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The Effect of Frequent Quizzing on Student Populations with Differing Preparation and Motivation in the High School Biology Classroom

Rebecca Lynn Kling Achord

Louisiana State University and Agricultural and Mechanical College

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THE EFFECT OF FREQUENT QUIZZING ON
STUDENT POPULATIONS WITH DIFFERING PREPARATION AND MOTIVATION
IN THE HIGH SCHOOL BIOLOGY CLASSROOM

A Thesis
Submitted to the Graduate Faculty of
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements of the degree in
Masters of Natural Sciences
in
The Interdepartmental Program in Natural Sciences

by
Rebecca Lynn Kling Achord
B.S., Louisiana State University, 2003
M. Ed, Louisiana State University, 2006
August 2015
I thank Dr. Joseph Siebenaller for his guidance, drive, and support of me completing this thesis and serving as my committee chair. I also thank Dr. Christopher Gregg for his assistance in statistical analysis and for serving on my committee. I also thank Dr. Evanna Gleason for serving on my committee. Lastly, I thank my family, co-workers, and cohort members for their continued assistance, encouragement, and motivation throughout this entire process. I would not have made it through this without all of you. This work was supported by NSF Grant 098847.
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This study was undertaken to test whether frequent quizzing would have different learning outcomes with the different populations within the classroom. Normalized mean learning gains were compared among classes that were quizzed or not quizzed. Allied Health Honors, Allied Health Academic and Academic classes in a high school biology classroom were given pre- and posttests in three units of study: protein synthesis, genetics, and classification. The same student population was also analyzed based on academic achievement levels: high, medium and low. In each unit, the experimental group was taught with traditional power point based lectures and guided notes, laboratories, activities, frequent questioning, and post-lecture quizzes. The control group was instructed with the same methods but did not complete the post-lecture quizzes but was allowed independent study time in the classroom to account for class time when the experimental group was quizzing. Pretest, posttest, learning gains, and effect size were calculated across each class type and achievement level.

All quizzed populations had a higher normalized learning gain than their non-quizzed counterparts in every unit. Even though the differences were not always statistically different, the student populations were positively affected by frequent quizzing. Frequent quizzing is an effective tool to increase learning in student populations in general, despite any differences in motivation or achievement. Further study with more groups of students may lead to a better understanding of how frequent quizzing impacts the learning of different student populations.
INTRODUCTION

The primary goal of education is to convey knowledge to students in a way that they can retain and access the information and develop cognitive skills. As outlined by the Louisiana Board of Education and Secondary Education, “every child is valued, every child will learn, and that the future of the state and its quality of life depend on an educated citizenry” (LA BESE, 2014). Educators are always looking for the most effective practices to ensure the highest level of mastery of the subject by all students. Classroom educators strive to meet this goal while teaching the state-mandated curriculum under limited time constraints and meeting the goals of end-of-course testing. Due to these time constraints and goals, classroom methods for improving student learning should be straightforward to implement and be validated by data before being incorporated into daily use.

Many educators give quizzes to assess student knowledge as a formative assessment after an interval of teaching. A formative assessment is a quick check for understanding that is completed within a unit of study. These quizzes (formative assessments) are used to determine the level of comprehension of the material at that point and are used to guide future lessons before the final summative assessment or unit test is given. The summative assessment is the culmination of all of the aspects of a unit of study and is usually administered as a unit test or a project.

Many studies have shown that the use of frequent quizzing, known as the testing effect, has enhanced student learning (Roediger et al., 2011 and Shirvani, 2009). With the testing effect, students are asked to recall the material several times through low stakes quizzing before completing the summative assessment. Even though many laboratory studies have shown that frequent quizzing aids in the learning process (Kornell et al. 2011), most teachers and
administrators do not consider quizzing as a teaching enhancement tool (McDaniel et al, 2011). The research described in this study was to see if the testing effect, elicited by frequent quizzing, was more effective in one segment of the student population over another in a high school setting. Does frequent quizzing help certain high school student groups recall information from lectures and retain more concepts over other populations of high school students?

A challenge for educators is the range of motivation, prior knowledge and abilities among students or sections of a course. This is exemplified in the present study. As with most schools, students in the present study are not homogenous. They come from different backgrounds and have different educational aspirations in high school. The populations studied were students in Allied Health Honors Biology, Allied Health Academic Biology, and Academic Biology classes. Students who are in the Allied Health classes have expressed a strong desire to become a medical or Allied Health professional, have an overall grade point average of 2.0 (on a 0 — 4.0 scale) or better, have and maintain a good disciplinary and attendance records, present themselves in a professional, respectful and mature manner, and maintain a positive attitude. In addition to the Allied Health requirements, students in the Honors classes must also have an overall cumulative grade point average of 3.3. Students within the Academic Biology class did not apply for or were not accepted to the Allied Health program or did not meet the criteria for the honors course. A regular Honors Biology course was not available for this study. To examine the effectiveness of frequent testing in improving student learning, students were compared based on their assignment to biology classes (Allied Health, Honors Allied Health and Academic Biology) and according to three achievement levels based on prior grade point average and a pretest in biology given at the beginning of the school year. Is the testing effect more pronounced in one of these groups? In other words is frequent testing a better educational tool for some groups of students?
Previous Studies

A number of studies examined whether frequent quizzing improved students’ retention of material. McDaniel et al. (2011), studied frequent quizzing in eighth grade science classes. Students were given a set of three quizzes on certain fact based target material. McDaniel et al. found that “quizzing increased students’ performance on unit exams from baseline levels of 79% correct (performance when target content was nonquizzed) to levels of more than 90%” (McDaniel et al., 2011). If you were to convert this to letter grades, students went from a “C” to an “A” on the target material. The placement and repetition of quizzes influenced the magnitude of the testing effect. Students were quizzed pre-lesson (before delivery of any lesson content), post-lesson (immediately after delivery of lesson content) and as a review quiz (24 hours before unit exam). A single pre-lesson quiz or pre-lesson quiz paired with either a post-lesson or review quiz did not enhance student learning. A single post-lesson quiz or review quiz did increase student learning and it showed that pairing post-lesson quizzing with review quizzing created the greatest learning gains.

The effectiveness of frequent quizzing in producing positive learning gains in a high school science classroom was studied by Evans (2013). In her study, she tested whether the same positive effects of quizzing identified in laboratory and collegiate settings would transfer into the academic setting of a high school where “the student’s motivational dynamics, study habits, and behavior were relatively diverse” and the students varied in age, gender, and academic preparedness (Evans, 2013). She found that in all instances, frequent quizzing was at least as effective as not quizzing at all. She also noted that positive learning gains effects were observed on at least half of the study population. Evans concluded that quizzing should be used as a diagnostic tool, feedback tool, and studying device within the high school science setting.
Shirvani (2009) examined whether daily quizzes had a significant impact on student mathematics achievement compared to weekly quizzes. “The results of this study indicated that using daily quizzing as an assessment strategy would significantly increase student mathematics achievement (on the final exam)” (Shirvani, 2009). He also concluded that students tend to procrastinate in their studies. Daily quizzes reduce procrastination by encouraging students to study on a daily basis and not cram at the end of a unit.

