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## Impact of teaching style on student learning of evolution

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# IMPACT OF TEACHING STYLE ON STUDENT LEARNING OF EVOLUTION

A Thesis

Submitted to the Graduate Faculty of the  
Louisiana State University and  
Agricultural and Mechanical College  
in partial fulfillment of the  
requirements for the degree of  
Master of Natural Sciences

in

The Interdepartmental Program in Natural Sciences

by

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B.S., Southeastern Louisiana University, 2002  
August 2012

## Table of Contents

|   |     |
|---|-----|
| List of Tables .....  | iii |
| List of Figures .....   | iv  |
| Abstract .....  | v   |
| Introduction .....  | 1   |
| Literature Review .....   | 5   |
| Methods .....   | 8   |
| Data and Results .....  | 10  |
| Conclusion .....  | 19  |
| References.....   | 21  |
| Appendix A: Principles of Effective Teaching.....                     | 23  |
| Appendix B: Key Concepts from the CINS.....                           | 23  |
| Appendix C: Menu of 12 Ways to Learn Complex Phenomena.....           | 24  |
| Appendix D: Outline of Daily Lessons.....                             | 24  |
| Appendix E: Evolution Guided Notes.....                               | 25  |
| Appendix F: Evolution Power Point.....                                | 29  |
| Appendix G: Natural Selection Activity .....                          | 38  |
| Appendix H: Individual Accountability, The Making of the Fittest..... | 46  |
| Appendix I: Blackboard Screen Shot .....                              | 47  |
| Appendix J: IRB Exemption .....                                       | 48  |
| Vita .....  | 49  |

## List of Tables

|  |    |
|--|----|
| Table 1 A: Results, 2011 .....   | 12 |
| Table 1 B: Results, 2012.....  | 12 |
| Table 2: Analysis of Homogeneity between Inquiry and Lecture, Pre-Test.....  | 13 |
| Table 3: Analysis of Differences between Inquiry and Lecture, Post-Test..... | 14 |
| Table 4: Analysis of Differences between Inquiry and Lecture, by Topic ..... | 14 |
| Table 5: ANOVA Analysis.....   | 16 |

## List of Figures

|   |    |
|---|----|
| Figure 1: Bar graph of 2011 raw data.....   | 13 |
| Figure 2: Bar graph of 2012 raw data.....   | 13 |
| Figure 3: Bar graph of percent correct, by topic, 2011.....   | 15 |
| Figure 4: Bar graph of percent correct, by topic, 2012.....   | 15 |
| Figure 5: Bar graph of percent correct, Unit Evolution Exam.....  | 16 |
| Figure 6: Bar graph of combined post-tests for both years.....  | 17 |
| Figure 7: Bar graph of raw scores, by topic, showing comparisons between pre-<br>and post-tests (2011)..... | 17 |
| Figure 8: Bar graph of raw scores, by topic, showing comparisons between pre-<br>and post-tests (2012)..... | 18 |

## **Abstract**

Natural selection is a topic that is laden with misconceptions. These misconceptions are often not addressed, and students can leave a biology classroom with the same incorrect ideas that they entered with. These misconceptions can be identified and addressed by using the Concept Inventory of Natural Selection (CINS). Furthermore, by teaching using methods that encourage hands-on, inquiry based techniques, students are more apt to reconcile these misconceptions and have a deeper understanding of the natural selection process.

The goal of my research was to show a positive correlation between reduction in student misconceptions about natural selection and inquiry based activities. Five classes of students (145 total students) completed the CINS twice; once as a pre-test, and again as a post-test. Three classes had the natural selection unit delivered in a lecture-based format with no hands-on activities. Two classes had the unit delivered with no lectures, but instead with inquiry activities that utilized methods and practices from the Reformed Teacher Observation Protocol (RTOP). Data was collected from both classes and compared. If teaching method plays a significant role in decreasing student misconceptions, there would be a statistically significant difference in gains between the teaching styles, which there was.

## **Introduction**

As a teacher, there is nothing more frustrating than spending several weeks on a topic, only to give an assessment and discover that my students have made no gains in their knowledge about that topic. This is particularly evident at my school. As an academic magnet high school, my students are very grade driven. They are experts on regurgitating information, however I have found that while they may know the “language” of science, they are extremely weak in relating various topics to one another, or using previous knowledge and connecting it to new ideas. For example, my students can take notes on Lamarck’s Theory of Evolution, the theory of use and disuse as mechanisms of evolution. However, their knowledge extends to strictly being able to define this theory; they are unable to apply the information to a given scenario, such as “why do giraffes have such long necks?” This frustration has led me to focus on how what I do in the classroom affects my students’ ability to understand complex topics and overcome misconceptions. By making students active participants in the learning process, I will help them understand the importance of true learning and rectify their misconceptions. I will focus my efforts on the topic of Natural Selection.

There has been much research done about how students learn best, and ways to differentiate learning. However, students are still falling behind in both math and science. In order to address this, many school districts, including East Baton Rouge Parish, have implemented reform and required teachers to reevaluate their own teaching methods. Garvin-Doxas states “to be successful, the driving force behind education reform should focus less on rote knowledge but more on students attaining a deeper conceptual understanding” (Garvin-Doxas *et al.*, 2008). In my own classroom, I can achieve this level of deeper student knowledge through encouraging my students to think like scientists, rather than to regurgitate information from a lecture. One

research-proven technique of inquiry-based instruction is demonstrated in the Reformed Teacher Observation Protocol (RTOP).

Most advocates support teaching and learning science in a student-centered manner; however, evaluation tools are not aligned to these efforts (Sawada *et al.*, 2002). RTOP was developed as a way to quantitatively measure how effective teachers were in the classroom. RTOP focuses on three major areas:

- Lesson design and implementation (focus on inquiry and exploration)
- Content (tying propositional knowledge and procedural knowledge together)
- Classroom Culture (diverse and decentralized communication)

Data from RTOP suggests that when teachers invest in a student-driven curriculum, student learning is enhanced and significant gains are shown (Sawada *et al.*, 2002). Specifically, RTOP focuses efforts that support “critical thinking and an environment that supports change” and a movement “away from traditional dialect and towards constructivism” (Sawada *et al.*, 2002). In order to achieve a successful RTOP classroom, the teacher must adhere to the fundamentals of effective teaching (Appendix A), as outlined by the American Association for the Advancement of Science in *Science for All Americans* (AAAS, 1989). Teachers who used the RTOP method of instruction showed a much higher gain between pre- and post- test scores than teachers who did not use the RTOP method, or used it infrequently (Lawson et al., 2002).

The use of inquiry-based, student-driven learning has been extensively researched in regards to teaching fundamentals of physics. Substantial gains were seen when interactive engagement activities were used when teaching introductory physics versus traditional lecture methods (Hake, 1998). However, not as much research has been done until recently on the effectiveness of teaching style in the biology classroom.



In order to determine if my students fully understand a particular scientific topic, a research-based assessment must be used. When studying the effectiveness of hands-on inquiry lessons in Physics, the Force Concept Inventory can be used. This assessment focuses on identifying student misconceptions, and exposing whether or not a student truly understands physics concepts on a deeper level. The Force Concept Inventory (FCI) indicated “disappointing level of understanding evidenced by students taught through standard lecture” and helped “trigger the current reform movement in physics education” (Klymkowsky *et al.*, 2008). The implementation of the Force Concept Inventory has led to radical changes in how Physics is taught, at both the high school and college level. Work is now underway to apply what was learned through the FCI to create a Biology Concept Inventory (BCI).

To create a successful BCI, several factors must be considered. It is complicated to make a clear and concise test for biological topics, specifically natural selection, because our language is filled with ambiguous words. Students and teachers fall into patterns of speaking metaphorically rather than literally (Anderson *et al.*, 2002). This can lead to misunderstandings of basic concepts, particularly in concepts related to natural selections. Ideally, a personal interview may be the best tool to identify misconceptions, but this is not feasible in most educational settings. However, when the interview and the Concept Inventory of Natural Selection (CINS) are compared, there is a positive correlation between the two. The written test includes ten natural selection/evolution concepts, with two questions for each concept (Appendix B). During the creation of the CINS, three versions were created, with Versions 2 and 3 being written to correct weaknesses in clarity and ambiguity of language. Version 3 also addressed alternative conceptions. Kuder-Richardson 20 (KR20) was used to measure the general internal consistency. This statistical test measures internal consistency of reliability for measures with two or more

dichotomous choices. KR20 for the CINS, version 3 test was measured at a coefficient of 0.64, with a good classroom test being one with a reliability coefficient of 0.60 or higher (Anderson *et al.*, 2002). For this research, Version 3 of CINS was used.

After Version 1 was field tested, it was noted that students fundamentally lack understanding about random processes (Garvin-Doxas *et al.*, 2008). Students are resistant to describe random events as the underlying process that drives natural selection. These same students prefer using the existence of drivers; in explanations, the students rarely understood that random events take place all of the time, giving rise to emergent behavior. In order to address these misconceptions, teachers must focus on an appreciation of randomness. To do this, I will design lessons that make my students explicitly state and confront their assumptions. These lessons will involve direct experimentation on randomness in a specific process. For example, students could examine how allele loss can result from selection OR genetic drift, or both. There are several computer models and simulations to test and retest student assumptions for validity. A valuable tool that addresses all of these is Ed's tool (<http://bioliteracy.colorado.edu/Literacy.shtml>), an online collaboration that specifically looks at student misconceptions through an online Biology Concept Inventory (Klymkowsky *et al.*, 2008).

