Measuring Academic Performance and Learning Gains through Illustrative and Descriptive Notecards in an Undergraduate Human Biology Class for Nonmajors

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ABSTRACT

MEASURING ACADEMIC PERFORMANCE AND LEARNING GAINS THROUGH ILLUSTRATIVE AND DESCRIPTIVE NOTECARDS IN AN UNDERGRADUATE HUMAN BIOLOGY CLASS FOR NONMAJORS

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Purpose: The purpose of this study was to explore the effectiveness of notecards, a study aid, on students' learning in three sections of a non-majors undergraduate Human Biology course. Moreover, the effectiveness of illustrations as study aids was compared with the effectiveness of descriptions as study aids. Presently, there is not much research on this particular topic, but notecards are a quite common method of studying.

Hypothesis: It was expected that the use of notecards would be more beneficial to student learning than no use at all. Furthermore, it was expected that drawing illustrations would be more effective than writing definitions or descriptions.

Method: Three Human Biology courses taught by the same instructor took part in the study. One class acted as the control in which they did not complete notecards, while the other two courses completed three notecards per unit. Of the two classes, one class completed notecards by drawing illustrations while the other course completed notecards in which students were to write definitions or descriptions. Pre-tests and post-tests were given at the beginning of the semester and the end of the semester, respectively, to identify students' overall knowledge retention and learning during the semester. Quantitative analyses of the

pre-tests and post-tests included a Paired t-test, a Wilcoxon Signed-Rank test, a Shapiro-Wilk's Test of Normality, a One-Way ANOVA including Effect Size and a Tukey post-hoc test, a calculation of Normalized Learning Gains, and a bar graph representation of the change in number of correct answers per question between pre-tests and post-tests of all groups. Short-term learning was evaluated by graphing average scores of weekly assignments for all groups and a Spearman's Correlation test comparing exam scores with their respective assignment scores. Kruskal-Wallis H tests were used to determine statistical significance between groups with regards to assignment scores as well as exam scores. Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons followed the Kruskal-Wallis H test regarding weekly assignments. A qualitative analysis of end-of-semester course evaluations was performed to determine how students felt about the notecard assignments.

Results: The Paired t-test and Wilcoxon Signed-Rank test showed that there was a statistically significant difference of change scores between the pre-tests and post-tests within each group meaning all sections of the course learned. The Shapiro-Wilk's test showed that data was normally distributed to continue the One-Way ANOVA tests. The results of the One-Way ANOVA showed that there was a statistically significant difference between all groups, and the Tukey post-hoc test pinpointed the statistical significance of the One-Way ANOVA between the illustration group and the control group. There was neither a statistically significant difference between the illustration group and the description group nor between the description group and the control group. The Effect Size was small-to-medium, $\omega = 0.044$. The Kruskal-Wallis H test performed on the weekly assignment scores showed there was a statistically significant difference between groups. Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons showed that, generally,

there was a statistically significant difference from the control group to the illustration group as well as from the control group to the description group, meaning students in the illustration group and the description group performed better on weekly assignments than the control group. The illustration group performed as well as the description group on weekly assignments. The weekly assignment and exam analysis compared average exam percentages and final exam percentages of each group to average assignment percentages to assess whether there were any certain notecard assignments, descriptive or illustrative, that led to different exam percentages between groups. Exam scores between all groups were similar and there was no specific trend between certain assignments and respective exam scores. Largely, in all groups, there was a positive correlation amongst exam scores and their respective assignments as well as a general positive correlation amongst the assignments and the final exam according to the results of Spearman's Correlation test. The Kruskal-Wallis H test performed on all five exam scores of each group showed there was not a statistically significant difference between exam scores of each group. By assessing the change in number of correct answers per question between pre-tests and post-tests, it was determined that learning in some specific content areas may have been improved by utilizing notecards (descriptive in some cases and illustrative in other cases) as a study aid whereas learning in other content areas were nearly equivalent across all groups. Student reflection on course evaluations showed a mixed reaction to the notecard assignments with some students regarding them as their least favorite part of the course and still others commenting on how helpful they were to their study.