Frequent quizzing has proven itself as a valuable teaching method to enhance recall within the classroom. Frequent quizzing allows more recall scenarios for the students. Roediger and Karpicke (2006) found that quizzing has two potential effects on learning where one is mediated and the other is a direct effect. Mediated learning encourages continuous studying, allows for feedback, and enables students to guide their future studies to the material that they do not know. With repeated testing, students are encouraged to study more frequently. Students are also given continuous feedback which allows them to notice and correct any misconceptions (Roediger and Karpicke, 2006). The direct effect states that the act of test taking enhances the mechanisms of recall and allows for enhancement of later retention. I hypothesize that students, who were not self-motivated would not seek out recall on their own by either self-quizzing, reviewing classroom notes, or working additional practice tests, would benefit more from the mandated recall scenarios that are presented as a graded assignment within the classroom by frequent quizzing.

Rationale for this Study

Based on the findings of previous studies that frequent testing is effective and because of the direct effect of testing (Roediger and Karpicke, 2006), quizzing may be useful regardless of student motivation or population. The present study was designed to test whether the
effectiveness of frequent testing differs among student groups based on their assignment to biology classes (Allied Health, Honors Allied Health and Academic Biology) and according to three achievement levels based on prior grade point average and a pretest in biology given at the beginning of the school year. Many studies have been completed showing that frequent quizzing, especially if performed post-lecture daily, enhances students overall learning gains. Information on the effects of frequent quizzing on different student populations is not readily available. The present study investigates the learning gains of different student populations within the school, as discussed above, to see if frequent quizzing in more beneficial to one population over another.
MATERIALS AND METHODS

Definition of the Study Population

This study was conducted with 194 biology students in a suburban public school in Louisiana. Students participated in this study as part of their prescribed curriculum in biology. All students and their respective guardians signed a waiver of informed consent to participate in this study (Appendix A and B). This project was approved by the Institutional Review Board at Louisiana State University (IRB#E8847).

These 9th to 12th grade students were both male and female and consisted of African Americans, Caucasians, Hispanics, and Asians and were representative of the school as a whole (Table 1). The school population consisted of 2125 students in 2014. Of those students, 23% received free or reduced lunch and 4% were students with disabilities.

Table 1. Number of students in the study group compared to the population of the school based on the October 1st, 2014 enrollment count of the student population of Dutchtown High School.

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>School Population</th>
<th>Study Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>African Americans</td>
<td>484</td>
<td>43</td>
</tr>
<tr>
<td>Caucasians</td>
<td>1521</td>
<td>136</td>
</tr>
<tr>
<td>Hispanics</td>
<td>67</td>
<td>7</td>
</tr>
<tr>
<td>Asians</td>
<td>41</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>12</td>
<td>4</td>
</tr>
</tbody>
</table>

Students from this study were from nine biology classes, labeled A-I, which consisted of two Allied Health Honors Biology, two Allied Health Academic Biology, and five Academic Biology classes. Students who are in the Allied Health classes have expressed a strong desire to become a medical or Allied Health professional, have an overall grade point average of 2.0 or better, have and maintain good disciplinary and attendance records, present themselves in a professional, respectful and mature manner, and maintain positive attitude. In addition to the Allied Health requirements, students within the Honors classes must also have an overall
cumulative grade point average of 3.3. Students within the Academic Biology class did not apply for the Allied Health program or meet the criteria for the honors course. A regular honors biology course was not available for this study. Once qualifications were met, students were randomly scheduled in assigned class sections at the beginning of the school year (Table 2).

At the beginning of the academic year, each biology student at the school was administered a pretest and their grade point averages (GPA) from the previous year were collected. Students were then given a raw achievement score, which was calculated by multiplying their GPA by twenty and averaging it with their pretest score. The overall mean was then calculated. For the purpose of analysis in this study, students were placed into ability groups based on the standard bell curve. Students who were within one standard deviation of the mean score were placed in the medium achievement level. Students who were above one standard deviation from the mean here placed in the high achievement level and those that were one standard deviation below the mean were placed in the low achievement level (Table 2).

Due to the number of courses within this study, a team of two different instructors was utilized. One instructor taught the Allied Health classes, both honors and academic, classes A, B, F, and G, respectively, while another instructor taught all of the academic classes that were not Allied Health, classes C, D, E, H, and I, respectively. To reduce the effect of having different instructors, they jointly planned the units using the same guiding questions, lesson plans, quizzes, and tests for the units. Both instructors used an interactive type lecture based classroom with guided notes for students to use during instruction. They also completed the same activities/labs within the class time and assigned the same homework assignments. The timeline for the units were also the same for each instructor. Within the school setting, a modified eight period class schedule is utilized. On Monday, Tuesday, and Friday of each week, the students
attend all eight classes for forty-five minutes. On Wednesday, students only attend their odd period classes for ninety-eight minutes while on Thursday, they attend their even classes for that same length of time. Each instructor has six classes that she instructs with two conference periods per day. One conference period is an odd numbered class while the other is an even numbered class to ensure there is a conference period available each day. Both instructors in this study had conference periods at sixth and seventh hour which allowed them to plan the units together thoroughly. The text, Modern Biology (Holt et al., 2002), was used as a resource for the content discussed for this study.

Table 2. Characteristics of the classes used in this study. Class type, number of students, and their grade and achievement levels are shown.

<table>
<thead>
<tr>
<th>Class Name</th>
<th>Class Type</th>
<th>Treatment</th>
<th>Number of Students</th>
<th>Grade</th>
<th>Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Allied Health Honors</td>
<td>Quizzed</td>
<td>26</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>Allied Health Academic</td>
<td>Quizzed</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>Academic</td>
<td>Quizzed</td>
<td>22</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>Academic</td>
<td>Quizzed</td>
<td>22</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>Academic</td>
<td>Quizzed</td>
<td>25</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>F</td>
<td>Allied Health Honors</td>
<td>Control</td>
<td>24</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>G</td>
<td>Allied Health Academic</td>
<td>Control</td>
<td>16</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>H</td>
<td>Academic</td>
<td>Control</td>
<td>24</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>I</td>
<td>Academic</td>
<td>Control</td>
<td>23</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>194</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>
Design

The units protein synthesis, genetics, and classification were chosen due to their placement within the curriculum and the concept integration within these units. The concepts within these units scaffold so it is imperative that students understand the previous day’s material before diving deeper into the content.

The 194 students were assigned to two categories, quizzed and non-quizzed, with each category having Allied Health Honors Biology, Allied Health Academic Biology, and Academic Biology students. There were 87 students in the control group while the other 107 students were in the experimental group.

