at Sauk Rapids Rice Middle School in Sauk Rapids, Minnesota. The school consists of sixth, seventh and eighth grades. There are 296 seventh graders at our school. I teach 151 of these students within four classes of life science. Our school follows a middle school model in which students have four core classes and one allied arts class every day. Students share their classes with the same team of students who also share the same teachers. Throughout their three years, students are instructed in physical science and basic chemistry in sixth grade, life science in seventh grade, and earth science in eighth grade.

The student population mainly consists of white students from middle class families. Many students live in rural areas around the city. In the past few years there has been a small but steady influx of minority students of African American, Somali, and Latino descent (Karen McNeal, personal communication, September 27, 2011). Even with a somewhat ethnically homogenous population, I find that my students vary greatly in their ability levels. Within my large classes of 38 students there are often huge disparities in reading and comprehension levels.

The biology content I am required to teach to seventh graders contains the basic concepts of cell functions and processes, genetics, evolution, and ecology that they will then be built upon in biology class during their sophomore year. In my last four years of teaching the same units and concepts, I have come to realize that there is indeed a “language of science.” In order to understand the overall concepts being presented, I also realized my students needed to have a highly developed understanding of related vocabulary. This was especially apparent to me as I taught a genetics unit last year. In

order to know how to complete a Punnett square and interpret the genetic information that it contained, students needed to understand and recall four academic, content specific vocabulary words: homozygous, heterozygous, phenotype and genotype. On the final unit test, I found there was a positive correlation between vocabulary comprehension and concept comprehension. If students knew the vocabulary, overall they did well on the unit test. The opposite was true if they did not have a firm grasp of the vocabulary.

From this experience I realized how essential vocabulary acquisition is to science. As I examined my techniques for teaching and learning vocabulary, I saw that there could be improvements to my current teaching strategies. Students are assigned textbook readings and questions based on each unit. Students have told me that this is very hard because many of the words are too technical or difficult for them to understand. Along with this, students are given a vocabulary sheet, in which they need to write the definition of the word taken from the textbook glossary, and draw and color a picture that somehow shows the word's meaning. However, I still do not feel that this is enough to give my students a full understanding of the words and concepts. I knew that I needed to develop and implement a more direct, research based vocabulary program within my life science classroom.

My focus question for this study was, does a mixed approach to vocabulary instruction increase student comprehension in seventh grade life science? This mixed approach included semantic mapping of unit vocabulary words, morphology and textbook reading strategy lessons instead of my standard curriculum. I also developed three sub-questions: will this help students to develop strategies to use when confronted with an unknown word in science texts; will this increase comprehension of academic, content

specific, conceptual vocabulary; is the treatment more effective than the non-treatment in learning the unit vocabulary and concepts?

### CONCEPTUAL FRAMEWORK

There are basic structures to spoken and written words that children become familiar with at a young age. Spoken sounds called phonemes make up syllables, which then make up words. A basic unit of meaning in a word is referred to as a morpheme (Graves, Juel, Graves & Dewitz, 2011). For example in the word *hats*, *hat* is a morpheme meaning an article of clothing worn on one's head, and *-s* is also a morpheme meaning more than one. Any morpheme that is not a word by itself is called an affix. Affixes are divided into prefixes, which are put at the beginning of words, and suffixes, which are put at the end (Graves et al., 2011). Young children first understand simple suffixes like *-s* and *-ed* and by the end of elementary school students gain a larger knowledge of more complicated affixes. Understanding word structure and having a morphological awareness can help students be successful in understanding new vocabulary (Kieffer, 2007). Longer multisyllabic words are broken into syllables and phonemes in order for the reader to pronounce them. These same words can also be broken into morphemes in order to give clues to their meaning (Bromley, 2007). The vocabulary used in science is often multisyllabic and polymorphic in nature.

Various types of vocabulary are used and understood by children. As young children learn to talk, they develop a listening/speaking vocabulary. These are the words people need to understand when listening to others and the words people learn to say (Young, 2005; Bromley, 2007). As children begin school, they develop a reading/writing

vocabulary, which is used to understand and express written thoughts in text. In the upper elementary grades, a core academic vocabulary begins to develop. These are words that do not regularly occur in conversation and are heard and read in more formal settings as well as in educational content areas like math, social studies or science (Templeton, Bear, Invernizzi, Johnston, 2010). These words are often completely new or they are more precise labels for already known vocabulary. Vocabulary developed in one specific content area is referred to as content specific academic vocabulary. New words in science are specific to each discipline and are often descriptions for entirely new concepts (Armbruster, 1992). An ability to understand academic, content specific vocabulary in science is often an indicator of how well students will comprehend science based texts and key concepts (Young, 2005).

Specific, targeted vocabulary instruction in content areas, however, has not always been effective in the past. An analysis of 14 different studies found that vocabulary instruction does not always increase comprehension of written texts (Graves, 1986). One such method uses dictionaries, or glossaries to simply look up definitions to new words. This method used on its own is not a dependable way to increase comprehension (Nagy, 1988). The reasons for this include that definitions taken from a dictionary are not always accurate, can be confusing, and do not always contain enough information for a person to understand the concept the word represents. While using a dictionary to learn a word's meaning can be one of many useful strategies in effective vocabulary instruction, it does not yield positive results on its own, nor does it foster positive attitudes toward learning new vocabulary (Nagy, 1988).

Another vocabulary learning strategy that has yet to be proven highly effective is

the use of context in determining word meanings. Many variables exist in being able to determine a word's meaning from context, including previous exposure to the word, the density of unknown words and the importance of the unknown word in understanding the surrounding text (Graves, 1986). The use of context clues was most useful when the unknown word was a synonym for an already known word, or when an unknown noun was described with adjectives within a passage. It has been found that using context clues by themselves have not helped students to understand conceptual vocabulary that they had no prior knowledge of because the text is often too limited (Graves, 1986; Beck, McKeown & Kucan, 2002). Because scientific vocabulary is conceptual in its nature, the use of dictionaries or context clues on their own are unlikely to increase comprehension, and would not be deemed as effective instruction. However, when used with an array of other word learning strategies, students can begin to build their own cognitive processes for deciphering new word meanings (Kieffer, 2007).

A teacher's curiosity about and appreciation for new words and their meanings can rub off on students (Bromley, 2007). Creating a culture of words can influence students' opinions and make learning new vocabulary a positive educational experience (Graves et al., 2011). Reading out loud is one of the most effective ways to expose students to new words and discuss the definitions of new words in a meaningful way (Graves et al., 2011; Bloodgood & Pacifici, 2004). Other ways to promote a culture of words within the classroom include sharing the discovery of new words and meanings, promoting the use of rhymes and puns, playing word games, and encouraging proper dictation (Graves et al., 2011). These incidental or less formal approaches to vocabulary instruction combined with a more systematic or direct approach can ultimately lead

students to more independent word learning (Gunning, 2010).

Effective vocabulary instruction uses a mixed approach to understanding new words. This term *mixed approach* means giving students multiple exposures to different types of direct vocabulary instruction and the results of numerous studies showed that providing a mixed approach or different vocabulary lessons or activities, increased student comprehension more than one or two exposures of the same type of instruction (Graves, 1986; Gunning, 2010). Having at least three exposures to a word including seeing it displayed in the room, manipulating the word and hearing it used in various contexts is also required in order to improve comprehension (Gunning, 2010). It is also recommended that these multiple exposures vocabulary occur before, during and after a unit of study, as well as while reading texts within that unit (Templeton et al., 2010).

Within a month long unit in science there can be dozens of new vocabulary words taught. Within a specific area of study or science unit there can be as many as 20 new words that students may not recognize. A maximum of seven new vocabulary words should be introduced to students at a time (Gunning, 2010). Along with these new terms there is often prerequisite conceptual vocabulary that must be understood. For example, in order to teach about autotrophs and heterotrophs, students must have a basic understanding of food and energy. It is also important to address any misconceptions there may be about the concept behind the new vocabulary. While this may postpone the initial unit lessons, it will build the background knowledge necessary to move forward and correctly introduce new topics (Armbruster, 1992).