Conclusions: All groups learned throughout the semester, and learning gains for the illustration group and the description group doubled compared to the control group. Short-term learning based on weekly assignments was increased for both the illustration and

description groups, but exam scores were not really affected by the different learning interventions. Exam scores were similar among the three groups, so notecards were neither superior nor inferior to the standard curriculum when it came to academic performance. The student divide concerning using notecards illuminated the idea that all students have different learning styles, and in the case of the present study, some students in one group may have preferred to complete the type of assignment of another group.

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CHAPTER I

INTRODUCTION

From high schools to college campuses, students of many disciplines are often seen in hallways, libraries, and rooms/dorm rooms flipping through a stack of notecards as they feverishly study for an upcoming exam. They use their notecards as a learning strategy to hopefully improve their overall knowledge and retention of a subject, thereby performing well on a quiz or an exam. Ultimately, students want to achieve good scores and higher learning in their courses, and educators have the same desire for their students. It is vital to students' education to know which learning styles and learning strategies prove useful to them individually for better exam performance and learning gains.

A common learning strategy utilized by students are the use of notecards—also referred to as flashcards—in which a word or question is written on one side while the other side contains the definition or answer to the question. Students can easily test themselves by flipping back and forth through the questions and answers on the notecards as well as remove notecards from that stack of notecards that they have mastered (Cancela, Sanchez, & Maceiras, 2012). Notecards are a popular method of studying because they are simple to make and students feel like they are actively "doing" something during their study time (Golding, Wasarhaley, & Fletcher, 2012). Additionally, notecards function in effectively connecting information for students and teachers alike and are a contemporary, fun learning strategy (Cancela et al., 2012).

Problem Statement

While notecards are a prevalent study aid amongst students across the nation, there is little research on the effectiveness of using notecards to improve exam performance (Golding et al., 2012). Moreover, there is no research associated with the effectiveness of creating notecards with illustrations compared to creating notecards with descriptive text. Most of the current research investigating notecards involves utilizing notecards for vocabulary learning and reading performance (Albers & Hoffman, 2012; Nakata, 2011; Zhu, Fung, & Wang, 2012), but there is not much research with regards to utilizing notecards to understand concepts.

Significance of the Problem

A common event associated with college science courses is the "weed-out" effect in which students decide to leave a science class or the sciences all together due to the dense, complex information they are expected to learn and poor academic performance (Tanner & Allen, 2004). The loss of students in the sciences is, in part, due to instructor teaching styles and *instructional selection*, the use of a single teaching method (Tanner & Allen, 2004). The 2009 report *Vision and Change in Undergraduate Biology Education: A Call to Action* urges that students' learning be the main focus for teaching and the entire college or university institution must be fully involved in order to improve undergraduate biology education (Brewer, et al., 2009). It is important for teachers to acknowledge and accommodate for students' different learning styles by stepping back and acting as more of a facilitator to learners' active learning, an approach called learner-centered learning (Emes & Cleveland-Innes, 2003).

There are many learning style inventories that classify students into their preferred learning styles. For example, the Grasha-Riechman Learning Style Inventory classifies students into independent, dependent, collaborative, competitive, contributive, or avoidant learners (Baykul et al., 2010). Another learning inventory is Kolb's four learning styles including divergers who enjoy peer interaction and observation, assimilators who prefer authoritave learning and observation, convergers who prefer authoritative learning and learning by doing, and accommodators who prefer peer interaction and learning by doing (Lu et al., 2007). In a learning style assessment called the VARK method, students can be categorized into visual, aural/auditory, read/write, and kinesthetic (learning by doing) learners and can be unimodal (prefer one learning style), bimodal (prefer two learning styles), trimodal (prefer three learning styles), and quadmodal (prefer all four learning styles) (Khanal, Shah, & Koirala, 2014). In a study investigating VARK learning style preferences among undergraduate biology students, nearly 50 percent of female students and 50 percent of males preferred visual learning, learning through illustrations, diagrams, and animations. However, females prefered aural learning (learning by listening) second to visual learning while males prefered read/write learning second to visual learning (Shankar, Blasubramanium, Dwivedi, Ramireddy, & Barton, 2014). Additionally, most first-year undergraduate students preferred a multimodal learning preference consisting of more than one learning style, while only about 14 percent preferred a unimodal approach of a single learning style (Prithiskumar & Michael, 2014). Understanding individual learning styles and strategies along with incorporating a variety of teaching methods in the classroom could be pivotal to student learning outcomes as seen by a study that showed that mismatched courses (learning styles did not match the student's) led to lower academic performance (Kinshuk, Liu, & Graf, 2009).