## Literature Review

In 2001, the University of Nevada, Reno, completed a study comparing teaching style (lecture versus inquiry) in an introductory undergraduate biology class for non-science majors. Researchers created two courses, Biology 100 (lecture and lab, for education majors) and Biology 110 (inquiry, for education majors). Researchers also used a third group for comparison (also named Biology 100) which included those students enrolled in a traditional class (lecture and lab) that were not education majors. Students were given the option of which class to take, however all groups were required to take a pre- and post-test, the NABT Biology Test. The lecture class was taught in a traditional format, which included a weekly lab. In the inquiry group, students participated in hands-on investigations that integrated scientific methodology. This group also participated in two lab meetings per week, which focused on student reflection and discussion. The traditional class was a mix of both lecture and inquiry. Sample size varied greatly between the three groups; Biology 100 (traditional, education majors) had 194 students ( $n=194$ ) while Biology 110 (inquiry, education majors) only had 14 students ( $n=14$ ) and Biology 100 (traditional, non-education majors) had 15 students ( $n=15$ ). ANOVA statistical analysis was used to analyze these three groups. ANOVA testing concluded that while sample sizes differed greatly, there was no significant difference between the pretest scores ( $p= 0.05$ ) and the groups were considered homogeneous. A second ANOVA analysis was run on the post-test scores of both groups, finding a significant difference between the three groups ( $p=0.001$ ). Therefore the researchers concluded that instructional format did prove to make a significant difference in the content learned in class (Wilden, *et al.*, 2002). One of the weaknesses of this study is one I found in my own research, namely limited sample size. A second weakness in this study was in the different content covered by different instructors. There was no guarantee that all of the

instructors were covering all of the same material, and at the same depth as each other. The overall quality of instruction could have been the determinant of success, rather than lecture versus inquiry lessons. Finally, more research should be completed on other majors, not only education majors; perhaps the inquiry methods used only benefit education majors.

A second study was conducted at the University of South Carolina (Timmerman, et al., 2008). The focus of this study was to investigate pre- and post-knowledge content in the areas of biodiversity, evolution, and plant and animal physiology. The researchers compared inquiry based teaching methods versus traditional, didactic methods. The study also examined student misconceptions to determine where the most emphasis should be placed when teaching these topics. The study took place over five semesters of the same introductory Biology course. A total of 1493 students ( $n=1493$ ) were given both the pre- and post-test. The test consisted of 40 multiple-choice items with ten corresponding to each of the major topics (biodiversity, evolution, and plant and animal physiology). The pre-test was administered during the first week of classes and the post-test during the last week. This was a faculty created test; this could be a weakness of this research if this test was biased toward inquiry learning (the tests were not available for review).

Researchers found notable gains in all of the topics presented, regardless of the method used to present the material. Where previously noted research has indicated that inquiry based methods were most effective in producing gains (Hake, 1998), this study does not agree. Researchers used effect sizes to determine gains. Effect sizes allow comparison of the student gains across varying methodologies. "An effect size is a measure of the pretest and post test scores normalized by the standard deviation in the pretest population." Gains were seen in all topics with an average effect size ranging from 1.0 to 2.1 (with an effect size of 1.0 considered a strong result). In biodiversity

and evolution, highest gains were seen using the inquiry method (average effect for all students  $1.0 \pm 0.1$  and  $1.1 \pm 0.3$ , respectively). However, greater gains were seen in plant and animal physiology using the traditional, didactic methods ( $1.8 \pm 0.2$  and  $2.1 \pm 0.4$ , respectively). The single largest effect found ( $3.7 \pm 1.4$ ) was in the primary literature part of the biodiversity unit, which was taught using inquiry methods. These results suggested that inquiry teaching of abstract topics produces more gains versus traditional lecture. However, this study also shows that teaching concrete topics such as physiology using didactic methods is more effective than inquiry methods. The research done in this study cannot definitively state that inquiry methods are always the better choice over traditional lecture methods (Timmerman, et al., 2008).

When creating the inquiry lessons to be used in my classes, emphasis was placed on teaching tools that were shown to be effective in helping students become comfortable using inquiry to learn. At Indiana University, an inquiry-based developmental biology course was used as a model. While this class did not focus on the same topics as my study, the authors' *Menu of 12 Ways to Learn Complex Phenomena* (Appendix 3) was extremely useful. The author's developmental biology course focuses on using the Socratic method, and the majority of students enrolled earned either an A or B (Malacinski, 2003). While this paper was helpful with providing guidance to the "how" of inquiry, the paper presented no research showing that this developmental biology class was more effective than the traditional lecture-based developmental biology class. These three papers provided the guidance to construct my own investigation into knowledge gains and elimination of misconceptions through inquiry lessons.

## Methods

Data was collected from two different academic years, all from high school freshman Biology I classes. Students are in a regular class, however the school as a whole is a magnet school. Demographically, the classes are 44% Caucasian, 42% African American, 10% Asian, 2% Hispanic, and 2% classified as other. Likewise, 25% of the students qualified for free or reduced lunch, an indicator of poverty. In 2011, a total of 58 students were enrolled in the class (n=58). In 2012, a total of 87 students were enrolled in the class (n=87).

Students entering Biology I have limited knowledge of evolutionary topics. As a whole, their previous content exposure in biology was delivered in a middle school life science class. This unit of content is delivered midway through the semester (samples of content can be found in the Appendixes); the students are both familiar with my methodology and comfortable asking questions. This is evident by their willingness to ask the same question many different ways, and successful completion of daily “exit tickets” and “bell-ringers” (quick opening and closing questions/reflections completed by students in journals, checked by me bi-weekly). Entering into this unit, all of the classes share a class average of “C” and are all at a level to understand these complex topics. A unit of genetics has just been completed and students understand genetic diversity and mutations; a class average of 86% mastery. Extra reinforcement of activities and lectures are available for all students in the form of textbook readings and workbook study questions.

At the beginning of every new unit, students were given a pre-test. For this particular unit, *The Natural Selection Concept Inventory* was used. This test consists of twenty questions, with two addressing each of the topics listed in Appendix B. Of the five biology classes, three were delivered in a lecture-based format, while two will be taught using inquiry-based methods.

However, all classes covered the unit in the same amount of time, six 90-minute class periods. The pre- and post-tests were given on the first and last day of the unit.

Materials used in both methods are outlined (Appendix D) and specific examples are also included in an appendix. Specific material can be furnished upon request. Lectures were delivered using power point presentations and guided notes. All students had access to both through Blackboard ®, an online educational tool. Inquiry activity instructions were given to the class as a whole, followed by cooperative grouping of 3-4 students. Students were grouped heterogeneously (based on results from the previous Genetics unit), with weaker students paired with higher performing students. Individual accountability was ensured through analysis questions (completed at home); this was done not only as reinforcement, but to assure that weaker students were not using stronger students as a crutch. Misconceptions were addressed as they surfaced with both groups. However, these misconceptions were addressed in whole class format for lecture driven classes, and individually or as peer groups in the inquiry class.

## Data and Results

After the initial pre-test was given to all students, it was analyzed to determine that all of the students had the same knowledge going in to the Evolution Unit. The students in the 2011 lecture classes ( $n=30$ ) scored a mean of 7.2 ( $\pm 0.5$ ) while the inquiry ( $n=28$ ) classes scored a mean of 8.9 ( $\pm 0.6$ ) (Table 1A). A statistical t-test between the groups produced a  $p= 0.84$ , with a  $p>0.05$  showing a homogeneous grouping (Table 2). The students in the 2012 lecture classes ( $n=57$ ) scored a mean of 6.1 (error in the mean of  $\pm 0.4$ ) while the inquiry classes ( $n=30$ ) scored a mean of 6.9 (error in the mean of  $\pm 0.6$ ). A student t-test between the 2012 groups produced a  $p= 0.206$ , with a  $p>0.05$  showing a homogeneous grouping (Table 2). To further test the groups for homogeneity, I also completed a single-factor ANOVA test of all pre-test scores, producing a  $p= 0.28$  (Table 5). The accepted  $p$  value to determine homogeneous class make-up is  $p > 0.05$ ; because both sets of classes compared demonstrated a value greater than 0.05, I will assume that all students came into the class with the same basic knowledge of evolutionary topics.

Upon completion of the unit, students were given the post-test, which was the same as the pre-test. Initially, a single-factor ANOVA analysis was run on all groups to check if there was any difference between groups. A  $p<0.05$  would indicate that there was a statistical difference between the groups. A value of  $p=0.0047$  was calculated, indicating there was a difference between the groups (Table 5).

The 2011 lecture classes scored a mean of 15.2 ( $\pm 0.5$ ) and the inquiry classes scored a mean of 16.7 ( $\pm 0.5$ ) (Table 1A). Both raw gains and normalized gains ( $g$ ) were calculated, and are noted on Table 1A. The 2011 lecture class was calculated to have a  $g$  value of +0.6, while the inquiry class showed a  $g$  value of +0.8. The 2012 lecture classes scored a mean of 16.4 ( $\pm 0.4$ ) while the inquiry classes scored a mean of 17.7 ( $\pm 0.5$ ) (Table 1B). The 2012 lecture class was



calculated to have a  $g$  value of +0.7, while the inquiry class showed a  $g$  value of +0.8. Both classes showed gains (Figures 1,2,6), but because I was more interested in which method, inquiry versus lecture, achieved higher scores, I completed a t-test comparing the groups. In 2011, the comparison of scores for inquiry versus lecture classes produced a  $p$  value of 0.046, and in 2012 a  $p$  of 0.016 (Table 3). During both years, the  $p$  value was less than 0.05, so it appears that the teaching methods produced different results. Finally, based on the comparison of normalized gains, the inquiry classes showed a larger gain.