In order to create an understanding of a word, new vocabulary must be related to student's everyday lives (Gunning, 2010). Especially in terms of new content specific

vocabulary, lessons on vocabulary need to activate students' background or prior knowledge of a concept (Bromley, 2007; Templeton et al., 2010; Gunning, 2010; Young, 2005). In science, vocabulary words are rarely associated with previously known concepts or words, and in order for a student to really understand the vocabulary, it must be related to something within the students known vocabulary and then built into its own independent concept (Armbruster, 1992). For instance, when introducing the concept of heredity, a teacher could discuss the physical features that students share with their parents and other relatives. This connects the new conceptual content specific vocabulary word heredity with an idea that students have known for a long time; they look like their parents.

Understanding conceptual vocabulary requires instruction that leads students into a deeper level of processing and understanding (Gunning, 2010). This is referred to as semantic knowledge. As one learns new words, these words are categorized into hierarchical arrangements within the brain (Templeton et al., 2010). New concepts can be taught by relating that which is previously known to that which is unknown. Simple definitions as well as in-depth explanations possibly using visual diagrams and models should also be provided. Teachers can also give examples and non-examples in order to identify the parameters the new concept (Graves et al., 2011; Young 2005). While teaching semantic knowledge can take a great deal of time to prepare and teach, it does provide thorough and effective introduction to new content specific vocabulary (Graves, 1986).

Semantic mapping is a way of organizing words into groups based on their conceptual meanings and using brainstorming techniques and graphic organizers to

understand words and their relationships with other vocabulary. The steps of semantic mapping include brainstorming, categorizing, labeling, and then arranging the terms graphically (Gunning, 2010). Semantic maps are especially useful in science as they go beyond simple definitions and focus on the relationships among the concepts. Semantic feature analysis and definition maps have been recognized for increasing concept comprehension in science (Armbruster, 1992; Nagy, 1996; Templeton et al., 2010; Young, 2005). Templeton and colleagues also recommend concept maps, concept sorts, Venn diagrams, and vocabulary notebooks as useful strategies for academic science vocabulary instruction (2010).

Having the ability to break a word into pieces and build meaning from these word parts is known as having morphological knowledge or awareness. This is a specific word learning strategy that students can use when they are presented with an unknown word while reading. The meanings of as many as 60% of multisyllabic words can be determined by analyzing the roots and affixes of words (Nagy & Scott, 2003). Students with greater morphological knowledge have higher reading comprehension scores (Kieffer, 2007; Graves, 1986). Struggling readers can also benefit from breaking words into syllables orally in order to recognize them when found within science texts or on multiple-choice tests (Bhattacharya, 2006). When teaching students how to apply their morphological awareness, it is advised to teach a sequence of prefixes, suffixes, and Latin and Greek roots that are found across content areas. Using familiar base words, students can build a general morphological knowledge and through guided practice apply this knowledge, which can be a strategy employed when confronted with unknown words (Templeton et al., 2010; Kieffer, 2007).

## METHODOLOGY

The purpose of this study was to determine how a mixed approach to vocabulary instruction, including semantic mapping of unit vocabulary words, morphology and textbook reading strategy lessons, affects student's comprehension in seventh grade life science. The research was implemented over two units of study in a six-week period. The intervention was given to two of my four seventh grade life science classes during the first unit. The content of this unit included mitosis, meiosis, asexual reproduction, and sexual reproduction. The second unit of treatment included Mendelian genetics. During this unit the two classes that had not received the treatment during the last unit were given the intervention and the two classes that had received the treatment became the non-treatment group. In this way, all students received the same treatment/non-treatment exposure, though in different units.

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. Sauk Rapids Rice Middle School Principal Larry Stracke approved the research project without the need for parental consent (Appendix A).

Based on my own preliminary research, and after discussions with language arts teachers, I chose to implement a treatment based on a mixed approach to vocabulary instruction using a mix of three different instructional strategies. The first strategy included lessons on the different ways to find the meaning of unknown words when reading a science based text or textbook. These included examining context clues, section headings, pictures or diagrams, breaking the words into morphemes, using the glossary, and asking an adult or peer. After explaining and demonstrating these

strategies, students were assigned to read the chapter out of the textbook related to the current unit. As students read independently, they were able to keep an inventory of the words they did not understand, as well as when they used the strategies described in the Textbook Reading Checklist (Appendix B).

The second strategy was to implement instruction on basic morphological word structure, with emphasis on commonly used prefixes and suffixes within the unit vocabulary. At the beginning of each class period, students would enter the classroom, write down two prefixes or suffixes in their notebook and guess their meanings. Once every student had guessed, I would use the interactive whiteboard to show the prefixes or suffixes, their meanings, and an example of a word containing the specific morpheme. Students were taught a total of 20 morphemes. As a review, at the end of the unit students incorporated the prefixes and suffixes into their unit study guide and played bingo using the morphemes and unit vocabulary.

The third strategy was introduced after students were taught the major concepts of the unit and had completed the unit vocabulary worksheets. Students were then introduced to semantic mapping. I described semantic mapping as a way of grouping and categorizing vocabulary in order to better understand their meanings and relationships to each other. The whole class then worked together to create semantic maps on the interactive whiteboard, first using a list of common foods and then using a list of cell organelles and processes. When I felt students had an adequate grasp of the process, they were then given paper to create semantic maps independently using the current unit vocabulary.

The first sub-question asked if the treatment affected students by helping them to

develop strategies to use when confronted with an unknown word in science texts (Table 1). To answer this I had students reflect on their own reading strategies, pre and post-treatment using the Vocabulary Self-Assessment (Appendix C) (Templeton et. al, 2010). This questionnaire was analyzed by assigning the numbers negative two through two to the Likert scale choices of *strongly disagree*, *disagree*, *neutral*, *agree* and *strongly agree*. I then compared the median answer choice for each question pre and post-treatment. I also gave a pre and post-treatment Reading Comprehension Test to answer sub-question one. These data were analyzed to determine if there was an increase from pre to post-test using a one-sided Wilcoxon signed-rank test at a 0.05 significance level (Appendix D). Personal notes and observations of my students were also collected (Table 2).

To answer sub-question two and determine specifically how a mixed approach to vocabulary instruction impacted students' comprehension of unit vocabulary, students were given Unit Vocabulary Tests before and after both units (Appendices E & F). In addition, all students were given a Common Science Morphology Test before and after the treatment (Appendix G). These data were analyzed to determine if there was an increase from pre to post-test using a one-sided Wilcoxon signed-rank test at a 0.05 significance level. Personal notes and observations of my students were also collected for sub-question two.

Lastly, to answer sub-question three and determine if the treatment was more effective than the non-treatment in helping students learn the unit vocabulary and concepts, all students completed a Post-Treatment Survey. Student answers were analyzed by assigning the numbers negative one, zero, and one to the Likert scale choices: *the vocabulary strategy didn't help me*, *not sure if it helped me*, and *helped me*

(Appendix H). I then compared the median answer choice for each question. The Unit Vocabulary Tests were again used as well as the Comprehensive Unit Tests (Appendix I & J). However, to answer this sub-question the assessments were analyzed by comparing the scores of the non-treatment group to that of the treatment group after the units. A one-sided Wilcoxon ranked sum test at a 0.05 significance level was used to determine if the median treatment score was greater than the median non-treatment score.