The use of notecards, a common learning strategy, has not been a widely researched area, and the research that does exist shows how academic performance can be improved by utilizing notecards (e.g. Golding et al., 2012). Moreover, students rely on themselves and are more independent learners when using notecards as a study aid (Cancela et al., 2012). Mostly, the research regarding notecards is focused on vocabulary learning and reading comprehension as studied by Albers and Hoffman (2012), Nakata (2011) and Zhu et al. (2012). Furthermore, there is little to no research comparing the use of notecards with illustrations to the use of notecards with definitions or descriptions which takes into account the VARK model of learning styles.

Purpose of the Study

Because there is little research devoted to notecards in the sense of learning concepts, especially illustrative notecards versus descriptive notecards, this study focuses on the use of illustrative notecards and the use of descriptive notecards in an undergraduate Human Biology course for nonmajors and how notecards affect academic performance and learning retention. This study is important because learning gains can be assessed when comparing drawing an illustration to writing a description or definition. The present study will help contribute to current notecard research which is greatly lacking.

Hypothesis

It was hypothesized that the use of notecards would increase the learning outcome and knowledge retention relative to the control group. Additionally, the use of illustrative notecards would yield higher learning and retention versus the group completing descriptive notecards. Statistical tests were conducted to assess academic performance across the three different groups—illustrative notecards group, descriptive notecards group, and the control group. The results of the study are discussed including the meaning of the findings, the limitations of the study, and implications for future research.

CHAPTER II

REVIEW OF LITERATURE

Learning is said to have taken place when an individual is able to alter his or her previous behavior based on an experience. Essentially, according to the Encyclopaedia Britannica (2014), "[w]hen an organism can perceive and change its behavior, it is said to learn." The act of learning is a personal one such that each person processes and comprehends new information in diverse ways where some individuals prefer to learn one way while others prefer to learn an entirely different way (Prajapati, Dunne, Bartlett, & Cubbidge, 2010). These diverse methods of learning are referred to as learning styles.

Learning Style Inventories

For students to learn successfully, teachers must take into account the variety of student learning styles that comprise their teaching environment. Learning styles are defined as "methods of gathering, processing, interpreting, organizing and thinking about information" (Khanal et al., 2014). There are various ways of classifying learning styles. One learning style classification system is the Grasha-Riechman Learning Style Inventory (GRLSI) which determines six types of learners: 1. independent learners who learn on their own, 2. dependent learners who rely on their teacher in learning, 3. collaborative learners who cooperate with others, 4. competitive learners who compete with others, 5. contributive learners who participate in activities, and 6. avoidant learners who are introverted and not interested in learning (Baykul, et al., 2010). Validity of the Grasha-Riechman inventory has been found to be low while its reliability has been found to be medium on a low-medium-good scale according to a study assessing learning styles of 6th to 8th grade students (Baykul, et al., 2010).