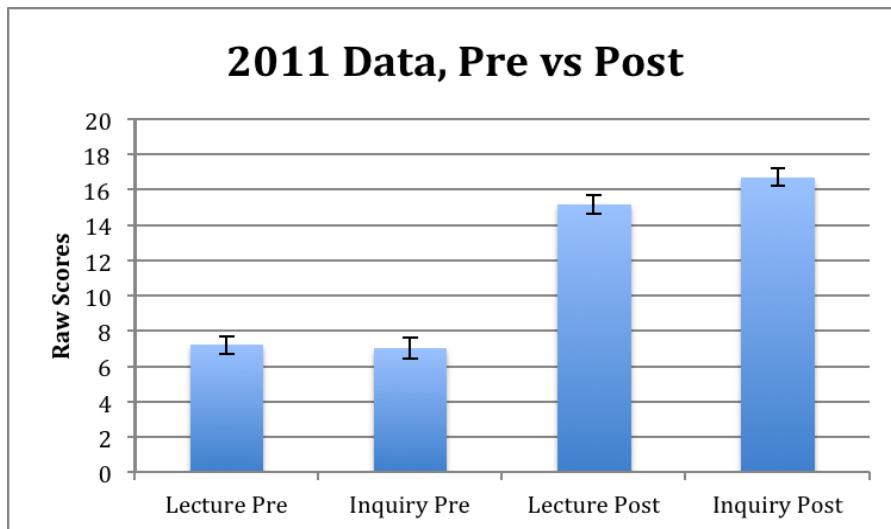
However, when the classes were broken down by the various categories, certain areas showed a statistical difference, while others did not (Table 4, Figures 3,4). In 2011, acceptable  $p$  values, less than 0.05, were calculated in both the areas of *Stable Populations* and *Differential Survival*. However, all of the other categories were above the 0.05 threshold. In 2012, only the *Natural Resources* and *Variation Inherited* showed statistical differences between the two teaching types. Finally, I looked at overall performance on this unit on my exam. This was a cumulative test, 75 multiple choice questions and 6 constructive response questions. On this exam, more topics were covered on evolution versus the CINS, including more discrete knowledge. The discrete portion constituted roughly 30% of the total exam. Overall, the inquiry groups did better each year (82% in 2011, 80% in 2012) versus lecture groups (76% in 2011, 79% in 2012) (Figure 5). However, when an ANOVA test was run on these groups, no significant differences were noted ( $p=0.18$ ).

**Table 1A: Results, 2011:** The calculated means, student number (n), range of uncertainties, raw and normalized gains from biology classes taught in 2011.

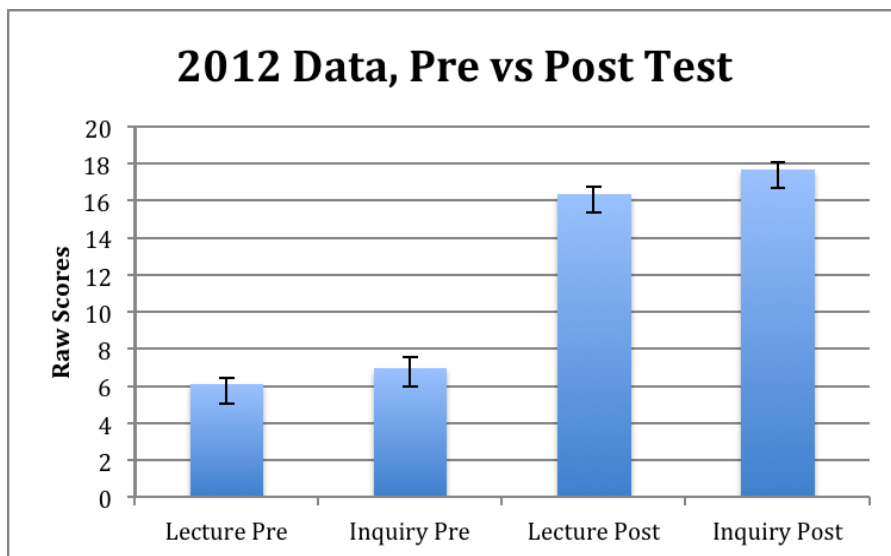
| <b>Class Type</b>    | <b>Mean</b>    | <b>N</b> | <b>Ranges</b> | <b>Raw Gains</b> | <b>Normalized Gains</b> |
|----------------------|----------------|----------|---------------|------------------|-------------------------|
| <b>Pre, Lecture</b>  | 7.2 (+/- 0.5)  | 30       | 6.7-7.7       |                  |                         |
| <b>Post, Lecture</b> | 15.2 (+/- 0.5) | 30       | 14.7-15.7     | 7.9 (+/- 0.4)    | 0.6 (+/- 0.04)          |
| <b>Pre, Inquiry</b>  | 8.9 (+/- 0.6)  | 28       | 8.3-9.5       |                  |                         |
| <b>Post, Inquiry</b> | 16.7 (+/- 0.5) | 28       | 16.2-17.2     | 9.7 (+/- 0.6)    | 0.8 (+/- 0.04)          |

**Table 1B: Results, Raw Scores 2012:** The calculated means, student number (n), range of uncertainties, raw and normalized gains from biology classes taught in 2012.

| <b>Class Type</b>    | <b>Mean</b>    | <b>N</b> | <b>Ranges</b> | <b>Raw Gains</b> | <b>Normalized Gains</b> |
|----------------------|----------------|----------|---------------|------------------|-------------------------|
| <b>Pre, Lecture</b>  | 6.1 (+/- 0.4)  | 57       | 5.7-6.5       |                  |                         |
| <b>Post, Lecture</b> | 16.4 (+/- 0.4) | 57       | 16.0-16.8     | 9.8 (+/- 0.5)    | 0.7 (+/- 0.03)          |
| <b>Pre, Inquiry</b>  | 6.9 (+/- 0.6)  | 30       | 6.3-7.5       |                  |                         |
| <b>Post, Inquiry</b> | 17.7 (+/- 0.4) | 30       | 17.3-18.1     | 10.8 (+/- 0.7)   | 0.8 (+/- 0.03)          |



**Figure 1:** Bar graph representing the raw scores of 2011 pre- and post-test scores, with error bars.



**Figure 2:** Bar graph representing the raw scores of 2012 pre- and post-test scores, with error bars.

**Table 2: Analysis of Homogeneity between Inquiry and Lecture, Pre-Test:** T-test results comparing the pre-test for various categories, where  $p > 0.05$  = not statistically significant

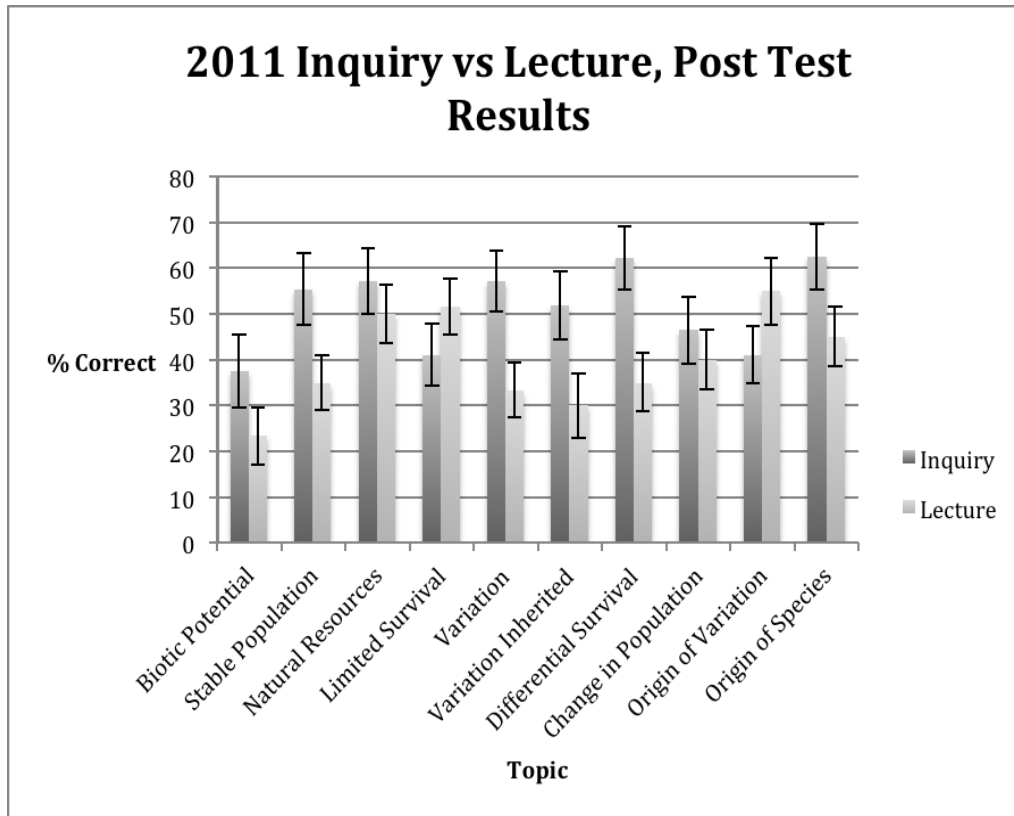
| Class Type               | T Test Results |
|--------------------------|----------------|
| 2012, Inquiry vs Lecture | 0.206          |
| 2011, Inquiry vs Lecture | 0.840          |
| Inquiry 2011 vs 2012     | 0.904          |
| Lecture 2011 vs 2012     | 0.699          |

**Table 3: Analysis of Differences between Inquiry and Lecture, Post-Test:** T-test results comparing the pre-test for various categories, where  $p < 0.05$  = significantly different.