Table 1  
*Data Triangulation Matrix*

Research Question	Data Source 1	Data Source 2	Data Source 3
Will the treatment help students to develop strategies to use when confronted with an unknown word in science texts?	Reading Comprehension Test	Vocabulary Self-Assessment	Teacher Observations
Will the treatment increase vocabulary comprehension?	Unit Vocabulary Tests	Common Science Morphology Test	Teacher Observations
Will the treatment be more effective than the non-treatment in learning the unit vocabulary and concepts?	Post-Treatment Survey	Unit Vocabulary Tests	Comprehensive Unit Tests

Table 2  
*Assessment and Analysis Methods*

Assessment Technique	Time Administered	Analysis Method
Reading Comprehension Test	Pre and Post-Treatment	Wilcoxon Signed-Rank Test
Vocabulary Self-Assessment	Pre and Post-Treatment	Answer Choice Median Comparisons
Common Science Morphology Test	Pre and Post-Treatment	Wilcoxon Signed-Rank Test
Post Treatment Survey	Post-Treatment	Answer Choice Median Comparisons, Open Answer Analysis
Unit Vocabulary Tests	Pre and Post-Treatment Pre and Post Non-Treatment	Wilcoxon Signed-Rank Test Wilcoxon Ranked Sum Test
Comprehensive Unit Tests	Post-Treatment Post Non-Treatment	Wilcoxon Ranked Sum Test

## DATA AND ANALYSIS

The results from the Vocabulary Self-Assessment post-treatment showed a decrease in agreement with the statement, “I learn the vocab by reading the textbook” ( $N = 139$ ). The median answer fell from *neutral* to *disagree*. There was also a decrease in agreement with the statement, “I make note cards to learn words;” the median answer again fell from *neutral* to *disagree*. However, there were also increases in agreement with certain statements after the treatment such as, “I use context to find meaning.” When presented with this statement, the median response increased from *neutral* pre-treatment to *agree* post-treatment. Lastly, an increase in median response from *neutral* to *agree* was determined for the statement, “I create and study semantic maps to learn words.”

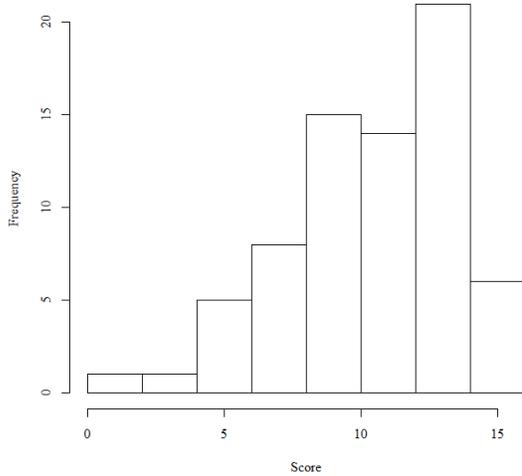
The results of the Wilcoxon signed-rank test on the first unit treatment group's Reading Comprehension Test scores showed a  $p$ -value of 0.99 ( $N = 71$ ). A 95% confidence interval estimates the sample median score to be -1.50 or greater. The  $p$ -value is above the 0.05 significance level and therefore the null hypothesis failed to be rejected. There was no statistical increase between the first unit treatment group's pre and post median test scores.

The results of the same statistical test on the same data collection tool for the second unit treatment group showed a  $p$ -value of 0.12 ( $N = 73$ ). A 95% confidence interval estimated the sample median score to be -0.00009 or greater. The null hypothesis again failed to be rejected and this test also showed there was no statistically significant increase between the second unit treatment group's pre and post Reading Comprehension Test median scores.

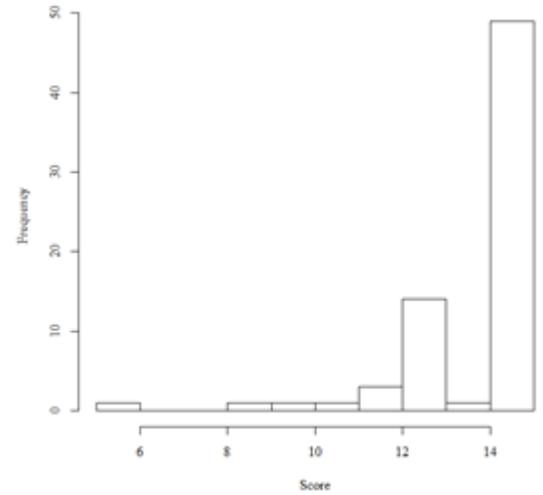
The  $p$ -value determined for the first unit treatment group's pre and post Chapter 4 Unit Vocabulary Test scores was 1.00. A 95% confidence interval estimated the sample median score to be -3.99 or greater. The same statistical test used on the second unit treatment group's pre and post Chapter 5 Unit Vocabulary Test scores also determined a  $p$ -value of one with a 95% confidence interval estimating the sample median score to be -8.99 or greater. The null hypothesis failed to be rejected and there was no statistically significant increase between either first or second unit treatment groups' pre and post Chapter 4 or Chapter 5 Unit Vocabulary Test median scores. While it was determined that there was no statistically significant increase in median score for the two tests, the distribution and variance of the data did change from pre to post test for both groups. The first unit treatment group had greater variance in their score range on the Chapter 4

### Unit Vocabulary Pre-Test (Figure 1).

In contrast the scores were more clustered to the right, with less variance in the post-test (Figure 2). In the post-test 66% of students received a perfect score of 15, as opposed to only eight percent in the pre-test.

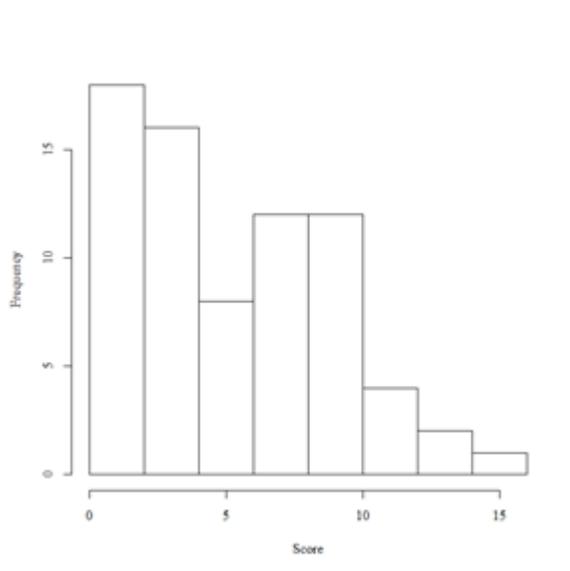


*Figure 1.* First unit treatment group's Chapter 4 unit vocabulary pre-test scores, ( $N = 71$ ).

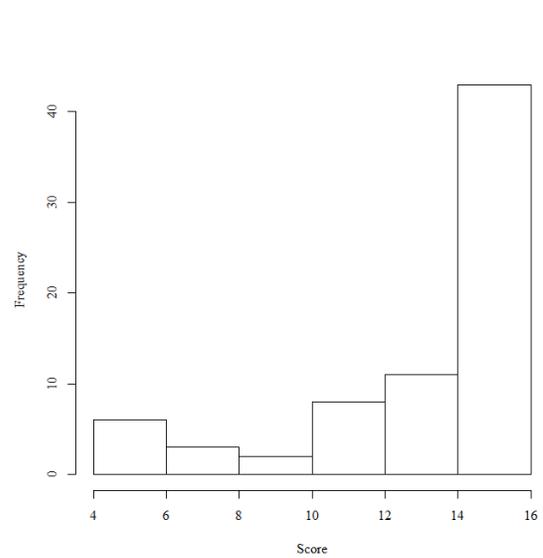


*Figure 2.* First unit treatment group's Chapter 4 unit vocabulary post-test scores, ( $N = 71$ ).