The Kolb Learning Style Inventory (KLSI) assesses students' information processing (how students take in information) preferences prior to the educational experience in order to identify and inform them of which learning strategies will help them be successful (Cole et al., 2014). The KLSI is based on Kolb's experiential learning theory which is a two-dimensional cyclical model comprised of 4 modes: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC) and active experimentation (AE), with all bases reached by the learner (Schenck & Cruickshank, 2015). How a person perceives information is categorized as concrete experience or abstract conceptualization while how a person processes information is categorized as active experimentation or reflective observation (Lu, Jia, Gong, & Clark, 2007). CE learners prefer peer interaction, RO relies largely on careful observation when making judgments, AC learners learn best in impersonal, authoritative learning situations, and AE learners rely heavily on experimentation and learning by doing (Lu et al., 2007). Kolb's experiential learning theory has some short-comings in that the "brain focuses on only one aspect of a lesson" (p. 78), therefore not reaching all four modes of learning; and it does not discern what information is important (Schenck & Cruickshank, 2015). Like GRLSI, KLSI has been found to have low reliability and limited validity (Lu et al., 2007).

The VARK model, developed by Neil Fleming, is a learning style classification system that categorizes students into four different learning modes based on what senses they prefer to use when gathering information (Prithishkumar & Michael, 2014). V refers to visual learners who have a better learning experience when seeing an illustration or video. They prefer to use graphs, diagrams, flowcharts, and pictures as their learning resources.

Aural (A) learners learn by hearing. They prefer listening to lectures and utilizing recorders to allow them to replay previous lectures. Read/write (R) learners learn through written words. They tend to read text and take notes verbatim, rereading their notes repeatedly. Kinesthetic (K) learners learn by doing. Students learn best when they have an experience that connects the information to real life actions and events (Khanal et al., 2014). Learners can be unimodal (V, A, R, or K), bimodal (two preferred modes of learning), trimodal (three preferred modes of learning) or quadmodal (all four modes of learning, VARK) (Payman et al., 2014). The VARK model is a popular learning style inventory due to its simplicity and reliability (Khanal et al., 2014).

In addition to accommodating a multitude of learning styles, the instructor must also be aware of other factors in the students' learning practices such as physical environmental needs, social environmental preferences, cognitive styles, time of day, and motivation (Reynolds, 2006).

Schenck & Cruickshank (2015) state that while learning styles connect to the *feeling* of success while studying, using learning strategies *does not actually* produce greater overall learning. Moreover, two studies have shown that accommodating students' different learning styles have little effect on academic performance (Wilkinson, Boohan, & Stevenson, 2014; (Rogowsky, Calhoun, & Tallal, 2014). A study of first year medical and dental students learning styles showed that overall academic performance was not influenced by learning style and was not affected by different learning style assessments (Wilkinson et al., 2014). Learning style preference and academic performance were also investigated amongst college-educated adults, but results indicated no statistical significance between both learning style preference and learning aptitude and both learning style preference and instructional method (Rogowsky et al., 2014). In these two cases, however, medical students and college-educated adults are academically successful students to begin with, so academic performance may not be affected the way it would be if undergraduate students were studied. For example, a study of 285 female Taiwanese undergraduate nursing students assessed student learning styles based on a cognitive personality test learning style inventory. Those learning style preferences were compared with academic performance, and a significant relationship between academic performance and learning style was revealed (Li, Yu, Liu, Shieh, & Yang, 2014).

Learner-Centered Learning Versus Teacher-Centered Learning

Because each student has a unique learning style, it is important to uphold a learner-centered environment rather than the traditional teacher-centered classroom. Learner-centered learning involves the student taking on the responsibility to learn while the teacher becomes more of a facilitator (Schroeder, 2012). Effective learner-centered learning strategies include students noting something they learn each class, comparing notes with other students to promote common understanding of the material, and diagramming a concept map in order to problem solve a case or question (Schroeder, 2012). Students are more in charge of their learning when teachers include more educational activities.