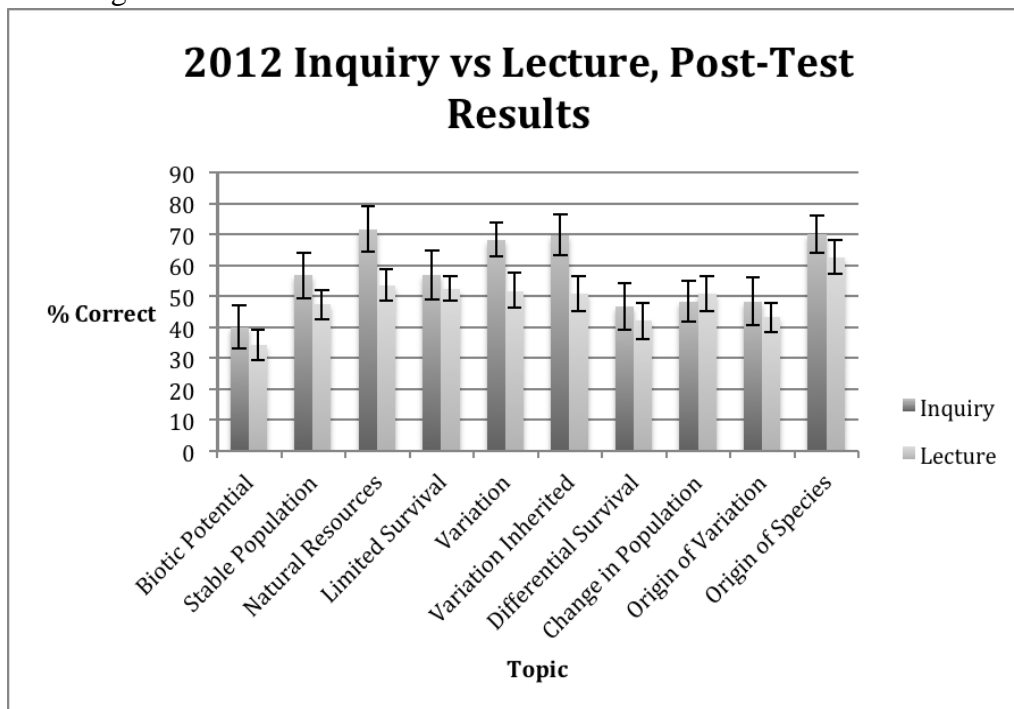
| Class Type               | T Test Results |
|--------------------------|----------------|
| 2012, Inquiry vs Lecture | 0.016          |
| 2011, Inquiry vs Lecture | 0.046          |

**Table 4: Analysis of Differences between Inquiry and Lecture, By Topic:** Calculated p values using T-test, broken down by categories presented on CINS. A  $p < 0.05$  = significantly different results between groups.

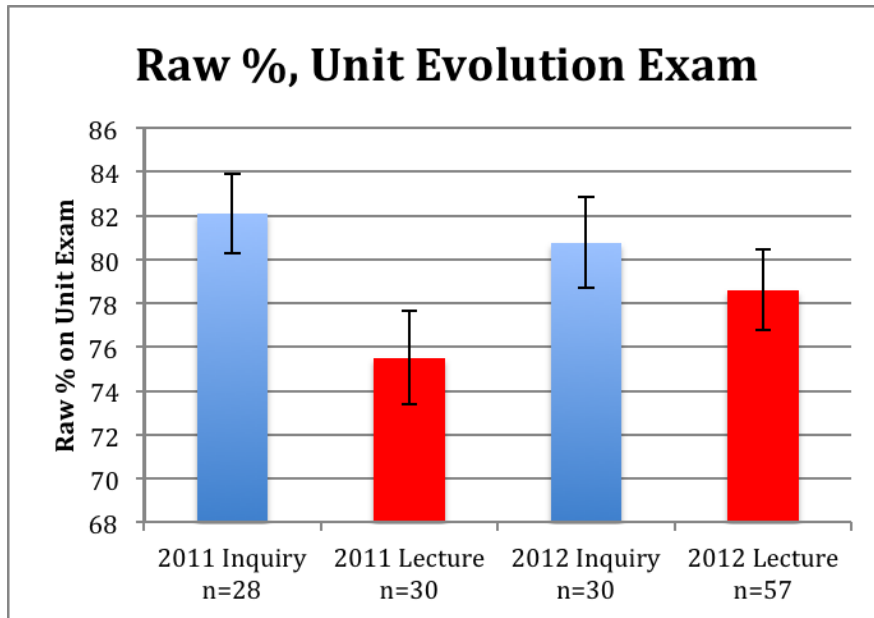
|                       | 2012, Inquiry vs. Lecture | 2011, Inquiry vs. Lecture |
|-----------------------|---------------------------|---------------------------|
| Biotic Potential      | 0.906                     | 0.591                     |
| Stable Population     | 0.620                     | <b>0.051</b>              |
| Natural Resources     | <b>0.008</b>              | 0.303                     |
| Limited Survival      | 0.108                     | 0.163                     |
| Variation             | 0.295                     | 0.415                     |
| Variation Inherited   | <b>0.018</b>              | 0.189                     |
| Differential Survival | 0.403                     | <b>0.026</b>              |
| Change in Population  | 0.128                     | 0.144                     |
| Origin of Variation   | 0.980                     | 0.453                     |
| Origin of Species     | 0.163                     | 0.703                     |



**Figure 3:** Bar graph depicting 2011 raw percentages correct for each topic, by teaching method, including error bars.



**Figure 4:** Bar graph depicting 2012 raw percentages correct for each topic, by teaching method, including error bars.

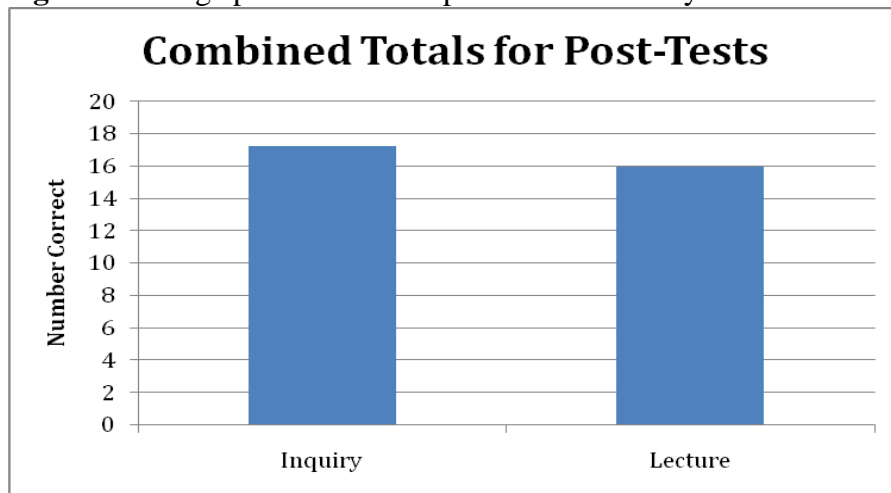


**Figure 5:** Bar graph of percent correct, Unit Evolution Exam, including error bars; ANOVA = 0.18.

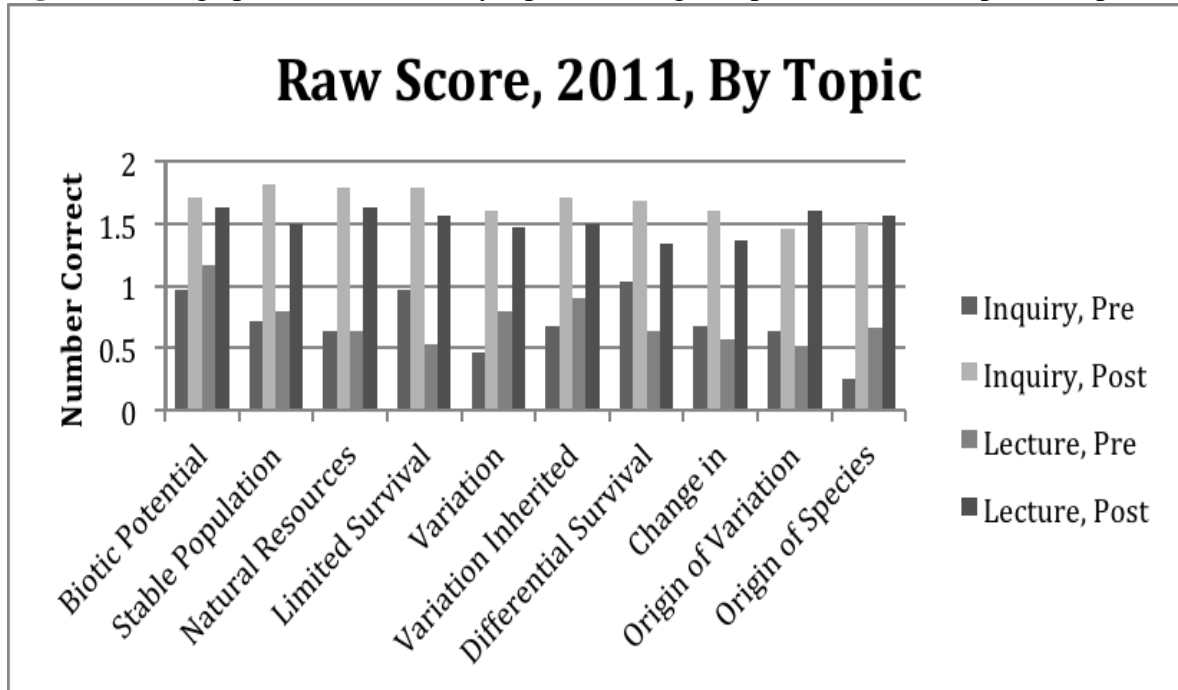
**Table 5:** Single Factor ANOVA Analysis: Table of ANOVA calculations for p values within all groups for pre- and post-tests, where a  $p > 0.05$  represents homogeneity and  $p < 0.05$  represents a difference.