The experimental group, which will be identified as the quizzed group, was instructed by traditional teaching methods, which involved PowerPoint based lecture, group and individual problem solving activities, class discussion, kinesthetic manipulatives, videos, frequent questioning and feedback, and post-lecture quizzing. Students within the quizzed group received feedback in the form of a question and answer session directly after quizzing. The control group, which will be called the non-quizzed group, was instructed with the same methods as the quizzed group, but did not receive quizzes or feedback based on the quiz questions during the chapter. The control group was allowed in class independent study time to account for class time where the experimental group was quizzing (Table 3).

Table 3. Experimental Design of the Study.

<table>
<thead>
<tr>
<th>Experimental Design</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental (Quizzed) Group</td>
<td>Control (Non-Quizzed) Group</td>
</tr>
<tr>
<td>Pre-test</td>
<td>Pre-test</td>
</tr>
<tr>
<td>Variable Lectures/Activities</td>
<td>Variable Lectures/Activities</td>
</tr>
<tr>
<td>Post-Lecture Quizzes</td>
<td>Independent Study Time</td>
</tr>
<tr>
<td>Post-test</td>
<td>Post-test</td>
</tr>
</tbody>
</table>
Procedure

For each chapter, students received a multiple choice pre and post-test. The questions on the pre- and post-test are identical except the order of questions and multiple choice answers are scrambled. The quiz questions covered the knowledge that was assessed with the pre- and post-test, but was not identical to eliminate the possibility of recognition of the question rather than information recall. Quiz questions were short answer, open-ended, or fill in the blank format.

A pre-test was administered to all students prior to delivery of the chapter material (see example questions in Appendix C). This pre-test was not recorded as a class grade and was analyzed without feedback to the students. The chapter materials were covered by sections and within the experimental group, quizzes were given at the completion of each section with immediate feedback about errors and misconceptions given by the teacher (see example questions in Appendix D). The quizzes were counted as a low-stakes grade and returned to the teacher for filing. The protein synthesis unit was seven days from pretest to posttest, while the genetics and classification units were each six days long. Upon completion of the chapter, a post-test was given to all students. The chapter post-test was counted as a class test grade. The multiple choice questions on the pre- and post-tests were scored as either correct or incorrect and counted as one point.

Fluctuating Populations

Because of the design of this study, only the students who were present for the entire chapter and completed both the pre- and posttest were included in the final student population. Any student who was absent for a pretest was immediately excluded and any student who was absent for a posttest had one week, outside of class time, to complete the make-up. Students who
transferred into or out of the course during the study were also omitted in the final data. In all, sixteen students were excluded for missing data points during analysis.

Calculating Mean Scores and Learning Gains

The pre- and posttest data of the experimental and control classes were compared with an unpaired t-test using GraphPad InStat version 3.10 for Windows (GraphPad Software, San Diego California USA, www.graphpad.com). The effects of two separate variables were analyzed: Class Type and Achievement Level. The normalized learning gain for each unit by population was calculated for each student (Hake, 1998). Learning gain = (pretest-post-test)/(total possible points – pretest). If the normalized learning gain for an individual student was determined to be a negative number, the value was replaced with a zero for analysis purposes. The power of the tests used, given the number of students in the classes, was also determined using StateMate version 2 for Windows (GraphPad Software, San Diego, CA, www.graphpad.com).

Effect size statistics have been recommended as complement to standard statistical testing. The effect size based on Cohen’s $d$ variant was also calculated for each of the population studies (Maher et al., 2013). Cohen’s $d = (\text{Mean Experimental Normalized Learning Gain} - \text{Mean Control Normalized Learning Gain})/\text{Pooled Standard Deviation}$. 
RESULTS

Three units, protein synthesis, genetics, and classification, were examined. The mean pre- and posttests, learning gains, and effect sizes were calculated for each population within the study unit.

Protein Synthesis

In the Protein Synthesis unit, the chapter material was delivered in sections with the experimental group taking quizzes after each section while the control group was allowed individual review time. The mean pre- and posttest scores are shown in Figure 1.

![Figure 1](image)

Figure 1. Mean test scores and standard error of means for each learning population for the Protein Synthesis unit. The number of students in each group is listed in Table 2. There are no statistical differences between the control (not quizzed) and experimental (quizzed) groups.

Based on the pre- and posttests for Protein Synthesis, the mean normalized learning gains were calculated (Table 4). Each student population exhibited a positive learning gain. There were no differences between the quizzed and control groups for any population group within this unit (P > 0.05). Based on the statistical power calculated using the StatMate model, to have an 80% power indication, the differences of the means for the Allied Health Honors Class type must be
0.11. The actual difference that was found is 0.06 which has a low (30%) power of detection as statistically significant. The Allied Health Academic class must be 0.19 difference to show significance with 80% power and the delta observed was 0.02 (< 10% power). The Academic class needed a difference in means of 0.14 and actually had 0.07 (30% power). The High Achievement group needed a 0.11 difference in mean but actually only had a 0.04 difference (20% power). For the Medium Achievement student group to show a statistically significance difference in the means with 80% power, the difference must be 0.12. The actual difference that was shown was 0.02 (< 10% power). The Low Achievement student group needed a 0.27 difference in means for 80% power but actually showed a delta of 0.05 (Figure 2).

Table 4. Mean Normalized Learning Gains for experimental (quizzed) and control (not quizzed) learning populations for the Protein Synthesis Unit. Cohen’s d and Effect Size value of each learning population for the Protein Synthesis unit. Numbers of students in each group are listed in Table 2.

<table>
<thead>
<tr>
<th>Class</th>
<th>Mean Normalized Learning Gain</th>
<th>Cohen’s d</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quizzed</td>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>Allied Health Honors</td>
<td>0.90</td>
<td>0.85</td>
<td>0.41</td>
</tr>
<tr>
<td>Allied Health Academic</td>
<td>0.76</td>
<td>0.74</td>
<td>0.11</td>
</tr>
<tr>
<td>Academic</td>
<td>0.63</td>
<td>0.56</td>
<td>0.27</td>
</tr>
<tr>
<td>High Achievement</td>
<td>0.91</td>
<td>0.87</td>
<td>0.30</td>
</tr>
<tr>
<td>Medium Achievement</td>
<td>0.69</td>
<td>0.67</td>
<td>0.09</td>
</tr>
<tr>
<td>Low Achievement</td>
<td>0.49</td>
<td>0.44</td>
<td>0.20</td>
</tr>
</tbody>
</table>
Figure 2. Power calculation for all comparisons of student populations for the Protein Synthesis Unit. A. Allied Health Honors. B. Allied Health Academic. C. Academic. D. High Achievement. E. Medium Achievement. F. Low Achievement. The star indicates the actual delta of the means for each group. Delta is the difference between mean normalized learning gains. The power was calculated using GraphPad StatMate to determine if the comparison in a completed experiment missed a small effect due to small sample size. The curve shows the computed power of a test to detect various hypothetical differences (delta) using the class sample sizes and standard deviations.