Though the mindset is currently shifting toward focusing on the learner, "many [community college educators] see teaching in terms of controlling: what students learn, how they learn, and how the learning is measured" (Reynolds, 2006, p. 55). Traditionally, the focus of the classroom has been on the instructor, and the instructor controls the learning environment through a solely lecture-based teaching method, the teacher-centered learning approach. The problem with this method is that post-secondary classrooms are currently filled with a rather diverse population in gender (broader spectrum of gender identity), age (larger range than in the past due to more non-traditional learners), ethnicity (culture, language, religion, racial characteristics), and race (genetically transmitted physical characteristics) for example (U.S. Department of Education, National Center for Education Statistics, 2013; Religion And Diversity In Schools, 2011). With such a diverse population of students in post-secondary classrooms, instructors must keep in mind the diversity of learning styles in their classrooms. Learner-centered learning is a way for a teacher to address different styles of learning (Kolb & Kolb, 2005). Furthermore, technology has advanced to a point where there are many digital resources available to students. For learner-centered environments, it is important for the teacher to understand how students use technology as a learning tool because incorporating what the students currently use to learn may enhance students' academic success (Kong & Song, 2013).

Due to the changing beliefs and assumptions in regards to the role of the student in learning, an evaluation of elementary school teachers' implementation of learner-centered learning showed that these teachers frequently utilized methods that featured learner-centered learning (Cubukcu, 2012). According to Emes & Cleveland-Innes (2003), undergraduate students in learner-centered classrooms are allowed to take part in forming their own learning experiences such that this practice can carry on for a lifetime. A role shift from students as a dependent of the teacher to the role of a participant in his/her own learning experiences is the necessary paradigm shift to attain learner-centeredness in an undergraduate classroom (Emes & Cleveland-Innes, 2003). For diverse student populations unsuccessful with a teacher-centered approach, deeper learning could be attained by instituting a more learner-centered approach (Brown, 2003). Learning through experience, the premise of learner-centered learning, rather than the traditional lecture provides an irreplaceable and unforgettable way of understanding and retaining knowledge (Smart & Csapo, 2007).

Learner-centered learning has been shown to improve student motivation and the use of learning strategies in the classroom. Cheang (2009) found that after implementing a learner-centered learning approach in a third-year pharmacotherapy course at Virginia Commonwealth University School of Pharmacy, students had a higher motivation score mean in areas such as intrinsic goal orientation, control of learning beliefs, and self-efficacy for learning and performance. Students who used critical thinking approaches (higher order learning rather than just learning facts) in the learner-centered classroom also had a higher postcourse mean score than the precourse mean score (Cheang, 2009). Not only has learner-centered learning been able to show enhanced student motivation and learning strategies in the classroom, but also the learner-centered approach to learning has been shown to improve students' academic performance. A study focusing on academic achievement of minority groups in elementary schools showed that the gap between minorities and non-minorities was completely closed in the learner-centered schools meaning that minority students were able to perform equally as well as their non-minority peers (Salinas & Garr, 2009). In addition to closing the performance gap between minority and non-minority elementary students, all students, including non-minorities, had higher scores in non-traditional aspects of tolerance and openness to diversity (Salinas & Garr, 2009).

While focusing on the learner is a good approach to attain better student motivation (Cheang, 2009) and better student academic performance (Salinas & Garr, 2009), it is difficult to incorporate every type of learning style in a course curriculum. Time and labor are huge barriers for instructors to implement a teaching style that encompasses an array of learning styles (Wyss, Dolenc, Kong, & Tai, 2013). A study about the application of the problem based learning (PBL) teaching method illuminated the struggles of a teacher changing her role in the classroom from leader to facilitator. The teacher had to interact with her students in an unfamiliar way, and students were unaccustomed to this new way of learning which made student engagement levels low at first (Wyss et al., 2013). Time is not on an instructor's side either due to the amount of course content they must teach in each lecture. One teacher said, "…It is easier to cover the entire curriculum if the number of hands-on activities is limited in favor of whole-group demonstrations and lectures…" (Wyss et al., 2013, p. 52).