|                                  |           |           |           |          |                |               |
|----------------------------------|-----------|-----------|-----------|----------|----------------|---------------|
| ANOVA<br>SUMMARY of<br>Pretests  |           |           |           |          |                |               |
| <i>Source of Variation</i>       | <i>SS</i> | <i>df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
| Between Groups                   | 34.7600   | 3         | 11.58669  | 1.27699  | 0.2846         | 2.66879       |
| Within Groups                    | 1279.35   | 141       | 9.073406  |          |                |               |
| Total                            | 1314.11   | 144       |           |          |                |               |
|                                  |           |           |           |          |                |               |
| ANOVA<br>SUMMARY: Post-<br>tests |           |           |           |          |                |               |
| <i>Source of Variation</i>       | <i>SS</i> | <i>df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
| Between Groups                   | 98.79521  | 3         | 32.93174  | 4.511796 | 0.004702       | 2.668793      |
| Within Groups                    | 1029.163  | 141       | 7.299031  |          |                |               |
| Total                            | 1127.959  | 144       |           |          |                |               |

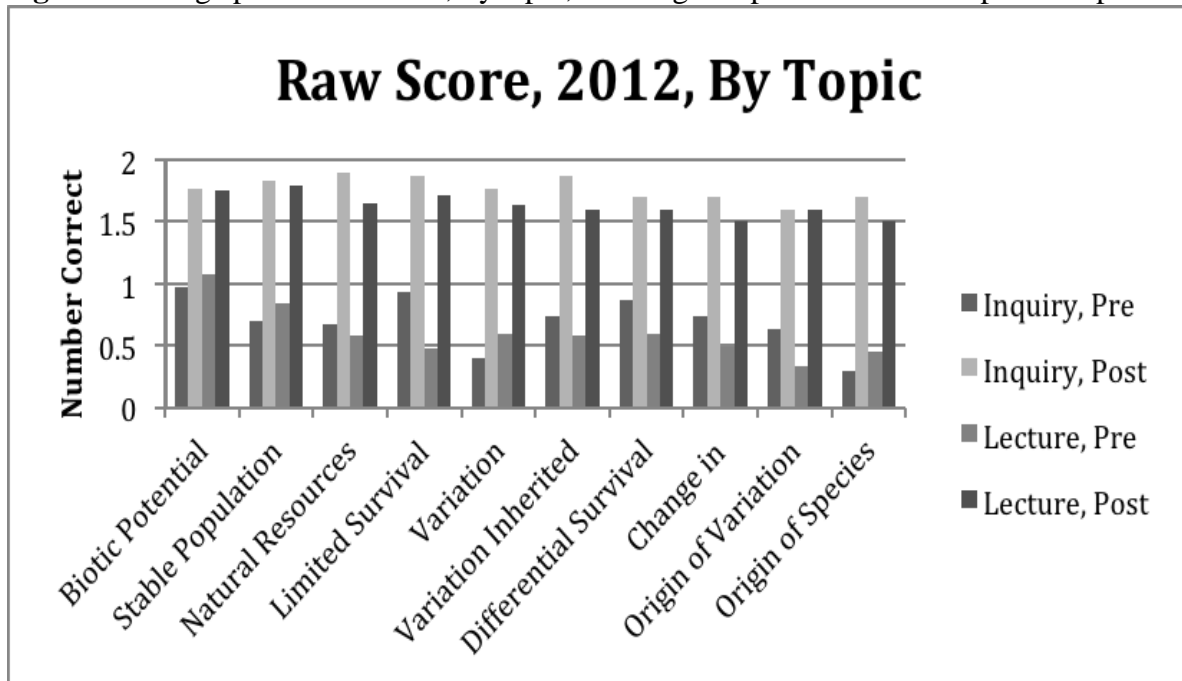
**Figure 6:** Bar graph of combined post-tests for both years



**Figure 7:** Bar graph of raw scores, by topic, showing comparisons between pre- and post-tests.



**Figure 8:** Bar graph of raw scores, by topic, showing comparisons between pre- and post-tests.





## Conclusion

Overall, analysis shows that teaching style, lecture versus inquiry, does appear to matter. In the limited scope that I was able to test my students, it does appear (based on normalized gains) students did master content better when taught using inquiry methods. While only two topics from each year showed statistical differences between the styles, 8 out of 2 topics in 2011, and 9 out of 1 topics in 2012, scored higher overall in the inquiry classes (Figures 7, 8). The likelihood that this was just a random event is low. When looking at individual topic mastery, it appears that the activities that were done enhanced student understanding of inheritance of genes, resources, stable populations, and differential survival. All of the hands-on activities that the inquiry classes completed were focused on these particular topics. The experience of actually having a tangible, student made model that represents these topics gave the inquiry students a deeper understanding of the material and allowed them to internalize the concepts, versus just memorizing information that was presented (i.e. the lecture classes). The difference between the two teaching groups on these particular topics led to an overall finding of apparent difference between the post-test scores.

Closer analysis of the data shows that besides the previously mentioned topics, the differences in other topics were not statistically different. This was due largely in part to the lack of inquiry activities targeted at those facets of evolution. Had I been able to find some great activities to supplement these ideas, I have no doubt that my inquiry students would have been statistically stronger in these areas, as well.

Overall, I would have to concur that inquiry methods do increase student understanding in complex scientific topics. However, I am still on the fence as to whether or not lecture has its place in the biology classroom. Inquiry activities use a considerable amount of time to both

prepare and implement in a high school setting. Time is something that is very limited in the Louisiana public school classroom. In an introductory biology course, many of the topics discussed are those discrete facts that lend themselves best to lecture. To truly create an ideal biology classroom, I believe both techniques are essential. Lecture to introduce new facts partnered with tactile, inquiry activities to tie the facts into over-encompassing ideas that tie all biology topics together.

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## **Appendix A: Principles of Effective Teaching**

|   |
|---|
| Teaching should be consistent with the nature of scientific inquiry:  |
| <ul style="list-style-type: none"><li>• Start with questions about nature</li><li>• Engage students actively</li><li>• Concentrate on the collection and use of evidence</li><li>• Provide historical perspectives</li><li>• Insist on clear explanations</li><li>• Use a team approach</li><li>• Do not separate knowing from finding out</li><li>• Deemphasize the memorization of technical vocabulary</li></ul> |
| Teaching should reflect scientific values:  |
| <ul style="list-style-type: none"><li>• Welcome curiosity</li><li>• Reward creativity</li><li>• Encourage a spirit of healthy questioning</li><li>• Avoid dogmatism</li><li>• Promote aesthetic responses</li></ul>   |
| Teaching should counteract learning anxieties:  |
| <ul style="list-style-type: none"><li>• Build on success</li><li>• Provide abundant experience using tools</li><li>• Support the role of girls, women, and minorities in science</li><li>• Emphasize group learning</li></ul>   |
| Science teaching should extend beyond the school  |
| Teaching should take its time   |

## **Appendix B: Key Concepts from the CINS**

|  |
|--|
| <ol style="list-style-type: none"><li>1. Biotic potential, carrying capacity</li><li>2. Resources are limited, competition</li><li>3. Limited survival</li><li>4. Genetic variation</li><li>5. Origin of variation</li><li>6. Variation is inherited</li><li>7. Differential survival, fitness, reproductive success</li><li>8. Descent with modification, evolution, change in gene pool over time, change in populations</li><li>9. Adaptation</li><li>10. Origin of the species</li></ol> |
|--|

### **Appendix C: Menu of 12 Ways to Learn Complex Phenomena**

- Begin at the beginning; select your learning style
- Collaborate
- Learn through metaphors
- Perform a context review
- Read alternative explanations
- Surf the web
- Construct a concept map
- Write it out
- Prepare a roadmap
- Construct a 3-D model
- Look at the big picture; step outside of yourself
- Work backwards, filling in gaps along the way

### **Appendix D: Outline of Daily Lessons**

|       | Lecture  | Inquiry   |
|-------|--|---|
| Day 1 | Pre-Test, Notes, Darwin and Evolution, assign WB 16-17 | (Students will have WB and reading complete prior to Day 2)<br>Pre-test, Intro to Evolution card sort and definitions |
| Day 2 | Notes, Evolution in Populations                        | HHMI Pocket Mouse Activity  |
| Day 3 | Notes, History of Life                                 | Peppered Moth Activity  |
| Day 4 | Notes, Human Evolution                                 | Fossil Activity   |
| Day 5 | Film, WB check   | Human Evolution Activity  |
| Day 6 | Post-Test  | Post-Test   |

## Appendix E: Evolution Guided Notes

### Theories of Origin

- \_\_\_\_\_
  - Belief that God created the universe and all life.
  - Cannot be \_\_\_\_\_ proven
- Life came from \_\_\_\_\_ matter.
  - \_\_\_\_\_ events resulted in the formation of the first \_\_\_\_\_.
  - Over \_\_\_\_\_ of years, these cells gave rise to life as we see it today.
  - \_\_\_\_\_
  - Scientifically \_\_\_\_\_
- \_\_\_\_\_ Origins
  - A meteor or asteroid collided with Earth and gave rise to life. (Where did this life come from?)
  - No \_\_\_\_\_, un-testable
- Theory of Evolution
  - \_\_\_\_\_ changes in a species over time.
  - Well-supported, \_\_\_\_\_

### Charles Darwin

- A \_\_\_\_\_ who traveled around the world collecting and studying \_\_\_\_\_ specimens.
- He sailed on the ship \_\_\_\_\_.
- Darwin collected many specimens of animals and plants.
- Proposed a \_\_\_\_\_ about the way life changes over time.
- Observations: Patterns of Diversity
  - Why were organisms so suited to their environment?
  - Why did some species live in one area, and not another, even though that area was well-suited for them?
- Observations: Living Organisms and Fossils
  - He also collected the preserved remains of ancient organisms called \_\_\_\_\_.
  - Why did some resemble organisms of today, and others were completely foreign?
- Observations: The Galapagos Islands
  - A small group of islands off \_\_\_\_\_ America that varied greatly in their \_\_\_\_\_.
  - Darwin observed that he could tell which island that the tortoise inhabited by the shape of its \_\_\_\_\_.