Based on the calculated Cohen’s d value, the effect size varies based on class type and achievement level (Table 4). When looking at the Allied Health Honors class type and the High Achievement student groups, quizzing revealed a small to medium positive effect on the student population. The Academic class type and the Low Achievement group exhibited a small positive effect when quizzing was present. Even though the values were positive, the Allied Health Academic class type and the Medium Achievement student groups did not have enough difference in their normalized learning gains to show an effect due to quizzing.
Genetics

In the Genetics unit, the chapter material was delivered in sections with the experimental group taking quizzes after each section while the control group was allowed individual review time. The mean pre- and posttest scores are shown in Figure 3.

Figure 3. Mean test scores and standard error of means for each learning population for the Genetics unit. The number of students in each group is listed in Table 2. There are no statistical differences between the control and experimental groups.

Based on the pre- and posttests for Genetics, the mean normalized learning gain was calculated (Table 5). Each student population exhibited a positive learning gain. For the quizzed Academic class, there was a significant improvement in learning gains \( P = 0.018 \) compared to the group which was not quizzed. Within the Medium Achievement population, significant improvement was also noted \( P = 0.0428 \) relative to the group that was not quizzed. All other quizzed groups showed improvement but none were statistically significantly different compared to the controls \( P > 0.05 \). Based on the power test calculated using StatMate, to have an 80% power of detecting a difference, the differences of the means for the Allied Health Honors class would need to be 0.17. The actual difference was 0.07 for which there is only 20% power. The Allied Health Academic class difference in means would need a delta of 0.19 for 80% power.
Table 5. Mean Normalized Learning Gains for experimental (quizzed) and control (not quizzed) learning populations for the Genetics Unit. *P < 0.05, the quizzed and control groups differ. Cohen’s d and Effect Size value of each learning population for the Genetics unit. Numbers of students in each group are listed in Table 2.

<table>
<thead>
<tr>
<th>Class</th>
<th>Mean Normalized Learning Gains</th>
<th>Cohen’s d</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quizzed</td>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>Allied Health Honors</td>
<td>0.86</td>
<td>0.79</td>
<td>0.35</td>
</tr>
<tr>
<td>Allied Health Academic</td>
<td>0.74</td>
<td>0.63</td>
<td>0.71</td>
</tr>
<tr>
<td>Academic*</td>
<td>0.61</td>
<td>0.50</td>
<td>0.45</td>
</tr>
<tr>
<td>High Achievement</td>
<td>0.89</td>
<td>0.80</td>
<td>0.09</td>
</tr>
<tr>
<td>Medium Achievement*</td>
<td>0.67</td>
<td>0.59</td>
<td>0.39</td>
</tr>
<tr>
<td>Low Achievement</td>
<td>0.46</td>
<td>0.41</td>
<td>0.34</td>
</tr>
</tbody>
</table>

The actual difference for this class was 0.11 (40% power). The High Achievement Group delta must be 0.18 for 80% power. The actual difference is 0.08 (25% power). For the Low Achievement student group to show a difference in the means, it must be 0.25. The actual difference that was shown was 0.05 which is <10% power (Figure 4).

Based on the calculated Cohen’s d value, the effect size varies based on class type and achievement level (Table 5). There was a medium to large effect on the Allied Health Academic class. When looking at the Allied Health Honors and Academic class type and the Medium Achievement group, quizzing showed a small to medium positive effect on the student population. The Low Achievement group exhibited a small positive effect. Even though the values were positive, the High Achievement student groups did not have enough difference in normalized learning gains to show an affect based on quizzing.
Figure 4. Power calculations for comparison of Allied Health Honors, Allied Health Academic, High and Low Achievement groups for the Genetics unit. A. Allied Health Honors. B. Allied Health Academic. C. High Achievement. D. Low Achievement. The star indicates actual delta of the means for each group. Delta is the difference between mean normalized learning gains. The power was calculated using GraphPad StatMate to determine if the comparison in a completed experiment missed a small effect due to small sample size. The curve shows the computed power of a test to detect various hypothetical differences (delta) using the class sample sizes and standard deviations.

Classification

In the Classification unit, the chapter material was delivered in sections with the experimental group taking quizzes after each section while the control group was allowed individual review time. The mean pre- and posttest scores are shown in Figure 5.
Figure 5. Mean test scores and standard error of means for each learning population for the Classification unit. The number of students in each group are listed in Table 2. There are no statistical differences between the control and experimental groups.

Based on the pre- and posttests for the Classification unit, the mean normalized learning gains were calculated (Table 6). Each student population exhibited a positive learning gain. The quizzed Allied Health Honors class showed a significant improvement in learning gains compared to the group which was not quizzed (P = 0.012). Within the Allied Health Academic class, significant improvement was also noted for the quizzed group compared to the controls (P = 0.0065). The Academic class quizzed also showed significant improvement over the group which was not quizzed (P = 0.024). All of the quizzed achievement groups showed improvement which was not different from the controls (P > 0.05). Based on the power test using StatMate, to have an 80% power indication, the differences of the means for the High Achievement Group must be 0.08. The actual difference found was 0.04 (25% power). The Medium Achievement Group difference needed a delta of 0.14 for 80% power of detection. The actual difference is 0.09 (45% power). For the Low Achievement student group a delta of 0.25 was needed for 80% power. The actual delta was 0.01 (<10% power; Figure 6).
Table 6. Mean Normalized Learning Gains for experimental (quizzed) and control (not quizzed) learning populations for the Classification Unit. *P < 0.05, **P < 0.01. Three of the six comparisons of groups that were quizzed and not quizzed differ. Effect Size value of each learning population for the Genetics unit. Numbers of students in each group are listed in Table 2.

<table>
<thead>
<tr>
<th>Class</th>
<th>Mean Normalized Learning Gains</th>
<th>Cohen’s d</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quizzed</td>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>Allied Health Honors*</td>
<td>0.91</td>
<td>0.84</td>
<td>0.73</td>
</tr>
<tr>
<td>Allied Health Academic**</td>
<td>0.92</td>
<td>0.79</td>
<td>1.13</td>
</tr>
<tr>
<td>Academic*</td>
<td>0.56</td>
<td>0.48</td>
<td>0.43</td>
</tr>
<tr>
<td>High Achievement</td>
<td>0.90</td>
<td>0.86</td>
<td>0.40</td>
</tr>
<tr>
<td>Medium Achievement</td>
<td>0.69</td>
<td>0.60</td>
<td>0.33</td>
</tr>
<tr>
<td>Low Achievement</td>
<td>0.47</td>
<td>0.46</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Figure 6. Power calculation for comparisons of student achievement groups for the Classification unit. A. High Achievement. B. Medium Achievement. C. Low Achievement. The star indicates actual delta of the means. Delta is the difference between mean normalized learning gains. The power was calculated using GraphPad StatMate to determine if the comparison in a completed experiment missed a small effect due to small sample size. The curve shows the computed power of a test to detect various hypothetical differences (delta) using the class sample sizes and standard deviations.