However, it is important for the instructor to try to include at least a few kinds of learning methods in a classroom as to avoid *instructional selection*, the use of a single teaching method (Tanner & Allen, 2004). Kinshuk et al. (2009) investigated university students' behavior and performance based on courses mismatched to their learning styles, and they found that learners with a strong preference toward a specific learning style struggled more in learning (achieving lower scores) than learners who were a little more flexible in their learning style preferences. Moreover, reflective learners performed better on exams in mismatched courses while active learners, more hands-on type learners, have more difficulties (Kinshuk et al., 2009). Based on this information, it is almost necessary to have multiple learning techniques available due to the diverse population of the modern undergraduate classroom just as with the modern K-12 classroom. Instructors should attempt to identify learners' styles and give applicable feedback, provide opportunities to clarify the difference between learning styles and learning strategies and their relationship and to implement learning contracts with the incorporation of learning style awareness into said contracts (Sadler-Smith & Smith, 2004).

Learning Styles and the Post-Secondary Science Classroom

The post-secondary science classroom is typically a medium-to-large lecture hall with the focal point at the front and center where the instructor lectures vast amounts of information for 50 to 75 minutes only two to three class periods a week. The key word here is *lecture.* Although undergraduate science students often acquire knowledge in these lecture-hall-type learning environments, they are not necessarily learning for meaningful understanding (Tomanek & Montplaisir, 2004). The lecture style is effective to aural learners (learn by listening) but neglects the other types of learners such as visual or active experimentation type learners. When assessing learning style preferences of students enrolled in an Applied Human Physiology course with the VARK learning style inventory, females and males differed significantly when it came to learning style preferences. Females preferred visual learning (46%), followed by aural (27%), read/write (23%), and kinesthetic (4%). Males, also, most preferred visual learning (49%), but this was followed by read/write (29%), aural (17%), and kinesthetic (5%) (Dobson, 2009). Aural learners had the highest overall mean class score and kinesthetic learners had the lowest mean scores in all portions of the class (Dobson, 2009). A study about VARK learning styles of undergraduate premedical students and medical students showed that 47.2% of students preferred a unimodal learning style compared to 52.7% of students who preferred a multimodal learning approach (Shankar et al., 2014). Another study related to VARK learning styles showed that 86.8% of first-year undergraduate medical students had a multimodal learning preference while only 13.8% preferred a unimodal approach, and the most common learning preference was bimodal, AK (33%) and AR (16.5%) (Prithishkumar & Michael, 2014).

More often than not, introductory science courses at the post-secondary level are high-risk courses, with up to half of the students earning a D or lower (Moore & LeDee, 2006). Furthermore, “switchers” (students who leave science courses and science majors) leave science due to the highly competitive class climate, inundated curricula, stringent grading practices, and the “weed-out” attitude of many science faculty (Tanner & Allen, 2004). "Switchers" and "nonswitchers" are not distinguishably different student populations (having different levels of academic ability) (Tanner & Allen, 2004). Consequently, the loss of the "switchers" is most likely due to instructor teaching styles, the science classroom environment, and the process of *instructional selction*—use of a single teaching method (Tanner & Allen, 2004). While there may not be a one-size-fits-all solution to this dilemma, incorporating classroom activities or out of class assignments that appeal to a multitude of student learning styles may help. Lee and Jabot (2011) found that students in an undergraduate sophomore-level genetics class achieved increased learning gains following the integration of actively engaging group quizzes in which the students received immediate, in-class feedback on their quizzes as well as discussed key genetics concepts. Moore and LeDee (2006) found that supplemental instruction, such as study activities available outside of class, improved students' academic behaviors such as attending more class periods, help sessions, and submitting more extra credit which could help them improve their academic performance over time. The options of in-class or out-of-class activities would broaden the range of students the post-secondary science instructor would be able to impact rather than only reaching to the aural student learners.