### Influences on Darwin

- \_\_\_\_\_ and \_\_\_\_\_
  - Two scientists
  - Formed important theories based on evidence about the changing \_\_\_\_\_.
  - Recognized that the Earth is many millions of years old

- Processes that changed Earth in the \_\_\_\_\_ are the same processes that operate in the \_\_\_\_\_.
- Darwin wondered that if the Earth could change over time, couldn't \_\_\_\_\_ change also?
- Concluded it would have taken many \_\_\_\_\_ for life to change in the way he suggested
- Supported the theory the Earth must be \_\_\_\_\_ old.
- Lamarck's Evolution Hypothesis
  - French naturalist, preceded Darwin
  - The first to propose that all living things have changed over time – and that all species were \_\_\_\_\_ from other \_\_\_\_\_.
  - Proposed that by selective \_\_\_\_\_ of \_\_\_\_\_ of organs, organisms acquired or lost certain traits during their lifetime.
  - These \_\_\_\_\_ could then be passed on to their \_\_\_\_\_.
  - Lamarck's Four Principles
    - Tendency toward \_\_\_\_\_
    - Use and disuse
    - Inheritance of \_\_\_\_\_ traits
  - Evaluating Lamarck's Theory
    - \_\_\_\_\_ in several ways
    - He did not know how traits are inherited.
    - He did not know that an organism's \_\_\_\_\_ has no effect on its \_\_\_\_\_ characteristics.
- Thomas Malthus (1798)
  - Observed that \_\_\_\_\_ were being born faster than people were \_\_\_\_\_.
  - If the human population continued to grow unchecked, sooner or later there would not be enough \_\_\_\_\_ or \_\_\_\_\_ for everyone.
  - Darwin connected these ideas to populations other than \_\_\_\_\_

#### Presenting Darwin's case for Evolution

- Darwin published his ideas on evolution in a book called - \_\_\_\_\_ in 1859.
- His Foundation:
  - \_\_\_\_\_ – differences among individuals of a species.
  - Found in all types of organisms
  - Breeders use this variation to select those variations that they found useful. (\_\_\_\_\_)

#### Evolution by Natural Selection

- The struggle for \_\_\_\_\_: members of each species competes for limited resources
- Survival of the fittest
  - \_\_\_\_\_ – inherited characteristic that increases an organisms chance of survival.



- Only the organisms that are \_\_\_\_\_ adapted to their environment survive to \_\_\_\_\_.
- Results in \_\_\_\_\_ in the inherited characteristics of a population
- \_\_\_\_\_ with \_\_\_\_\_
  - Over long periods, natural selection produces organisms that have different structures, establish different niches, or occupy different habitats.
  - As a result, species today look different from their \_\_\_\_\_

#### Darwin's Evidence of Evolution

- The \_\_\_\_\_ record
  - Compared fossils from different layers
- \_\_\_\_\_ distribution of living species
- \_\_\_\_\_ body structures
  - Structures which have different mature forms, but develop from the same \_\_\_\_\_ tissues.
  - \_\_\_\_\_ organs – organs that serve no useful function in an organism.
- Similarities in embryology
  - The early stages, or embryos, of many animals with \_\_\_\_\_ are very similar.
  - For example, all vertebrate embryos develop \_\_\_\_\_ structures, even though only fish have gills as adults.
  - The same groups of embryonic cells develop in the same order and in similar patterns to produce the \_\_\_\_\_ and \_\_\_\_\_ of all vertebrates.
  - These common cells and tissues, growing in similar ways, produce the homologous structures discussed earlier.

#### Part II

#### Evolution in Populations

- \_\_\_\_\_: All members of the same species that live in a particular location at the same time.
- Genes and Variation
  - \_\_\_\_\_: all of the genes, including all of the different alleles, present in a population
  - \_\_\_\_\_: number of times a gene occurs in a gene pool
  - Evolution is the \_\_\_\_\_ in relative frequency of alleles in a gene pool
- Sources of Genetic Variation
  - \_\_\_\_\_: change in DNA
    - Mistake in \_\_\_\_\_
    - \_\_\_\_\_, chemicals
  - Gene shuffling
    - During \_\_\_\_\_
- Natural Selection on Single-Gene Traits

- Leads to only two distinct \_\_\_\_\_
- \_\_\_\_\_ are determined by frequency of alleles, as well as dominance
- Examples of Single-Gene Traits in Natural Selection
  - \_\_\_\_\_: A structural adaptation that provides protection for an organism by copying the appearance of another species.
    - Copy appearance of a predator or poisonous species.
  - Camouflage
    - A structural adaptation that enables an organism to blend in with its surroundings.
    - More likely to escape \_\_\_\_\_, survive, and reproduce.
- Natural Selection on Polygenic Traits
  - More \_\_\_\_\_
  - Three ways can affect distribution of phenotypes: (NEED TO KNOW GRAPHS)
    - \_\_\_\_\_
    - \_\_\_\_\_
    - Disruptive

#### Genetic Drift

- \_\_\_\_\_ frequencies in a population change as a result of random events or chance, not natural selection
- more common in \_\_\_\_\_ populations

#### Genetic Equilibrium

- Frequency of alleles \_\_\_\_\_ change from generation to generation.
- Only when the genetic equilibrium is \_\_\_\_\_ does a population change.

#### Evolution vs. Genetic Equilibrium

- \_\_\_\_\_ - \_\_\_\_\_: Allelic frequencies in a population will remain constant unless one or more factors cause those frequencies to change.
- 5 factors under which evolution will NOT occur:
  - \_\_\_\_\_ mating
  - \_\_\_\_\_ population
  - No migration
  - No \_\_\_\_\_
  - No natural selection

#### Speciation

- Formation of a \_\_\_\_\_ species
- As new species evolve, populations become reproductively \_\_\_\_\_
- Reproductive isolation: when populations can no longer \_\_\_\_\_ and produce fertile offspring.

#### Mechanisms of Isolation

- \_\_\_\_\_: differences in courtships rituals
- \_\_\_\_\_: physical separation

## Appendix F: Evolution Power Point

### Evolution

Darwin, Lamarck, and Population  
Evolution

### Origin of Life

### Theories of Origin

#### Creationism

- Belief that God created the universe and all life.
- Cannot be scientifically proven

#### Life came from non-living matter.

- Random events resulted in the formation of the first cells.
- Over millions of years, these cells gave rise to life as we see it today.
- Spontaneous generation
- Scientifically disproved

### Extraterrestrial Origins

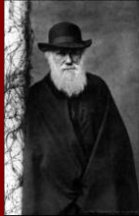
- A meteor or asteroid collided with Earth and gave rise to life. (Where did this life come from?)
- No evidence, un-testable

### Theory of Evolution

- Genetic changes in a species over time.
- Well-supported, testable

### Charles Darwin

- A naturalist who traveled around the world collecting and studying biological specimens.
- He sailed on the ship H.M.S. Beagle.



- Darwin collected many specimens of animals and plants.
- Proposed a hypothesis about the way life changes over time.

### Observations: Patterns of Diversity

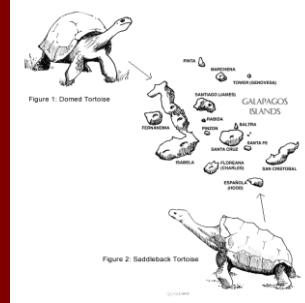
- Why were organisms so suited to their environment?
- Why did some species live in one area, and not another, even though that area was well-suited for them?

### Observations: Living Organisms and Fossils

- He also collected the preserved remains of ancient organisms called fossils.
- Why did some resemble organisms of today, and others were completely foreign?



- A small group of islands off South America that varied greatly in their climates.
- Darwin observed that he could tell which island the tortoise inhabited by the shape of its shell.



## Influences on Darwin

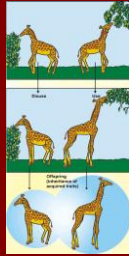
- Two scientists
- Formed important theories based on evidence about the changing Earth.
- Recognized that the Earth is many millions of years old
- Processes that changed Earth in the past are the same processes that operate in the present.

- Darwin wondered that if the Earth could change over time, couldn't life change also?
- Concluded it would have taken many years for life to change in the way he suggested
- Supported the theory the Earth must be extremely old.

- French naturalist, preceded Darwin
- The first to propose that all living things have changed over time – and that all species were descended from other species.
- Proposed that by selective use or disuse of organs, organisms acquired or lost certain traits during their lifetime.
- These traits could then be passed on to their offspring.

### Lamarck's Principles

1. Tendency toward perfection
2. Use and disuse
3. Inheritance of acquired traits



### Evaluating Lamarck's Theory

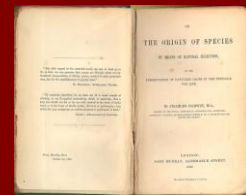
- Incorrect in several ways
  1. He did not know how traits are inherited.
  2. He did not know that an organism's behavior has no effect on its inheritable characteristics.

### Thomas Malthus (1798)

- Observed that babies were being born faster than people were dying.
- If the human population continued to grow unchecked, sooner or later there would not be enough space or resources for everyone.
- Darwin connected these ideas to populations other than humans

### Presenting Darwin's case for Evolution

- Darwin published his ideas on evolution in a book called *On the Origin of Species* in 1859.