Based on the calculated Cohen’s d value, the effect size varies based on class type and achievement level (Table 6). There was a very large effect on the Allied Health Academic class when quizzing was present in this unit. When looking at the Allied Health Honors class type, quizzing showed a medium to large positive effect on the student population while the Academic
class and High Achievement groups demonstrated a small to medium effect. The Medium Achievement group exhibited a small positive effect when quizzing was present. The only group that was not affected by quizzing was the Low Achievement Students.
DISCUSSION

McDaniel et. al (2007) established that the testing effect enhances learning in the classroom. This study took into account the variability of students’ motivation and attendance in a college course that was not accounted for in the laboratory studies previously completed (Roediger and Karpicke, 2006). Roediger (2011), found that repeated quizzing led to increased student performance by a letter grade when it was maintained for several months in a middle school classroom. The present study expanded on previous research involving the testing effect and was designed to determine if the testing effect, elicited by frequent quizzing, was more effective in one segment of the student population over another in a high school setting.

Protein Synthesis

For the Protein Synthesis unit, all student populations showed a positive learning gain but there were no statistical differences within any population between the quizzed and control groups (Table 4). It is evident from the power test (Figure 2), that the low number of students within the study greatly affected the statistical significance testing. Due to this fact, the effect size becomes very important due to the fact that it normalizes the small study to the standard deviation. The effect size shows that there is a positive small to medium effect on both the Allied Health Honors and High Achievement classes when quizzing is present and a small effect in Academic and Low Achievement students (Table 5). Within this unit, it is evident that the upper level (Honors and High Achievement) and lower (Academic and Low Achievement) level students benefitted more from frequent quizzing (Table 5). As a whole, this is a more abstract and complex unit that is not addressed in the lower level life sciences so students have less background knowledge to pull from. In class discussions for this topic, it was noticeable that upper level students were reviewing their material daily outside of class to help increase their
scores on the low stakes quizzes. The current study is in agreement with the McDaniel et al. (2011) study which also showed that even if students were motivated to study the content, low stakes quizzing allowed for more retention of the course material. Traditionally, lower level students do not review their material daily and the recall that was provided through the quizzing alleviated misconceptions and provided the quizzed group an advantage over the control group.

Genetics

The genetics unit showed a positive normalized learning gain for all students (Table 6). Both the Academic class and Medium Achievement student group showed a significant growth when quizzing was present within the classroom (Table 6). Again, the number of students within the study limited the statistical significance testing (Figure 4). When examining the effect size (Table 7), the Allied Health Academic class showed a medium to large improvement when quizzing was present. The Allied Health Honors and Academic Class showed a small to medium positive effect and the Low Achievement group showed a small positive effect from quizzing. These trends may have been affected by the amount of homework that was given within this unit. Due to the amount of application based questions, genetics is a concept that must be practiced to master. This unit included many activities (Webquest, Practice Sheets, etc.) that were to be completed outside of class time concerning different types of inheritance, Punnett squares, and pedigrees. These materials caused the students to recall the concepts that were addressed within the class from that day. The majority of upper level students (89%) completed these assignments while majority of the lower level students did not complete these assignments on their own; only 27% completed their work. The significant difference in the Academic and Medium Achievement groups could be due to the inconsistency that was evident with the completion of outside of class activities by these different student populations. Of the Medium Achievement group, 57%
completed their assignments. In previous studies, the retrieval or recall of information has been shown to increase test scores with various techniques (McDaniel, 2007). These techniques included reviewing, studying, practice problems, labs and other techniques. The completion of the out of class activities could have provided just as much or possibly more recall than the low stakes quizzing from this study.

Classification

The classification unit also showed positive normalized learning gain for all students (Table 8). When looking at the outcomes for the classification unit, all of the class types (Allied Health Honors, Allied Health Academic, and Academic) showed a significant improvement for the quizzed over not quizzed groups (Table 8). This difference was not seen when analyzing the outcomes based on achievement group (High, Medium, and Low). Looking at effect size, the Allied Health Academic class showed a very large effect, while the Allied Health Honors showed a medium to large effect. Both the Academic class and the High Achievement group showed a small to medium positive effect while the Medium Achievement group showed a small effect (Table 9). It is evident that quizzing was positive for all class types within this unit of study. This could be due to the fact that majority of the classification unit is based on knowledge and comprehension and not many application type questions were presented. The fact that students were exposed to test-like questions, and adjusted their studying to accommodate the question type (Mayer et. al, 2009) could also contribute to the result. The recall that frequent quizzing provides on the knowledge based questions allows students within any class type to successfully perform on this subject.
SUMMARY AND CONCLUSIONS

This study compared the effect of frequent quizzing on different student populations within the high school science classroom. All quizzed populations had a higher normalized learning gain than their non-quizzed counterparts in every unit. Even though the differences were not always statistically different, the student populations were positively affected by frequent quizzing. Provided with this evidence, educators can use quizzing as not only a formative assessment, but as a way to enhance student learning through frequent recall. The findings in this study agree with other researchers’ studies (Evans, 2013; Roediger et. al, 2011; Shirvani, 2009) that frequent quizzing does enhance recall and academic attainment. Trends within this study also show that frequent quizzing can positively influence all student populations regardless of the class type or student achievement level. Not only does frequent quizzing prove to be a positive influence on memory recall, but it can be used by the teacher to identify misconceptions and learning gaps that students have, thus allowing for topics to be reviewed before any summative assessments take place. Frequent quizzing is an effective tool to increase learning in student populations in general, despite any differences in motivation or achievement. In this study, all quizzes were immediately discussed and correct answers were given to the questions. In future studies, one could investigate whether it is the actual quizzing or the review of correct answers immediately following the quizzes that allows for the greater retention of materials.
REFERENCES


APPENDIX A: PARENT CONSENT FORM

Consent Form

Title of Research Study: “The Effect of Frequent Quizzing on Different Student Populations in the High School Biology Classroom”

Project Director: The following investigators are available for questioning about his study.
Rebecca Achord, Dutchtown High School 225-621-8250
Dr. Joseph F. Siebenaller, Louisiana State University 225-578-2601

Purpose of the Research: The purpose of the study is to investigate if there is an increase in student content knowledge at Dutchtown High School using the instructional strategy of frequent quizzing.