The second unit treatment group showed similar changes from pre to post test on the Chapter 5 Unit Vocabulary Test. There was greater variance and the scores were skewed more to the left. Forty eight percent of students scored five or less out of 16 total points on the pre-test (Figure 3). The Chapter 5 Vocabulary Post-Test showed less variance, with data skewed more to the right. Fifty two percent of students earned perfect scores of 16 on the post- test (Figure 4).



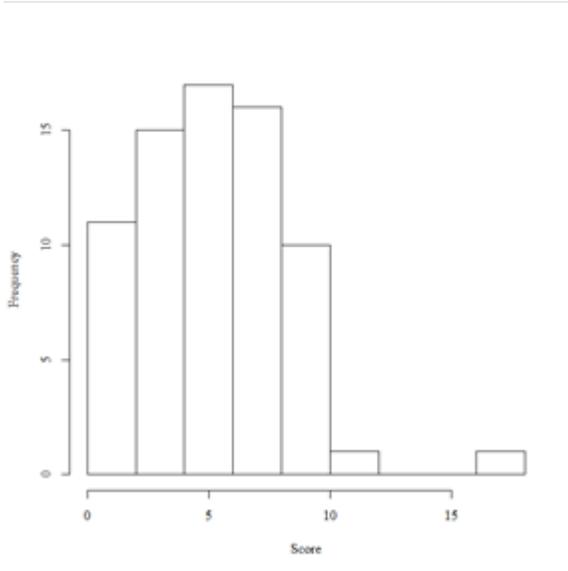
*Figure 3.* Second unit treatment group's Chapter 5 unit vocabulary pre-test, ( $N = 73$ ).



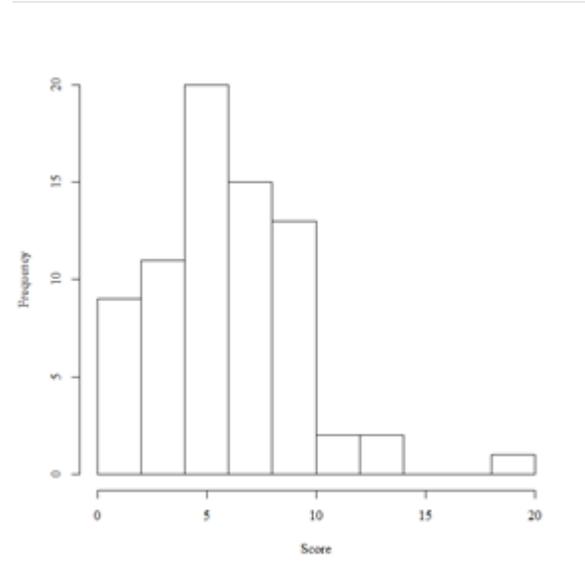
*Figure 4.* Second unit treatment group's Chapter 5 unit vocabulary post-test, ( $N = 73$ ).

Both the first and second treatment groups'  $p$ -value when testing for statistical significance between the pre and post Common Science Morphology Tests was determined to be one with a 95% confidence interval estimating the sample median score to be -12.00 or greater. There was no statistically significant increase between the pre and post-test median scores for this data collection tool.

It is again important to point out the change in the data distribution for both treatment groups from pre to post test. Both groups again showed greater variance, with data skewed to the left in the pre-test (Figures 5 & 6). In the first unit treatment group, 46% of students scored five or less out of 20 total points on the pre-test. The second treatment group had similar results on the pre-test with 51% of students scoring five or less out of 20 total points.



*Figure 5.* First unit treatment group's common science morphology pre-test scores, ( $N = 71$ ).



*Figure 6.* Second unit treatment group's common science morphology pre-test scores, ( $N = 73$ ).

The Common Science Morphology Post Tests showed less variance and data skewed to the right for both first and second treatment units (Figures 7 & 8). Sixty seven percent of students in the first unit treatment group scored 17 or more out of 20 points on the post-test and 69% of students in the second unit treatment group scored 17 or more on the same test.

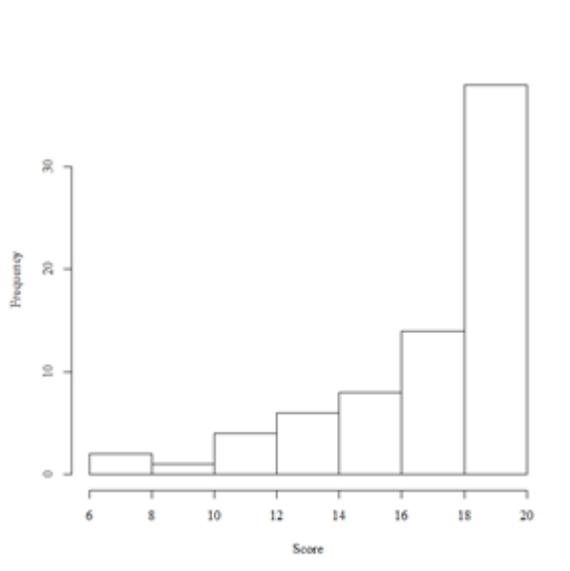


Figure 7. First unit treatment group's common science morphology post-test scores, ( $N = 71$ ).

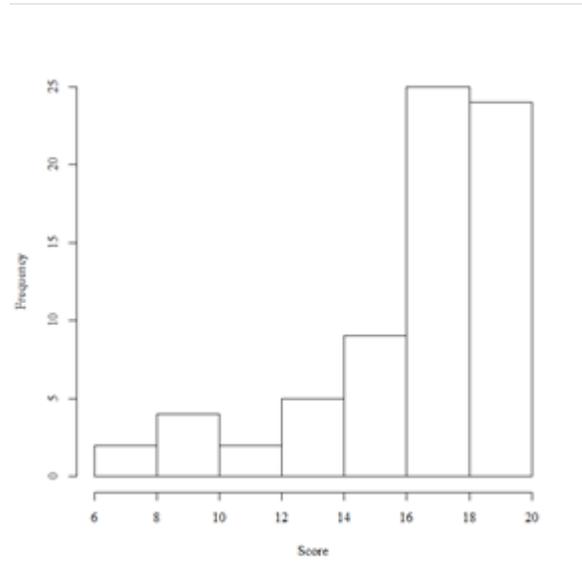
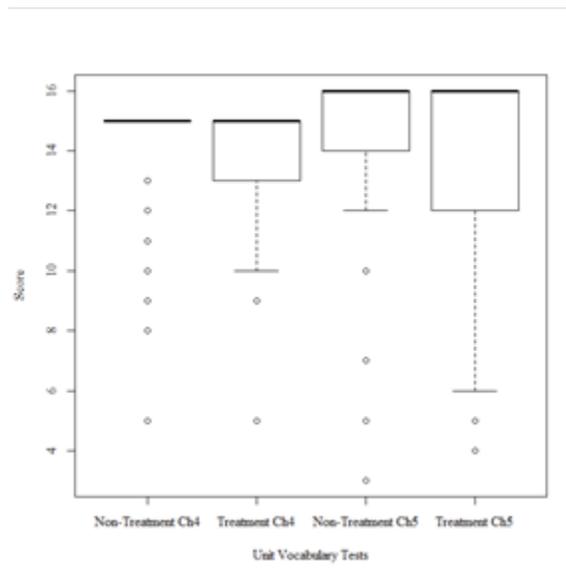


Figure 8. Second unit treatment group's common science morphology post-test scores, ( $N = 73$ ).

On the Post-Treatment Survey, when asked if learning specific prefixes and suffixes helped in understanding unit vocabulary, the median response was *yes it helped me* ( $N = 144$ ). One student commented that, “I think it helped me because I now know what the prefixes mean. It helps me know what the words mean.” Another student agreed that, “It helped me learn what a lot of really hard science words actually mean.” When asked if filling out The Vocabulary Strategies Worksheet while reading the textbook chapter helped to understand unknown words, the median response was *not sure if it helped me*. Students had mixed responses including, “Instead of skipping the words, I had to actually figure them out,” but also “It didn't help me because my mind was so bored when I was reading it that I don't remember it.” Similar results were shown when asked if creating a semantic map helped to understand the vocabulary. The median response was, *Not sure if it helped me*. Student comments ranged from, “It was like doing art and it helped,” to “it was too confusing and it felt like busy work.”