### His Foundation

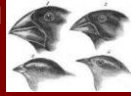
- Natural variation – differences among individuals of a species.
  - Found in all types of organisms
  - Breeders use this variation to select those variations that they found useful. (Artificial selection)

### Evolution by Natural Selection

1. The struggle for existence: members of each species competes for limited resources



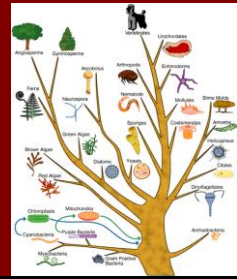
## Evolution by Natural Selection



### 3. Descent with modification

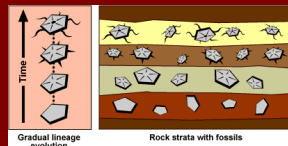
- Over long periods, natural selection produces organisms that have different structures, establish different niches, or occupy different habitats.
- As a result, species today look different from their ancestors

**Common descent – All species – living and extinct – were derived from common ancestors.**



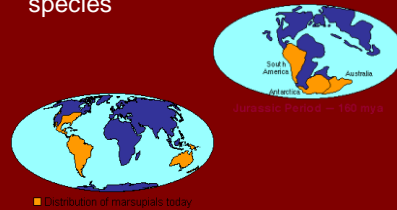
## Darwin's Evidence of Evolution

- The fossil record
- Compared fossils from different layers



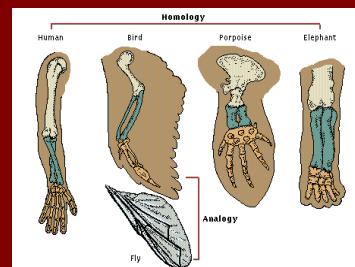
## Darwin's Evidence of Evolution

- Geographic distribution of living species



## Darwin's Evidence of Evolution

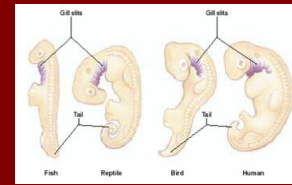
- Homologous body structures
  - Structures which have different mature forms, but develop from the same embryonic tissues.
  - Vestigial organs – organs that serve no useful function in an organism.



## Darwin's Evidence of Evolution

- Similarities in embryology
- The early stages, or embryos, of many animals with backbones are very similar.
- For example, all vertebrate embryos develop gill-like structures, even though only fish have gills as adults.

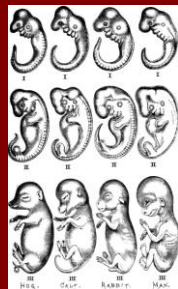
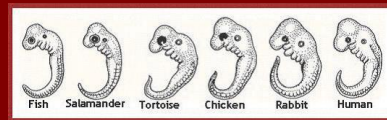
## Gill Slits



## Why?

- The same group of embryonic cells develop in the same order and in similar patterns to produce the tissues and organs of all vertebrates.
- These common cells and tissues, growing in similar ways, produce the homologous structures discussed earlier.

## Comparison of Embryos



## Evolution in Populations

Part 2



## Genes and Variation

- Gene pool: all of the genes, including all of the different alleles, present in a population
- Relative frequency: number of times a gene occurs in a gene pool
- Evolution is the change in relative frequency of alleles in a gene pool

## Sources of Genetic Variation

- Mutations: change in DNA
  - Mistake in replication
  - Radiation, chemicals
- Gene shuffling
  - During meiosis

## Natural Selection on Single-Gene Traits

- Leads to only two distinct phenotypes
- Ratios are determined by frequency of alleles, as well as dominance

## Examples of Single-Gene Traits in Natural Selection

## Mimicry

- A structural adaptation that provides protection for an organism by copying the appearance of another species.
  - Copy appearance of a predator or poisonous species.





## Camouflage

- A structural adaptation that enables an organism to blend in with its surroundings.
  - More likely to escape predators, survive, and reproduce.



### Genetic Drift

- Allelic frequencies in a population change as a result of random events or chance, not natural selection
- more common in small populations

### Genetic Equilibrium

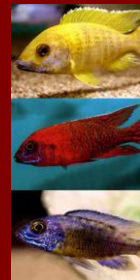
- Frequency of alleles does not change from generation to generation.
- Only when the genetic equilibrium is disrupted does a population change.

### Evolution vs. Genetic Equilibrium

- Hardy-Weinberg principle : Allelic frequencies in a population will remain constant unless one or more factors cause those frequencies to change.
- 5 factors under which evolution will NOT occur:
  - Random mating
  - Large population
  - No migration
  - No mutation
  - No natural selection

### Speciation

- Formation of a new species
- As new species evolve, populations become reproductively isolated
- Reproductive isolation: when populations can no longer interbreed and produce fertile offspring.



## Appendix G: Natural Selection Activity

### ***The Making of the Fittest: Natural Selection and Adaptation***

*(Adapted from HHMI Activity)*

#### **Introduction:**

The tiny rock pocket mouse weighs just 15 grams, about as much as a handful of paperclips. A typical pocket mouse is just about 170 millimeters long from nose to rump, shorter than an average pencil. Their impact on science, however, has been enormous. What's so special about these little mice?

Populations of rock pocket mice are found all over the Sonoran Desert in the southwestern United States. There are two common varieties—a light-colored variety and a dark-colored variety. Similarly, there are two major colors of substrate, or surface materials, that make up the desert floor. Most of the landscape consists of light-colored sand and rock. Here and there, however, separated by several kilometers of light-colored substrate, are patches of dark volcanic rocks that formed from cooling lava flows.

The illustrations that follow represent snapshots of pocket mouse populations. Each illustration shows the color variation at two different locations, A and B, at a particular moment in time over a period of several hundred years. **NOTE:** The images are out of order.

#### **Materials:**

- colored pencils

#### **Procedure:**

1. Count the number of light and dark mice present at each location at each moment in time. Record your counts in the spaces provided above each illustration.
2. Place the illustrations in what you think is the correct order from oldest to most recent. Indicate your order by circling the appropriate number under the illustration.
3. Explain how you decided which illustration represents the most recent pocket mouse population and why you positioned the others in the sequence as you did.

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**Location A:** number of mice with light fur \_\_\_\_\_

number of mice with dark fur \_\_\_\_\_

**Location B:** number of mice with light fur \_\_\_\_\_

number of mice with dark fur \_\_\_\_\_



When all four illustration pages are placed in order, this one is:

**1<sup>st</sup> (oldest)    2<sup>nd</sup>    3<sup>rd</sup>    4<sup>th</sup> (most recent)**

(Circle the appropriate number)



**Location A:** number of mice with light fur \_\_\_\_\_

number of mice with dark fur \_\_\_\_\_

**Location B:** number of mice with light fur \_\_\_\_\_

number of mice with dark fur \_\_\_\_\_



When all four illustration pages are placed in order, this one is:

**1<sup>st</sup> (oldest)    2<sup>nd</sup>    3<sup>rd</sup>    4<sup>th</sup> (most recent)**

(Circle the appropriate number)

**Location A:** number of mice with light fur \_\_\_\_\_

number of mice with dark fur \_\_\_\_\_

**Location B:** number of mice with light fur \_\_\_\_\_

number of mice with dark fur \_\_\_\_\_



When all four illustration pages are placed in order, this one is:

**1<sup>st</sup> (oldest)    2<sup>nd</sup>    3<sup>rd</sup>    4<sup>th</sup> (most recent)**

(Circle the appropriate number)



**Location A:** number of mice with light fur \_\_\_\_\_

number of mice with dark fur \_\_\_\_\_

**Location B:** number of mice with light fur \_\_\_\_\_

number of mice with dark fur \_\_\_\_\_



When all four illustration pages are placed in order, this one is:

**1<sup>st</sup> (oldest)    2<sup>nd</sup>    3<sup>rd</sup>    4<sup>th</sup> (most recent)**

(Circle the appropriate number)