Description of Study: Over the course of the 2014-2015 school year, the investigator will introduce the process of frequent quizzing within units of the normal biology curricula. The investigator will administer a pretest to all participants to determine the students’ prior knowledge of the content. The content will be delivered to all students using PowerPoint based lecture, group and individual problem solving activities, class discussion, kinesthetic manipulatives, videos, etc. The investigator will administer frequent quizzes and discuss the answers to the study group. The control group will be allowed independent study time during class. After the unit content has been delivered, the investigator will administer a posttest to determine how much knowledge the participants gained over the course of the unit and a survey will be given to the participants to determine their viewpoint on frequent quizzing.

Benefits: It is anticipated that students will see an improved academic performance due to the ability to recall and retain content information from the use of frequent quizzing.

Risks: I foresee no potential risks to the subjects. All scheduled activities will be a part of the normal school day and will be part of good instructional practice.

Right to Refuse: Your participation is entirely voluntary, and you may withdraw consent and terminate participation at any time without consequence. Whether or not your child participates in the study will not affect his/her grade or involvement in class-related activities.

Protection of Confidentiality: All students, the teacher, and the school will be given pseudonyms to protect their identity and privacy when reporting on the study.

Financial Information: There is no cost to the study nor will any monetary compensation be given.

Signature: I have been fully informed of the above-described procedure with its benefits and risks and give my permission for the participation of my child in the study.

____________________  ______________________  _______________________
Child’s Name  Parent’s Signature  Parent’s Name (Print)

____________________
Date
APPENDIX B: STUDENT ASSENT FORM

Student Assent Form

I, ____________________________ (Print Name), agree to be in a study to help my teacher find ways to educate students at Dutchtown High School by using frequent recall with quizzing. I understand that I will have to work to the best of my abilities while in this study. I will devote my time towards this study by participating in all quizzes, in-class study time, classroom and at home activities, and assessments all while observing classroom rules at all times. I am fully aware that I can decide to stop being in the study at any time without getting in trouble or affecting my grade. I understand that my grade will not be affected whether or not I participate in the study.

__________________________________________  ____________  ____________
Student’s Signature  Date  Age

__________________________________________
Witness’ Signature

Date
APPENDIX C: PRE- AND POSTTEST

Protein Synthesis

1. Nitrogen bases are combined in a particular way when replicating DNA. They always pair
   a. A with G and C with T
   b. A with T and C with G
   c. C with G and A with U
   d. G with T and A with C

   Use the figure below to answer question 2.

2. In DNA, there are 4 different types of nucleotides, shown above. They each have a different type of
   a. Phosphate group
   b. Sugar
   c. Nitrogen base
   d. None of the above

3. The enzyme that breaks the hydrogen bonds of the double helix in DNA is
   a. DNA Polymerase
   b. Helicase
   c. Peptidase
   d. RNA Polymerase

4. What is the role of tRNA in protein synthesis?
   a. to build a sequence of codons
   b. to build mRNA
   c. to carry amino acids to ribosomes
   d. to fold polypeptide chains

   Use the diagram below to answer number 5.

5. The Diagram shows a ribosome conducting an important cellular process. What process is the ribosome conducting?
   a. The ribosome is using genetic information contained in a strand of mRNA to create a specific protein.
   b. The ribosome is using a single strand of DNA as a template to create a matching strand of RNA
   c. The Ribosome is using DNA as a template to create another DNA strand so that genetic information can be passed to offspring.
   d. The ribosome is using the genetic information contained in a protein to create a matching strand of DNA.

6. DNA is a nucleic acid found in all living cells. What is one reason DNA is linked to all body functions?
   a. DNA secretes the proteins that cells need to work
   b. DNA produces five-carbon sugars that can be used for energy
   c. DNA provides the information required to build proteins
   d. DNA controls the production of ATP, the source of energy for the cell

7. The shape of DNA is called a ___ while the shape of mRNA is ____.
   a. Single helix, t-shaped molecule
   b. Double helix, straight molecule
   c. Straight molecule, double helix
   d. Double helix, t-shaped molecule
8. What is the sugar found in DNA?
   a. Deoxyribose  
   b. Glucose  
   c. Ribose 
   d. Sucrose 

9. What is the enzyme that finds and “glues” the complementary bases on the open DNA?
   a. Amylase  
   b. Helicase  
   c. Polymerase 
   d. Lipase 

10. mRNA is formed by copying the DNA during a process called ___. This takes place in the ___.
    a. Transcription, nucleus  
    b. Transcription, ribosome  
    c. Translation, nucleus  
    d. Translation, ribosome 

11. Which type of RNA carries the code from the nucleus to the ribosome?
    a. mRNA  
    b. tRNA  
    c. rRNA  
    d. DNA 

12. Which part of a chromosome has the code for a protein?
    a. Chromosome  
    b. Allele  
    c. Gene 
    d. Nucleus 

13. What type of bond hold nitrogen bases together?
    a. Covalent  
    b. Ionic  
    c. Hydrogen 
    d. No bond 

14. Which nucleotide base is not found in an RNA molecule?
    a. Cytosine  
    b. Adenine  
    c. Uracil  
    d. Thymine 

15. Which of the following would represent the DNA sequence for which the mRNA sequence was made?
    mRNA sequence: CUCAAGUGCUUC
    a. CUCAAGUGCUUC  
    b. GAGUUCACGAAG  
    c. GAGTTCACGAAG  
    d. AGACCTGTAGGA 

16. Unlike DNA, RNA
    a. Is a polymer made up of nucleotides  
    b. Contains the nitrogen base, thymine 
    c. Contains the sugar ribose 
    d. Does not contain the nitrogen base, uracil 

17. _______ and _________ are the scientists credited with discovering the structure of DNA.
    a. Franklin and Watson  
    b. Crick and Hooke  
    c. Franklin and Crick 
    d. Crick and Watson 

18. The tRNA sequence for the mRNA listed in number 15 is
    a. GAGUUCACGAAG  
    b. GAGTTCACGAAG  
    c. CUCGAACGUCUU  
    d. CUUCGUGAUCUU 

19. The diagram below shows the bases found on a section of an mRNA molecule. Suppose a mutation caused the sixth base in the sequence below to change from cytosine to guanine. Explain how this error would affect the final chain of amino acids.
    a. The protein would not change 
    b. The protein would be larger than needed because transcription would not end 
    c. The protein would have one wrong amino acid inserted 
    d. The protein would shorter because of early termination of the gene sequence
20. Using the images above, what is the correct sequence of amino acids produced?
   a. TYR-LEU-GLY-LEU-ILE
   b. TYR-PHE-GLY-SER-ILE
   c. ILE-LEU-GLY-LEU-TYR
   d. ILE-PHE-GLU-SER-PR
Genetics

1. The father of genetics is

2. What is the probability that the offspring of a homozygous dominant individual and a homozygous recessive individual will exhibit the dominant phenotype?
   a. 25%        b. 50%        c. 75%        d. 100%