When comparing the treatment and non-treatment groups' median student scores on the Chapter 4 Unit Vocabulary Unit Test, a  $p$ -value of 0.24 was observed with a 95% confidence interval estimating the median to be -0.00004 or greater. The  $p$ -value observed for the treatment and non-treatment groups' Chapter 5 Unit Vocabulary Test median scores was 0.08 with a 95% confidence interval estimating the median to also be -0.00004 or greater. No statistically significant increase was determined between the treatment and non-treatment group median scores. When examining the data more closely, there was similar distribution and variance between the two groups on both of the tests (Figure 9).



*Figure 9.* Comparison of Chapter 4 and 5 unit vocabulary tests.

A similar result was shown when comparing the two groups' Chapter 4 and 5 Unit Test scores. The observed  $p$ -value for the Chapter 4 Unit Test scores was 0.96 with a 95% confidence value estimating the median score to be -2.00 or greater. The  $p$ -value determined for the Chapter 5 Unit Test scores was 0.12 with a 95% confidence interval estimating the median score to -0.00003 or greater. There was ultimately no statistically

significant increase between the median treatment and non-treatment score on either of the Chapter Unit Vocabulary or Comprehensive Unit Tests. A comparison of the data using a boxplot showed little to no difference in data distribution (Figure 10).

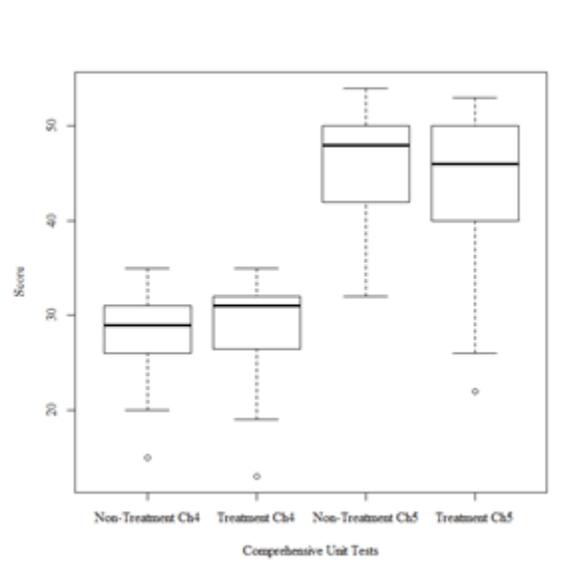


Figure 10. Comparison of Chapter 4 and 5 comprehensive unit tests.

## INTERPRETATION AND CONCLUSION

The results of this study showed no statistical differences in the median of any of the data collection instruments from pre to post-test or between treatment and non-treatment group. However, the data did show increases in median scores on almost all collection instruments pre to post-test and decreases in distribution. I conclude that a mixed approach to vocabulary instruction, including semantic mapping of unit vocabulary words, and morphology and textbook reading strategy lessons, increases student comprehension of the unit concepts, but no more than my standard curriculum.

Student feedback supported this as most students felt the prefix lessons helped, but they were unsure about the Vocabulary Strategies Worksheet or the semantic mapping

activity. Throughout the units, when students asked me about a meaning of a word, I was able to quickly help them break the word apart in order to find the meaning. Students who did not receive the intervention were to do this as well as students who did receive the intervention. After listening to student conversations, I determined that students are taught many prefixes pertinent to life science in their language arts classes. This is positive in terms of increasing student morphological awareness in all academic areas, however it may have influenced this study. I will continue to periodically present students with various morphemes as it did increase understanding and overall, students felt it was valuable.

Students that struggle with reading or are more kinesthetic learners had trouble with the textbook reading strategies. It was also difficult for students to be self-guided while using the Vocabulary Strategies Worksheet. Several students had difficulty filling out the worksheet and asked, “How many words do I need?” to which my response was, “As many as you need in order to understand the text.” Perhaps using the worksheet for multiple units or even throughout the course of a school year may have helped students to fully utilize the strategies in order to enhance their own learning and feel fully comfortable with them.

Students had similar issues creating semantic maps using their unit vocabulary words. I saw that student learning styles and personality types played a part in their ability to create a map. Students that were comfortable with more abstract thinking processes excelled at making their maps, while more concrete learners struggled. As I made my way around the room helping students, multiple students needed further explanation on how to create a map and were not able to come up with ways to categorize

the words on their own.

In order to create the map and show the relationships between the words, students needed to already have a firm grasp on the word meanings. While most students seemed to be proficient in their understanding of the vocabulary definitions and excelled at creating their map (Figure 11), there were a small group of students who did not. In the future, these students could receive a modified map in which the structure had already been created for them and they would need to place the words in the correct place. As with the textbook reading strategies, I believe students need more time to fully develop their understanding of how to create and use a semantic map in order to feel that it is valuable in understanding scientific vocabulary.

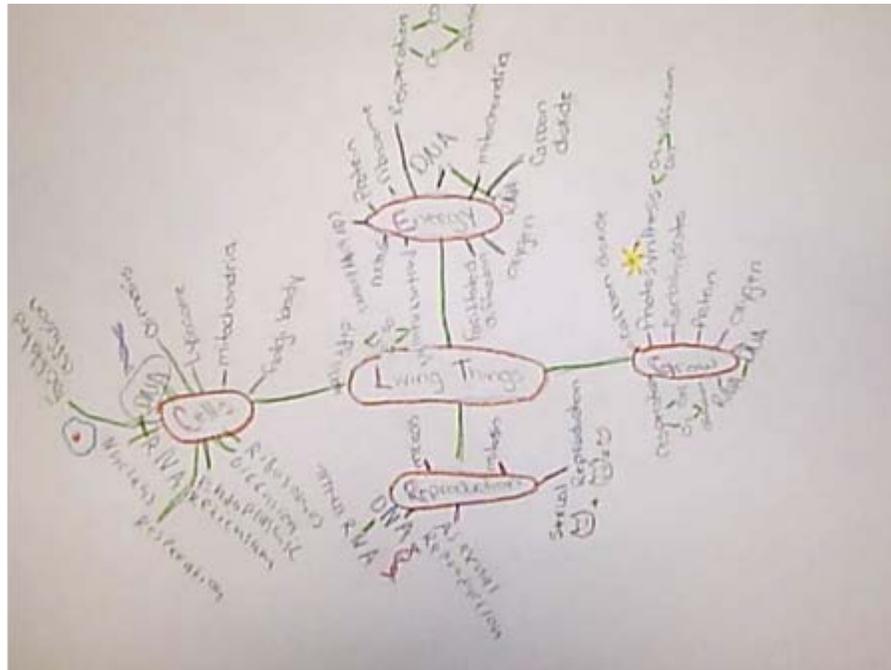


Figure 11. Proficient student semantic map.

Students need multiple ways to explore new words in science and using any of the strategies implemented in this study will help increase understanding. Furthermore, in a classroom containing vast differences in student ability, an array of strategies are

needed in order to differentiate curriculum to meet student needs. Overall, I feel that these strategies will be incredibly useful to me in the future in serving these purposes. These will be a few of many vocabulary strategies that I will use and will continue develop in order to increase student comprehension of incredibly complex, academic, concept based vocabulary.

### VALUE

The development, implementation and analysis of this capstone project influenced my teaching in multiple ways. First and foremost, I have become more knowledgeable about conceptual vocabulary acquisition and have shared this knowledge with other teachers at my school. Within our science department, I have helped to develop a list of common and specific science vocabulary terms for grades six through eight, as well as a reference guide containing various strategies and activities for learning vocabulary in science. I have been recognized as a leader in this area as other teachers have come to me for help in creating a more strategic vocabulary curriculum within their own science classroom. This experience has given me a better understanding of how students develop meaning from words in science and other subject areas, and I am constantly applying this to my daily instruction and lessons.