<u>Learning Styles and Improving Post-Secondary Biology Education</u>

In regards to improving the quality of undergraduate biology education, the 2009 final report of a national conference organized by the American Association for the Advancement of Science underscores three major recommendations as summed up by Musante (2011): "(1) All undergraduate biology curricula should include the described "core concepts for biological literacy" and "core competencies and disciplinary practice," (2) students' learning must be the focal point for teaching, and (3) there must be full-scale institutional investment to improve undergraduate biology education" (p. 512). For students' learning to be the focal point for teaching, teachers should avoid being the sole speakers in the class. In a study where two high school biology teachers were observed, it was found that the more frequently the teachers posed questions, the less frequently the students raised questions (Gioka, 2007). Contrary to this finding, student questions are the best way of determining their current level of understanding (Gioka, 2007). What these findings mean is that students need to actively participate in class even by simply asking questions. When teachers pose questions, they must ask higher-order critical thinking types of questions such as “Why do you think that is?” in order to promote students’ deeper understanding. In another study regarding learner-centered learning, students preferred a combination of both a learner-centered approach and a teacher-centered approach to reach course goals (Rutledge, 2008). Students thought the learner-centered approach was engaging and piqued their interests, and the teacher-centered approach made them feel more confident in their learning from an expert in the field of biology.

To address the third point of the 2009 AAAS final report, for any change in teaching approaches and more meaningful learning to occur, instructional institutions as a whole must lay the groundwork in order for individual classrooms to have any chance of maintaining a better level of learning. An example of the level of learning currently achieved by undergraduate students in a lecture hall setting is the small exploratory study conducted by Tomanek and Montplaisir (2004) which was to determine whether and how students created their own self-directed learning and whether meaningful learning occurred due to student efforts. They found that students used the exams as their motivation to prepare notes or other study aids, and students were strategic about the information on which they focused and based it on what the instructor emphasized in the lectures. They were only successful with questions posed to them that resembled those of an old exam, performing poorly on unfamiliar questions still related to the topic. This meant that students probably were only learning to be successful on the exams rather than creating a deeper, meaningful learning experience. Learning to be successful on exams is what usually occurs at the introductory course level for undergraduates. Tomanek and Montplaisir (2004) advise that instructors must implement consistent, frequent in-class exercises solving unique problems which should be graded in a meaningful way including evaluative feedback.

Curricular changes and teaching approaches are often overlooked because they take a lot of effort on the parts of the instructor and institution. Traditional lecture seems to be the easiest approach when considering time and effort invested. This does not have to be the case, as Goldstein (2011) discovered in her study regarding the incorporation of active learning and quantitative skills in an undergraduate introductory biology course. By making small-scale changes, such as changing the approach to a dissection, rather than large-scale changes (the kinds of which instructors and institutions are wary), Goldstein (2011) found that introductory biology students' statistical analysis skills improved and their attitudes about the quantitative analyses were positive. Essentially, the teacher can make a small change in how they teach that does not require too much additional time and students still benefit academically and emotionally.

To resolve the "weed-out" effect of introductory science courses, it is important for instructors to consider Felder and Silverman's Dimensions of Learning Styles in Science. These are: 1) the type of information students receive, sensory or intuitive, 2) the modality in which they receive it, visual or verbal, 3) the process by which they receive it, actively or reflectively, and 4) the order in which they receive it, sequentially or globally (Tanner & Allen, 2004). Sensory learning (learning facts) and intuitive learning (learning concepts) are important to consider in order for students to have a base knowledge and a way to apply that knowledge to scientific problems. Because undergraduate science classes are typically lecture-based (verbal), visual materials may be lacking. However, it is necessary to include illustrations, animations, and videos to reach out to the visual learners in the classroom. Active learners prefer to learn by doing such as engaging in investigations, group work , and discussions while reflective learners tend to prefer individual work, opportunities for reflection, and taking in information in a solitary setting. Therefore, both individual and group work should be included in a science course. Felder and Silverman's fourth, and final, dimension refers to how learners build new knowledge for themselves (Tanner & Allen, 2004). Sequential learners are people who prefer order and a linear path to new information while global learners prefer creating an overview of large concepts and breaking the large concepts in to smaller details. To accommodate both of these manners of learning, teachers must not only present facts and details to students, but also present opportunities for grasping the larger picture. Moreover, Tanner and Allen (2004) advise that the key to retaining possible "switchers" (students who leave the sciences) is to implement differentiated instruction rather than a singular approach to teaching.