3. In certain flowers, red is incompletely dominant over white. If a pure red is crossed with a pure white, all offspring will be

4. The passing of traits from parents to offspring is called

5. An example of a sex linked trait is:
   a. Hemophilia        c. Sickle Cell Anemia
   b. Down syndrome        d. Cystic Fibrosis

6. Using the image above. Which individuals would express the trait?
   a. A, E, G only        c. B and H only
   b. C, D, F only       d. B, C, D, F, H only

7. Mendel’s findings that the inheritance of one trait had no effect on the inheritance of another became known as
   a. Dominance        c. Separate convenience
   b. Universal inheritance   d. Independent Assortment

8. The phenotype of an organism
   a. Represents its genetic composition
   b. Reflects all the traits that are actually expressed
   c. Each gene of an organism ends up in a different gamete
   d. Each gene is found on a different molecule of DNA
9. An individual that is heterozygous tall for a trait and an individual homozygous short for the trait are crossed and produce many offspring that are
   a. All the same genotype  
   b. Of two different genotypes  
   c. Of three different genotypes  
   d. Of four different genotypes

10. Tallness is dominant to shortness in pea plants. Which of the following represents a genotype of a pea plant that is heterozygous tall?
   a. T  
   b. TT  
   c. Tt  
   d. tt

In humans, having freckles (F) is dominant to not having freckles (f). The inheritance of these traits can be studied using a punnett square similar to the one pictured here.

11. Refer to the illustration above. The genotype represented in box “1” is the Punnett square would
   a. Be homozygous for freckles  
   b. Be heterozygous for freckles  
   c. Have an extra freckle chromosome  
   d. Not have freckles at all

12. Refer to the illustration above. The genotype that is in box “3” of the Punnett square is
   a. FF  
   b. Ff  
   c. ff  
   d. None of the above

13. Refer to the illustration above. The genotypic ratio of the Punnett square would be
   a. 1:1  
   b. 3:1  
   c. 1:3  
   d. 1:2:1

14. Refer to the illustration above. This is a dihybrid cross because
   a. The organisms that were crossed die.  
   b. It crosses two traits.  
   c. There are two results for every cross.  
   d. The only offspring are heterozygous.

15. Refer to the illustration above. The phenotype represented by the cell labeled “1” is
   a. Round, yellow  
   b. Round, green  
   c. Wrinkled, yellow  
   d. Wrinkled, green

16. Refer to the illustration above, The genotype represented by the cell labeled “2” is
   a. RRYY  
   b. RrYY  
   c. RrYy  
   d. rrYy
17. Which of the following is the best explanation for the observation that females rarely get the disease colorblindness?
   a. Large quantities of male hormones are necessary in order for the gene carrying the disease to be expressed
   b. Female fetuses that carry the gene die before birth
   c. The only way for a female be colorblind is having a colorblind dad and a mother who also has the gene.
   d. A female could only be colorblind by having both parents that are carriers of the gene.

18. Which of the following is controlled by codominance in humans?
   a. Sickle cell anemia  
   b. Blood type  
   c. Hemophilia  
   d. Cystic fibrosis

19. What would be the blood type of a person who inherited an A allele from one parent and an O allele from the other?
   a. Type A  
   b. Type B  
   c. Type AB  
   d. Type O

20. While studying several generations of a particular family, a geneticist observed that a certain disease was found equally in males and females and all the children who had the disease had parents that has the disease. The gene coding for this disease is probably
   a. Sex-linked recessive  
   b. Sex-linked dominant  
   c. Autosomal recessive  
   d. Autosomal dominant
Classification

1. Which characteristic is shared by most plants but not by any fungi?
   a. Ability to photosynthesize  
   b. Ability to reproduce sexually  
   c. Cell walls  
   d. Membrane-bound nuclei

2. A group of similar species is called a ____.
   a. Class  
   b. Genus  
   c. Order  
   d. Variation

3. How do protists differ from plants and animals?
   a. Protists are usually unicellular.  
   b. Protists have many nuclei in each cell.  
   c. Protists produce their own food.  
   d. Protists usually lack DNA.

4. Linnaeus’s system of naming organisms was called ____.
   a. Binominal nomenclature  
   b. Common names  
   c. Spontaneous generation  
   d. Taxonomy

5. ____ is an organism’s internal and external structure and appearance.
   a. Homology  
   b. Morphology  
   c. Analogy  
   d. Biogenetics

6. What do you call it when two species become dissimilar because they are living in different environments?
   a. Bi-evolution  
   b. Co-evolution  
   c. Convergent Evolution  
   d. Divergent Evolution

7. A ____ is a group of organisms that can create fertile offspring.
   a. Genus  
   b. Kingdom  
   c. Phylum  
   d. Species

8. _____ was the first to classify organisms.
   a. Carlos Linnaeus  
   b. Aristotle  
   c. Robert Hooke  
   d. Antoine van Leeuwenhoek

9. Which of the following hierarchical levels of classification would include the most organisms?
   a. Class  
   b. Family  
   c. Order  
   d. Genus

10. Scientist discover an underwater cave that has a new, multicellular species within it. When they examine the species more carefully, they notice that it has a nucleus, is heterotopic and does not have a cell wall. What kingdom should the scientist place the new organism?  
   a. Eubacteria  
   b. Plant  
   c. Animal  
   d. Protist

11. Scientist notice an underwater volcano vent that has temperatures that are almost boiling near it. They take a water sample from that area back to their lab for further study. Under the microscope, they notice they have unicellular organisms that do not have a nucleus in them. Which kingdom is this organism classified in?  
   a. Archaebacteria  
   b. Eubacteria  
   c. Protist  
   d. Fungi

12. When in the rainforest of South America, scientist discover a small colonial organism. They take a sample and examine it more closely. The organism is multicellular and when they look at the cells, the scientist see a nucleus, cell wall and chloroplast. Which kingdom does this organism belong to?  
   a. Fungi  
   b. Plant  
   c. Eubacteria  
   d. Protist
13. Which of the following is the correct scientific names for humans?
   a. Homo sapiens  b. Homo sapiens  c. H. sapiens  d. They are all correct

14. Scientists proposed a classification system that set up six kingdoms, including Archaebacteria and Eubacteria. What is a key difference between species in these two kingdoms?
   a. Archaebacteria can survive in extreme environments that eubacteria cannot tolerate.
   b. Eubacteria are relatively large single-celled organisms compared with archaeabacteria.
   c. Archaebacteria live in colonies, while eubacteria live as separate cells.
   d. Eubacteria are eukaryotes, while archaeabacteria are prokaryotes.

Use the following chart to answer questions 15-16.