Before this classroom based research project I had no idea about formative and summative assessment. Now I am perpetually monitoring my students using various formative assessment techniques in order to gauge their understanding of the concepts being taught in my classroom. Be it entrance slips, exit slips, post-its, graphic organizers, homework or written personal observations, I continue to try to assess, adjust and

differentiate my curriculum to the needs of my students. In the past, I gained this sort of understanding only at the end of a unit after the test had been graded and it was too late to help students. Now I can help students deal with confusion and misconceptions before the final assessment, which ultimately helps my students and I to feel more successful.

Lastly, I am very excited that I have become so familiar and proficient in my statistical analysis skills. I now understand what many statistical tests actually measure and the assumptions that must be maintained in order for them to be valid. Sample size, distribution and data type are extremely important when determining the appropriate statistical test to use in order to analyze the data from a specific research study. The results from these tests also must be scrutinized and supported, not only by p-values, but with confidence intervals as well. Furthermore, I now can see clearly the difference between statistical significance and practical significance. Statistics can be an invaluable tool for analyzing the meaning of data, but must always be placed back into the context for which they are being used. This is especially important in education, which is influenced by many variables.

Overall, I found this study to be beneficial to both my students and myself. Students were exposed to different strategies for learning vocabulary that will ultimately enhance their own metacognitive abilities to analyze and develop an understanding of a new word in science. They had multiple exposures to words in multiple activities that were appropriate for different learning styles. I will continue to use and improve the vocabulary strategies I developed in this study and hope they will continue to bring success for both students and teachers.

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APPENDICES

APPENDIX A

INFORMED CONSENT FORM



### Sauk Rapids-Rice Middle School

941 First Street South Sauk Rapids, MN 56377 218.831.9173 fax: 218.831.8977

I, Larry Stracke, Principal of Sauk Rapids-Rice Middle School, verify that the classroom research conducted by Irene Wilcox is in accordance with School Board policy and commonly accepted educational settings involving normal educational practices. To maintain the established culture of our school and not cause disruption to our school climate, I have granted an exemption to Irene Wilcox regarding informed consent to conduct a survey with her students.

*Larry Stracke*  
(Printed Name)

LARRY STRACKE  
(Printed Name)

1-21-13  
(Date)

ENTHUSIASM | ENERGY | EXCELLENCE | ENGAGED

Larry Stracke  
Principal  
larry.stracke@rdsd.org

Jessica Mowczak  
Administrative Director of Middle Schools  
jessica.mowczak@rdsd.org

APPENDIX B

TEXTBOOK READING CHECKLIST

Name: \_\_\_\_\_  
Date: \_\_\_\_\_ HR: \_\_\_\_\_

### Textbook Reading Guide

#### **Pre-Reading**

Write 1-2 sentences about your prior knowledge on this topic.

#### **During Reading**

Complete the checklist for any/all words you read and don't understand

Unknown Word:				
Rate it: 0,3,5				
Guess:				
<b>Check strategies used:</b>				
Examine other parts of the sentence				
Examine pictures on the page				
Examine section headings				
Break the word apart				
Use the glossary				
Ask someone				
Definition:				
Rate it again: 0,3,5				

Continue on backside if needed

#### **Post Reading**

Write 3 to 4 sentences summarizing what you read

APPENDIX C

VOCABULARY SELF-ASSESSMENT\*

\*Adapted from Templeton et. al, 2010 pg. 127

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

Date: \_\_\_\_\_ HR: \_\_\_\_\_

### Vocabulary Self-Assessment

<b>Do I know the meaning of the vocabulary?</b>	Strongly Agree 1	Agree 2	Neutral 3	Disagree 4	Strongly Disagree 5
1. I learn the vocab by reading the textbook.	___	___	___	___	___
2. I learn the vocab in the class lectures.	___	___	___	___	___
3. I learn the vocab through classroom activities.	___	___	___	___	___
<b>Do I know how to learn the vocabulary?</b>					
5. I break words apart to find meaning.	___	___	___	___	___
6. I use the context to find meaning.	___	___	___	___	___
7. I use the glossary to understand words.	___	___	___	___	___
8. I ask for help when I don't understand a word.	___	___	___	___	___
9. I make note cards to learn words.	___	___	___	___	___
10. I complete and study vocab worksheets. to learn words.	___	___	___	___	___
11. I create and study semantic maps to learn words.	___	___	___	___	___
<b>Can I read the vocabulary?</b>					
12. When I read the textbook I know the meaning of most of the words.	___	___	___	___	___
13. I can pronounce the most of the words.	___	___	___	___	___
14. I can read the words easily without having to pronounce them.	___	___	___	___	___
15. There are a few words I don't know when I read (less than 5 per page).	___	___	___	___	___
16. There are many words I don't know when I read (more than 5 per page).	___	___	___	___	___
17. I need more help/resources to learn vocab.	___	___	___	___	___
18. I can learn the vocab easily.	___	___	___	___	___

APPENDIX D

READING COMPREHENSION TEST

Name \_\_\_\_\_



## Vertebrate Classification: Phylum Chordata

By Cindy Grigg

Biologists have described more than one million different kinds of living things on Earth. In order to study them, scientists divide them into groups based on similar traits. One system of classification divides all living things into five different kingdoms. They are animals, plants, fungi, monera, and protista. Some scientists use a six-kingdom system. This system divided monera into archaebacteria and eubacteria.

The kingdoms are then divided into five smaller groups: phylum, class, order, family, genus, and species. The animal kingdom is divided into about thirty-five different phyla (plural of phylum), or major groups. The animal kingdom has more species than any other kingdom.

Although a jellyfish and a person may not look very much alike, they belong to the same kingdom. People and jellyfish are both classified as animals. Animals are many-celled organisms that must obtain their food by eating other organisms. In addition, most animals reproduce sexually and can move from place to place. Biologists look for these characteristics in deciding whether an organism is an animal.

One important characteristic used to classify animals is whether or not they have a backbone or spine. An animal that does not have a backbone is called an invertebrate. Jellyfish, worms, spiders, and insects are all invertebrates. Most animal species are invertebrates (about ninety-five percent of all animals).

Vertebrates are all animals that have a backbone. Vertebrates are in the phylum Chordata. Members of this phylum are called chordates. Chordates share some common traits. At some point in their life cycle, they have a notochord, a nerve cord, and pharyngeal (fay-uh-juh) slits in the neck or throat. The notochord is a flexible rod that supports the animal's back. Lancelets are one chordate species that keep the notochord throughout their life cycle. Unicelsters, on the other hand, have a notochord in the larval stage, but lose it when they reach the adult stage.



In most vertebrates, the notochord (part or all of it) is replaced by hard bone. Sharks are one type of vertebrate animal that have backbones made of cartilage. Cartilage is softer than bone. It is a connective tissue that is flexible and strong.

All chordates have a nerve cord that runs down their back. For example, your spinal cord connects your brain to your nerves so that electrical signals can move in both directions. Crustaceans and worms have nerve cords, but they don't run down their backs.

The third thing chordates have in common is slits in their throat area called pharyngeal slits. Fish keep their slits as part of their gills through their whole life cycle. Many vertebrates lose their slits before birth. Humans are one of these. The slits either close or develop into other structures, such as the jaw and the ear.

The backbone, or spine, is made up of small bones called vertebrae. These small bones have a hole in the center of them that the spinal cord runs through. The vertebrae have joints between them that allow flexibility. You can bend over to pick up something off the floor because of your flexible vertebrae.