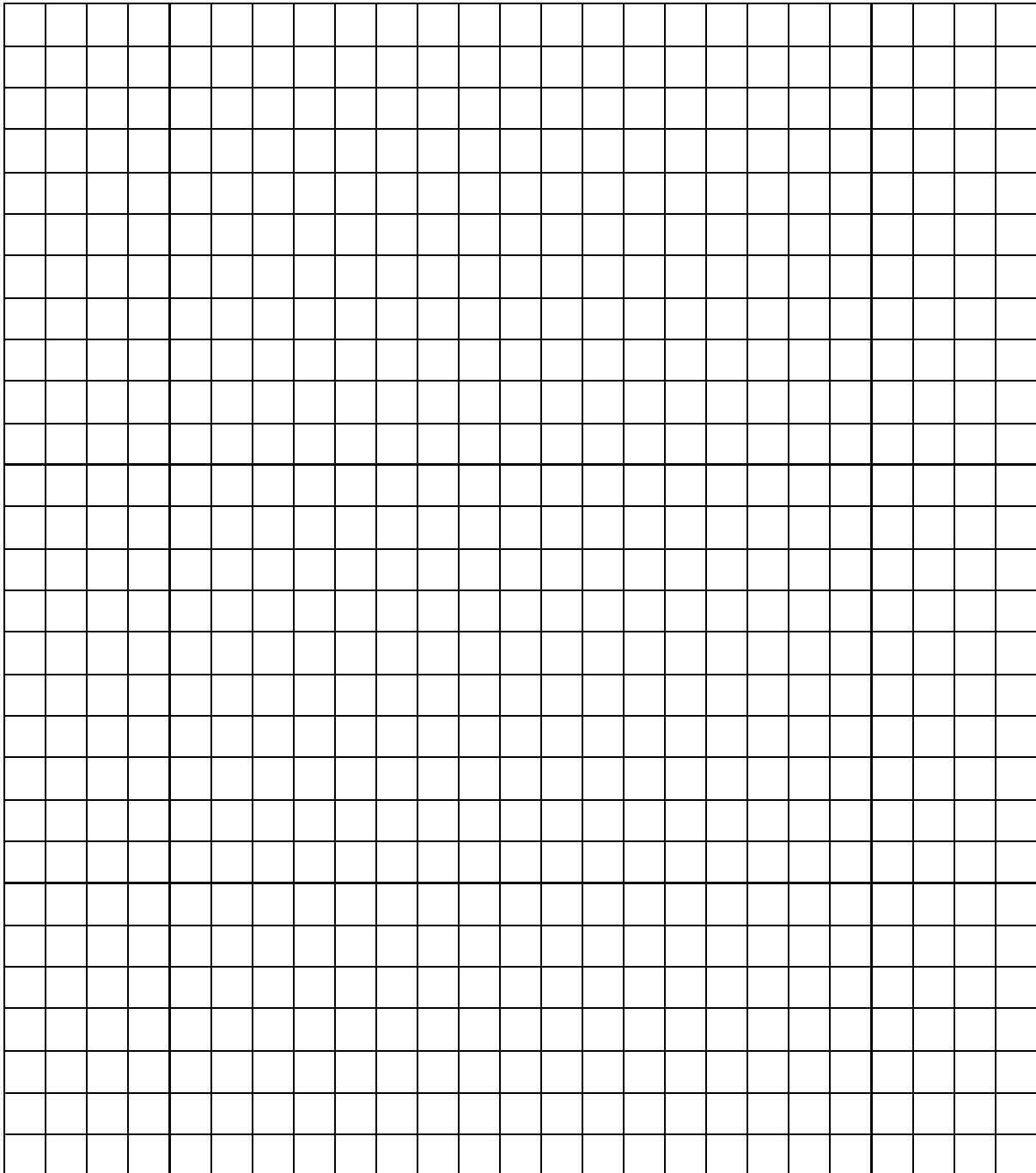


4. Watch the film *The Making of the Fittest: Natural Selection and Adaptation*. As you watch, look for an explanation for the differences among the illustrations that will help you to confirm that the order in which you arranged the illustrations is correct. Think about the following as you watch the film:
  - Why are some mice light and some mice dark?
  - Does fur color provide any selective advantage or disadvantage?
  - What role does the pocket mouse play in the desert food web?
  - What can explain the differences among the illustrations
5. Using what you learned by watching the film, check the order in which you arranged the illustrations. Change the numbers you circled under the illustrations as necessary. Once you are satisfied you are correct, fill out the data table using the counts you recorded above the illustrations.

**Sequence**

|                       |                               | <b>First<br/>(oldest)</b> | <b>Second</b> | <b>Third</b> | <b>Fourth<br/>(most recent)</b> |
|-----------------------|-------------------------------|---------------------------|---------------|--------------|---------------------------------|
| <b>Location<br/>A</b> | Number of mice with light fur |                           |               |              |                                 |
|                       | Number of mice with dark fur  |                           |               |              |                                 |
| <b>Location<br/>B</b> | Number of mice with light fur |                           |               |              |                                 |
|                       | Number of mice with dark fur  |                           |               |              |                                 |

6. Use colored pencils to prepare a bar graph based on the data that shows the distribution of the mice at locations A and B through time. Be sure to provide appropriate titles and labels for the x- and y-axes. You may record all of your data for each time period (A and B) on one bar graph or split A and B and make two graphs



**Questions:**

1. Explain why a pocket mouse's color influences its overall success. Remember that "success" is defined by an organism's ability to survive and produce offspring.

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2. Explain the presence of dark-colored mice at Location A. Why didn't this phenotype become more common in the population?

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## Appendix H

Individual Accountability, The Making of the Fittest

Name:

1. Write a scientific summary describing changes in the rock pocket mouse populations at Location B. Your summary should include:
  - a description of how the population has changed over time
  - an explanation of what caused the changes
  - a prediction that describes what the population will look like 100 years in the future. Your prediction should be based on trends in the data you have organized. You can assume that environmental conditions do not change over the 100 years.

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2. Use the data and what you've learned about evolution to explain how mutation is random, but natural selection is not random.

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Blackboard Academic Suite - Windows Internet Explorer

http://blackboard.ebrps.k12.la.us/webapps/portal/frameset.jsp?tab\_id=\_2\_1&url=%2fwebapps%2fblackboard%2fexecute%2fauncher%3ftype%3dCourse%

File Edit View Favorites Tools Help

★ Favorites ★ Free Hotmail Web Slice Gallery

Blackboard Academic Suite

Home Help Logout

EBRPS Learning Community Courses

Announcements  
Course Information  
Staff Information  
Course Documents  
Assignments  
Communication  
Resources/Links  
Tools

Tools  
Communication  
Course Tools  
Course Map  
Control Panel  
Refresh  
Detail View

BIOLOGY 2011-2012 [BRMH-STU-LHH-SCH-001] > RESOURCES/LINKS > UNIT 5 [EDIT VIEW](#)

Unit 5

Evolution  
[Evolution2012.ppt](#) (1.639 Mb)

Evolution Guided Notes  
[Evolution2012.doc](#) (36 Kb)

History of Life  
[The History of Life2012.ppt](#) (1.142 Mb)

History of Life Guided Notes  
[The History of Life2012.doc](#) (33 Kb)

Taxonomy  
[classification of life ppt](#) (6.162 Mb)

Taxonomy Guided Questions  
[classification of life pp questions.doc](#) (60 Kb)  
To be completed BEFORE class

Evolution Concept Map

Start How to Quickly Take a Sc... East Baton Rouge Parish... E:\Courses\BIO\Unit 5 E... MNS\_Font\_Rough Draft... Blackboard Academic... 2:45 PM

## Appendix J: IRB Exemption

### Application for Exemption from Institutional Oversight

Unless qualified as meeting the specific criteria for exemption from Institutional Review Board (IRB) oversight, ALL LSU research/ projects using living humans as subjects, or samples, or data obtained from humans, directly or indirectly, with or without their consent, must be approved or exempted in advance by the LSU IRB. This Form helps the PI determine if a project may be exempted, and is used to request an exemption.



Institutional Review Board  
Dr. Robert Mathews, Chair  
131 David Boyd Hall  
Baton Rouge, LA 70803  
P: 225.578.8692  
F: 225.578.6792  
irb@lsu.edu  
lsu.edu/irb

-- Applicant, Please fill out the application in its entirety and include the completed application as well as parts A-E, listed below, when submitting to the IRB. Once the application is completed, please submit two copies of the completed application to the IRB Office or to a member of the Human Subjects Screening Committee. Members of this committee can be found at <http://www.lsu.edu/screeningmembers.shtml>

-- A Complete Application Includes All of the Following:

(A) Two copies of this completed form and two copies of part B thru E.

(B) A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1&2)

(C) Copies of all instruments to be used.

\*If this proposal is part of a grant proposal, include a copy of the proposal and all recruitment material.

(D) The consent form that you will use in the study (see part 3 for more information.)

(E) Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing or handling data, unless already on file with the IRB. Training link: (<http://phrp.nihtaining.com/users/login.php>)

(F) IRB Security of Data Agreement: (<http://www.lsu.edu/irb/IRB%20Security%20of%20Data.pdf>)

1) Principal Investigator: Dr. Dana Browne

Rank: Professor

Dept: Physics

Ph: 8-6843

E-mail: phowne@lsu.edu

2) Co Investigator(s): please include department, rank, phone and e-mail for each

Laurie Horton  
Teacher  
225-907-4518  
lhorton@ebschools.org

IRB# E5561 LSU Proposal #

☒ Complete Application

☒ Human Subjects Training

3) Project Title: Implication of Inquiry Lessons VS Lecture in the High School Classroom

**Study Exempted By:**  
Dr. Robert C. Mathews, Chairman  
Institutional Review Board  
Louisiana State University  
203 B-1 David Boyd Hall  
225-578-8692 | [www.lsu.edu/irb](http://www.lsu.edu/irb)  
Exemption Expires: 7-17-2014

4) Proposal? (yes or no) No

If Yes, LSU Proposal Number

Also, if YES, either

☐ This application **completely** matches the scope of work in the grant

OR

☐ More IRB Applications will be filed later

5) Subject pool (e.g. Psychology students) High school students

\*Circle any "vulnerable populations" to be used: (children <18; the mentally impaired, pregnant women, the aged, other) Projects with incarcerated persons cannot be exempted.

6) PI Signature

Date

29 June 2011 (no per signatures)

\*\* I certify my responses are accurate and complete. If the project scope or design is later changes, I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU institutions in which the study is conducted. I also understand that it is my responsibility to maintain copies of all consent forms at LSU for three years after completion of the study. If I leave LSU before that time the consent forms should be preserved in the Departmental Office.

Screening Committee Action: Exempted ☒ Not Exempted ☐ Category/Paragraph 1

Reviewer

Mathews

Signature

*Robert Mathews*

Date

7/18/11

## **Vita**

Laurie L. Font was born in Baton Rouge, Louisiana, in September 1972. She attended elementary, middle, and high school in Baton Rouge, Louisiana. She graduated from Belaire High School in May 1990. She then entered Southeastern Louisiana University in August 1998 and earned her degree in Applied Biological Sciences in December 2002. She entered the Graduate School at Louisiana State University Agricultural and Mechanical College in June 2010 and is a candidate for a Master of Natural Sciences. She has been a high school teacher in East Baton Rouge Parish for the past 8 years and is currently teaching at Baton Rouge Magnet High School.