<table>
<thead>
<tr>
<th>KINGDOM:</th>
<th>Animalia</th>
<th>Animalia</th>
<th>Animalia</th>
<th>Animalia</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYLUM:</td>
<td>Chordata</td>
<td>Chordata</td>
<td>Chordata</td>
<td>Chordata</td>
</tr>
<tr>
<td>CLASS:</td>
<td>Mammalia</td>
<td>Mammalia</td>
<td>Mammalia</td>
<td>Mammalia</td>
</tr>
<tr>
<td>ORDER:</td>
<td>Carnivora</td>
<td>Carnivora</td>
<td>Cetacea</td>
<td>Carnivora</td>
</tr>
<tr>
<td>FAMILY:</td>
<td>Canidae</td>
<td>Canidae</td>
<td>Delphinidae</td>
<td>Felidae</td>
</tr>
<tr>
<td>GENUS:</td>
<td>Canis</td>
<td>Chrysocyon</td>
<td>Tursiops</td>
<td>Panthera</td>
</tr>
<tr>
<td>SPECIES:</td>
<td>familiaris</td>
<td>brachyurus</td>
<td>Truncates</td>
<td>tigris</td>
</tr>
<tr>
<td>COMMON NAME:</td>
<td>Dog</td>
<td>Wolf</td>
<td>Dolphin</td>
<td>Tiger</td>
</tr>
</tbody>
</table>

15. Which animals are more closely related?
   a. Tiger and Dolphin  
   b. Wolf and Tiger  
   c. Dog and Wolf  
   d. Dog and Dolphin

16. Write the scientific name for the tiger.
   a. Pantheria tigris  
   b. Felidae panther  
   c. Felidae tigris  
   d. Tigris pantheria

17. Use the dichotomous key to classify the following Wacky Organism.
   a. Ru-ela Brella  
   b. Giggles  
   c. Rita Nita  
   d. Grif Leon

18. Use the dichotomous key to classify the following Wacky Organism.
   a. Grif Leon  
   b. Eggur Ondy  
   c. Mosk Cara  
   d. Hex Oculate
19. Which animal is most closely related to rodents and rabbits?
   a. Primates  
   b. Crocodiles  
   c. Sharks  
   d. Birds

20. What are the shared derived characteristics of primates and ray-finned fish?
   a. Four limbs, amniotic egg, and hair  
   b. Four limbs and amniotic egg  
   c. Eggs with shells  
   d. Bony skeleton and vertebra
APPENDIX D: QUIZZES

Protein Synthesis

1. What does DNA stand for?
2. You have a DNA strand C A T C G G. What would the complementary DNA strand consist of?
3. Describe what DNA looks like in detail.
4. What is the overall function of RNA?
5. List the three types of RNA and give their specific function.
6. You have a DNA strand that consist of A T C G A T T. What would be the mRNA that would correspond with it?
7. What is the structure pictured below? Label each part.

8. Contrast DNA and RNA. (3 reasons)
9. Transcribe and Translate the following:
   T A C A G G T T C C C T
Genetics
1. Who is the father of genetics?

2. Which law states that the two alleles for a trait split during the formation of gametes?

3. What is heredity?

4. Which law states that the inheritance of one trait has no effect on the inheritance of another trait?

5. In pea plant’s height, tall (T) is dominant to short (t).
   a. List a homozygous recessive genotype for pea plants.
   b. List one genotype that would allow for tall plants.
   c. The phenotype for Tt is ____.

6. In humans, free earlobes are dominant to attached earlobes. A homozygous recessive individual and a heterozygous individual have children.
   a. Draw a Punnett Square to show the cross.
   b. List all genotype(s) of the offspring.
   c. List all phenotype(s) of the offspring.

7. In some rabbits, fur color is incompletely dominant. A black rabbit mates with a white rabbit.
   a. Draw a Punnett Square to show the cross.
   b. List all genotype(s) of the offspring.
   c. List all phenotype(s) of the offspring.

8. In some cows, fur color is codominant. A black cow mates with a white cow.
   a. Draw a Punnett Square to show the cross.
   b. List all genotype(s) of the offspring.
   c. List all phenotype(s) of the offspring.

9. List one example of a sex linked trait.

10. It is very unlikely for a woman to exhibit a sex-linked genetic disorder. Explain why.

11. If a male exhibits a X-linked trait, what can be said about all of his daughters?

12. Why is the image above considered a dihybrid cross?

13. The genotype for the blue box is ____.

14. The phenotype for the blue box is ____.

15. Which individuals in generation three show the trait?

16. How is individual II-1 related to individual II-4?

17. Could this trait be considered sex-linked? Explain why you think so.

18. Could this trait be considered dominant? Explain why you think so
Classification

1. What is a taxonomist?
2. Define classification.
3. A group of similar classes is called a ____.
4. Put the following in order from largest to smallest: Family, Phylum, Domain, Order, Kingdom
5. Why were bacteria separated into two different domains?
6. Identify two characteristics that make animals different from plants?
7. Why were fungi not considered as part of the plant kingdom?
8. What characteristics would an organism have to have to be classified as a protist?
9. Differentiate between the terms analogous and homologous.
10. What is one structure that is analogous to a bat wing? Why?

11. Use the following dichotomous key to identify the names of the following shapes.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Object has only straight lines on the outside, go to 2</td>
</tr>
<tr>
<td></td>
<td>Object has at least one curved line on the outside, go to 4</td>
</tr>
<tr>
<td>2</td>
<td>Object is filled in---Azul calamus</td>
</tr>
<tr>
<td></td>
<td>Object is not filled in, go to 3</td>
</tr>
<tr>
<td>3</td>
<td>Object has four equal sides---Quadratis rufus</td>
</tr>
<tr>
<td></td>
<td>Object sides are not equal---Rectangulo crudus</td>
</tr>
<tr>
<td>4</td>
<td>Object has one continuous curving line, go to 5</td>
</tr>
<tr>
<td></td>
<td>Object has curved and straight lines---Azul undo</td>
</tr>
<tr>
<td>5</td>
<td>Object is filled in---Ovalado rufus</td>
</tr>
<tr>
<td></td>
<td>Object is not filled in---Orbis crudus</td>
</tr>
</tbody>
</table>

a. 

b. 

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Rebecca Lynn Kling Achord was born in Baton Rouge, Louisiana in March 1981 to Randy and Rhonda Kling. She attended George Washington Carver Primary and Gonzales Middle School before she graduated with distinguished honors from East Ascension High School in Gonzales, Louisiana in May 1999. The following August, she entered Louisiana State University Agricultural and Mechanical College and in December 2003 earned a Bachelor of Science. Rebecca entered graduate school in May 2005 at Louisiana State University Agricultural and Mechanical College and earned her Master of Education in August 2006. She reentered graduate school at Louisiana State University Agricultural and Mechanical College in May 2013 and is a candidate for Master of Natural Sciences. Rebecca has been a high school teacher at Dutchtown High School in Geismar, Louisiana in Ascension Parish for nine years where she teaches Biology and Health Science II and heads the biology department.