The backbone is part of a vertebrate's endoskeleton. An endoskeleton is inside the body. The endoskeleton supports and protects the body. It helps give it shape. It gives the muscles a place to attach. Part of the endoskeleton is the skull and ribs. The skull protects the brain. The ribs attach to the vertebrae and protect the internal organs, especially the heart and lungs.

There are several advantages to having an endoskeleton. It grows as the animal grows. In contrast, arthropods (a group including crabs and caterpillars) have an exoskeleton. An exoskeleton is on the outside of the body. Some exoskeletons are hard, like a crab's shell. Some are leathery, like a caterpillar's. Animals with an exoskeleton must shed them as they grow larger. Have you ever found an empty insect exoskeleton?

In addition, an endoskeleton forms a frame that supports the body from the inside. This frame holds the body upright, against the pull of gravity. It also enables the animal to move easily. Because of these advantages of an endoskeleton, vertebrates can grow bigger than animals with an exoskeleton.

The chordate phylum is further divided into five classes. They are mammals, birds, reptiles, amphibians, and fish.

Name \_\_\_\_\_



Vertebrate Classification: Phylum Chordata

### Questions

- \_\_\_\_\_ 1. Vertebrates, or chordates, are all animals that have:
- a backbone
  - notochord and a nerve cord
  - slits in the throat area
  - all of the above
  - none of the above
- \_\_\_\_\_ 2. What is a notochord?
- a backbone
  - a skeleton inside the body
  - a flexible rod that supports the animal's back
  - a skeleton outside the body
- \_\_\_\_\_ 3. What is a nerve cord?
- the connection between the brain and the nerves where messages travel
  - a spinal cord
  - both a and b
  - none of the above
- \_\_\_\_\_ 4. What are pharyngeal slits?
- slits in the throat area
  - fish gills
  - voice box
  - none of the above
- \_\_\_\_\_ 5. What are vertebrae?
- small bones making up the backbone or spine
  - bones that the spinal cord runs through
  - bones that have joints allowing the spine to bend
  - all of the above
- \_\_\_\_\_ 6. All vertebrates have an:
- arthropod
  - exoskeleton
  - invertebrate
  - endoskeleton
- \_\_\_\_\_ 7. A tunicate:
- keeps its notochord its whole life
  - only has a notochord as a larva
  - only has a notochord as an adult
  - does not have a notochord
- \_\_\_\_\_ 8. What is the function of the endoskeleton?
- it acts like a shield on the outside of the body
  - it gives something for muscle to connect to
  - it can be a home for the organism
  - it can be shed and replaced by a new endoskeleton
- \_\_\_\_\_ 9. An advantage of having an endoskeleton is:
- vertebrates can grow bigger
  - vertebrates can move faster
  - vertebrates can eat more
  - vertebrates can live longer
- \_\_\_\_\_ 10. A phylum is:
- A vertebrate with an exoskeleton
  - A vertebrate with an endoskeleton
  - A major group within a Kingdom
  - A separate Kingdom

APPENDIX E

CHAPTER 4 VOCABULARY TEST

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

Date: \_\_\_\_\_ HR: \_\_\_\_\_

**Chapter 4 Vocabulary Test**

Match the vocabulary word with the correct definition.

- |   |  |
|---|--|
| 1. asexual reproduction _____               | A. structure in cell's nucleus that contains genetic information.            |
| 2. chromosome _____                         | B. a sex cell found in the female reproductive organs                        |
| 3. diploid _____                            | C. hereditary material wound up into chromosomes                             |
| 4. DNA _____                                | D. a cell with two pairs or 46 total chromosomes.                            |
| 5. egg _____                                | E. when a new organism is produced from 1 parent                             |
| -----                                       |  |
| 6. fertilization _____                      | A. a sex cell with half or 23 total chromosomes.                             |
| 7. gene _____                               | B. process in which the nucleus divides creating 2 identical nuclei          |
| 8. haploid _____                            | C. process that creates four haploid sex cells                               |
| 9. meiosis _____                            | D. the joining of egg and sperm in sexual reproduction                       |
| 10. mitosis _____                           | E. a section of DNA containing instructions for creating a specific protein  |
| -----                                       |  |
| 11. mutation _____                          | A. when 2 sex cells form two parents create a new organism                   |
| 12. RNA _____                               | B. a permanent change or mistake in a gene or chromosome                     |
| 13. sexual reproduction _____<br>fertilizes | C. a new diploid cell formed when a sperm<br>an egg                          |
| 14. sperm _____                             | D. a sex cell found in the male reproductive organs                          |
| 15. zygote _____                            | E. it carries codes for making proteins from the<br>nucleus to the ribosomes |

APPENDIX F

CHAPTER 5 VOCABULARY TEST

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

Date: \_\_\_\_\_ HR: \_\_\_\_\_

**Chapter 5 Vocabulary Test**

Match the vocabulary word with the correct definition.

- |                                 |   |
|---------------------------------|---|
| 1. allele _____                 | A. a trait that covers up or dominates another allele                       |
| 2. dominant _____               | B. an organisms genetic makeup  |
| 3. genetic engineering _____    | C. the study of how traits are inherited through actions of alleles         |
| 4. genetics _____               | D. the form that a gene may have for a trait                                |
| 5. genotype _____               | E. methods to change the arrangement of a gene's DNA                        |
| -----                           |   |
| 6. incomplete dominance _____   | A. the outward physical appearance or behavior of an organism               |
| 7. heredity _____               | B. when an intermediate phenotype is created                                |
| 8. heterozygous _____           | C. describes an organism with two different alleles                         |
| 9. homozygous _____             | D. describes an organism with the same alleles                              |
| 10. phenotype _____             | E. the passing of traits from parent to offspring                           |
| -----                           |   |
| 11. hybrid _____                | A. when a trait is influenced by multiple genes                             |
| 12. purebred _____              | B. a trait that is covered over or dominated by another allele              |
| 13. polygenic inheritance _____ | C. describes an organism with two different alleles for a trait             |
| 14. punnet square _____         | D. an allele inherited on a sex chromosome and can cause genetic disorders  |
| 15. recessive _____             | E. describes an organism with the same alleles for a trait                  |
| 16. sex-linked gene _____       | F. a tool used to predict the probability of certain traits in an offspring |

APPENDIX G

COMMON SCIENCE MORPHOLOGY TEST

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

Date: \_\_\_\_\_ HR: \_\_\_\_\_

### Common Science Morphology Test

Write the letter of the matching meaning to the correct prefix.

- |                       |                      |
|-----------------------|----------------------|
| 1. _____ a-           | A. alike, similar    |
| 2. _____ di-          | B. many              |
| 3. _____ tri-         | C. color             |
| 4. _____ poly-        | D. not or non        |
| 5. _____ chrom-       | E. having oxygen     |
| 6. _____ hered/herit- | F. two or double     |
| 7. _____ homo-        | G. different         |
| 8. _____ hetero-      | H. cell              |
| 9. _____ aero-        | I. sugar             |
| 10. _____ geno-       | J. three             |
| 11. _____ pheno-      | K. heir              |
| 12. _____ endo-       | L. appear            |
| 13. _____ exo-        | M. outer or external |
| 14. _____ oxy-        | N. internal          |
| 15. _____ ribo-       | O. genetic           |
| 16. _____ cyto        | P. air or gas        |

Write the letter of the matching meaning to the correct suffix.

- |                  |                                      |
|------------------|--------------------------------------|
| 17. _____ -sis   | A. the study of                      |
| 18. _____ -ology | B. piece of living matter            |
| 19. _____ -plast | C. a process, state or condition     |
| 20. _____ -oid   | D. indicates likeness or resemblance |

APPENDIX H

POST-TREATMENT SURVEY

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

Date: \_\_\_\_\_ HR: \_\_\_\_\_

Post-Treatment Survey

1. Do you think learning scientific prefixes and suffixes helped you to understand the unit vocabulary? (Circle One)

Didn't help me

Not Sure if it helped me

Helped me

Explain why you think this:

2. Do you think filling out the vocabulary strategies worksheet while reading about Meiosis helped you better understand this process? (Circle One)

Didn't help me

Not Sure if it helped me

Helped me

Explain why you think this:

3. Do you think creating a semantic map helped you to understand the unit vocabulary? (Circle One)

Didn't help me

Not Sure if it helped me

Helped me

Explain why you think this:

APPENDIX I

CHAPTER 4 COMPREHENSIVE UNIT TEST



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

- \_\_\_\_ 15. The rungs of the DNA ladder are made of \_\_\_\_.
- |              |                   |
|--------------|-------------------|
| a. sugar     | c. nitrogen bases |
| b. phosphate | d. carbon         |
- \_\_\_\_ 16. \_\_\_\_\_ is the term for the joining of an egg and sperm.
- |                  |            |
|------------------|------------|
| a. fertilization | c. meiosis |
| b. mitosis       | d. RNA     |



- \_\_\_\_ 17. Refer to the illustration above. The cell in diagram 1 is in
- |               |              |
|---------------|--------------|
| a. metaphase. | c. anaphase. |
| b. telophase. | d. prophase. |
- \_\_\_\_ 18. Refer to the illustration above. Mitosis begins with the stage shown in diagram
- |       |       |
|-------|-------|
| a. 1. | c. 3. |
| b. 2. | d. 4. |
- \_\_\_\_ 19. Refer to the illustration above. The cell shown in diagram 5 is in
- |               |              |
|---------------|--------------|
| a. metaphase. | c. anaphase. |
| b. telophase. | d. prophase. |
- \_\_\_\_ 20. The point at which two chromatids are attached to each other in a chromosome is called a(n)
- |                 |               |
|-----------------|---------------|
| a. chloroplast. | c. gamete.    |
| b. centromere.  | d. centriole. |

Put the phases in order. (Use 1 for the first phase, 2 for the second, etc.)

- \_\_\_\_ 21. Anaphase
- \_\_\_\_ 22. Metaphase
- \_\_\_\_ 23. Telophase
- \_\_\_\_ 24. Interphase
- \_\_\_\_ 25. Prophase

- \_\_\_\_\_ 26. Mitosis can help cells reproduce in order to:  
a. grow                      c. repair cells  
b. replace cells            d. all of the above
- \_\_\_\_\_ 27. A change in the nitrogen base pairs of DNA is referred to as a:  
a. diploid                    c. haploid  
b. mutation                d. gamete
- \_\_\_\_\_ 28. In prophase chromatin changes into:  
a. chromosomes            c. DNA  
b. RNA                      d. genes
- \_\_\_\_\_ 29. In metaphase centrioles attach to what organelle?  
a. ribosomes                c. DNA  
b. spindle fibers          d. centromeres
- \_\_\_\_\_ 30. In which phase does mitosis end and two new nuclei are created?  
a. prophase                c. metaphase  
b. anaphase                d. telophase
- \_\_\_\_\_ 31. During which phase does DNA replication occur?  
a. interphase               c. prophase  
b. metaphase               d. anaphase

32. (2pts) Explain how multicellular organisms grow in complete sentences.

33. (2pts) Explain why haploid sex cells need to have only half of an organisms chromosomes in complete sentences.

APPENDIX J

CHAPTER 5 COMPREHENSIVE UNIT TEST

Name: \_\_\_\_\_  
 Date: \_\_\_\_\_ HR: \_\_\_\_\_

## Chapter 5 Genetics Test

Please write answers on line on the left side of the question number.

### Multiple Choice. Select the best answer.

1. A different form of a gene. Can be dominant or recessive.
  - a. allele
  - b. phenotype
  - c. mutation
  - d. genotype
2. The Father of Genetics.
  - a. virchow
  - b. hooke
  - c. mendel
  - d. watson
3. Consists of the traits inherited from your parents.
  - a. hybrid
  - b. heredity
  - c. purebred
  - d. genetics
4. An organism's physical appearance or behavior.
  - a. genotype
  - b. homozygous
  - c. phenotype
  - d. heterozygous
5. When more than 2 alleles control a trait .
  - a. incomplete dominance
  - b. polygenic inheritance
  - c. multiple alleles
  - d. chromosome disorder
6. This type of allele covers up other alleles.
  - a. mutation
  - b. dominant
  - c. recessive
  - d. heredity
7. An organism with 2 different alleles for a trait is considered this.
  - a. recessive
  - b. homozygous
  - c. dominant
  - d. heterozygous
8. When 2 alleles are dominant and a blending of traits occurs.
  - a. incomplete dominance
  - b. polygenic inheritance
  - c. multiple alleles
  - d. chromosome disorder
9. This type of allele gets covered up by a dominant allele.
  - a. mutation
  - b. dominant
  - c. recessive
  - d. heredity
10. When changes or errors occur in the DNA during mitosis.
  - a. allele
  - b. phenotype
  - c. mutation
  - d. genotype
11. If you wanted to selectively breed to create a good racing dog which two dogs would you breed together?
  - a. fast dog with slow dog
  - b. fast dog with fast dog
  - c. slow dog with slow dog
  - d. fat dog with fat dog
12. Which of the following is a genetic trait:
  - a. natural blue eyes
  - b. tan from a tanning bed
  - c. dyed red hair
  - d. large/fat body type because of diet



26. If 2 horses have the dominant brown hair color, is it possible for their offspring to have the recessive black hair color? (Mark A, B, C or D)

- a. No, they could both be heterozygous
- b. Yes, they could both be heterozygous
- c. No, they can both only be homozygous
- d. Yes, they can both only be homozygous

27. Which of the following are true? (Mark A, B, C or D)

- I. A single gene can control a single trait.
- II. A single gene can influence multiple traits.
- III. A single trait can be controlled by multiple genes.

- a. I, II, and III
- b. II and III only
- c. I and III only
- d. I and II only

For each trait Write Genetic or Environmental.

28. Green eye color: \_\_\_\_\_

29. Scared of horses because one kicked you: \_\_\_\_\_

30. Right or Left Handed: \_\_\_\_\_

31. Height: \_\_\_\_\_

32. Your hair turns blonde in the summer: \_\_\_\_\_

For each statement mark True or False.

33. Skin color could be a genetic or an environmental trait.

34. Humans have only been selectively breeding organisms for the past 10 years.

35. Homozygous organisms have two of the same letters.

36. Identical twins have the exact same DNA.

37. Tay Sachs is an example of a recessive genetic disorder.

38. Color blindness is an example of incomplete dominance.

39. Blood type is controlled by only 2 alleles.

40. If you cross 4 O'Clock flowers, red and white will create a pink flower.

41. Recessive Genetic Disorders are most often passed from two carrier parents to offspring.

42. A toy poodle has never been selectively bred by humans and can be found in the wild.

Complete the punnet square word problems.

\*please make sure I can tell the difference between your small and large W's  
in sheep, white wool color (W) is dominant to black wool color (w). A shephard  
breeds a heterozygous sheep with a black sheep.

43. Create and complete a punnet square to show possible offspring.

44. List the possible genotypes for the lambs.

45. List the possible phenotypes for the lambs.

46. What are the chances of having a white lamb? \_\_\_\_\_%

47. What are the chances of having a black lamb? \_\_\_\_\_%

In grizzly bears, brown fur is dominant to black fur. A purebred brown bear is bred with  
a hybrid brown bear.

48. What letter represents the dominant brown color?

49. What letter represent the recessive black color?

50. Create and complete a punnet square to show the possible offspring.

51. List the genotypes for the cubs.

52. What percent of the cubs will have the same phenotype as their parents?

Essay: Write down Mendel's 3 Principles of Genetics

53.

54.

55.