Importance of Study: Notecards—Illustrative Versus Descriptive

The present study focuses on the use of notecards as study aids and whether drawing illustrations of scientific concepts is better, worse, or equivalent, with regards to learning, to writing descriptions/definitions of the same scientific concepts.

Notecards

Notecards are a common learning strategy amongst students in all grades. Wissman, Rawson, & Pyc (2012) studied how and when 374 undergraduate students used notecards. They found that students chose to utilize notecards to memorize information, preferred using smaller stacks of notecards when studying, and kept notecards in their stack until they mastered the material. Research shows that the use of notecards help improve student performance on exams. Student participants in an undergraduate level introductory psychology course performed better on exams in which they utilized notecards as their study aid, and most of the students utilized self-generated notecards rather than computer-generated notecards (Golding et al., 2012). There was not a statistically significant difference in vocabulary learning between electronic, digitized, or paper flashcards (Nikoopour & Kazemi, 2014). Moreover, students learn to self-direct their own learning method when studying notecards because they rely more on themselves than the teacher to learn content (Cancela et al., 2012).

Scientific text and illustrations

Vilppu, Mikkila-Erdmann, and Ahopelto (2013), found that students who employed a deeper, independent learning style performed better after reading text than reproductive and support-dependent learners (learners with poorer learning strategies). Students learned more meaningfully with text that included information that broke misconceptions of a scientifc concept rather than just the text without the misconception information. In one study related to grade performance and text in science, the amount of time first-year undergraduate students spent reading their science textbooks was not a good indicator of their high school biology grades and was not significantly related to science ACT scores (Wyss et al., 2013). In a recent eye-tracking study, researchers computed the number of eye fixations students made on text with and without illustrations (concrete or abstract) and found that readers of the illustrated text, either concrete or abstract, outperformed readers of only text, and there was no statistically significant differences between the readers of the abstract text and readers of the concrete text (Mason, Pluchino, Tornatora, & Ariasi, 2013). It matters what type of illustration accompanies the text because in one study, enjoyable, decorative images paired with text led to poor metacomprehension accuracy compared to text supplemented with conceptual illustrations (Jaeger & Wiley, 2014).

As stated previously, computer-generated notecards were neither better nor worse than traditional notecards (Nikoopour & Kazemi, 2014), but a study concerning a learner-generated drawing strategy showed that students who drew pictures related to the biological process of influenza scored significantly higher on a multiple choice comprehension test than the control group of students who only read about the biological process of influenza (Schmeck, Mayer, Opfermann, Pfeiffer, & Leutner, 2014). Making the illustration the students' own may promote student understanding of concepts because textbook illustrations may turn out functionally useless if the learner does not perceive the illustration in the intended manner (Carney & Levin, 2002).

Torcasio and Sweller (2010), however, found that informative illustrations were redundant and added to the working memory load in information processing of the brain when elementary students were learning to read. Hence, the illustrations were unnecessary and, in fact, impeding to processing and storing information in the brain. Moreover, texts are more likely to be utilized to understand the scientific concept, whereas illustrations are more likely used as a visual cognitive instrument on demand (Hochpochler et al., 2013). Students referred to the illustrations only when they could not fully understand the text.

Project Outline and Hypothesis

This research study focused on determining the effectiveness of illustrative notecards to that of descriptive notecards. Three course sections of an introductory human biology course were established as three groups (Control, Descriptive Notecards, Illustrative Notecards) tested in this study. The control group did not complete notecard assignments whereas the other two groups completed either illustrative or descriptive notecards. Assessment included a set of pre- and post-tests, course exams, and weekly assignments (the control group's standard curriculum that included quizzes and both of the notecard groups' modified curriculum including notecard assignments). There were three objectives to the present study: 1. To determine the effectiveness of using notecards as a study aid on exam performance and knowledge retention, 2. To determine whether the use of illustrative notecards vs. descriptive notecards yield different learning outcomes, and 3. To relay to the educational community whether notecards are an effective learning strategy in biology curriculum. It was hypothesized that the use of notecards would increase the learning outcome and knowledge retention relative to the control group, and moreover, the use of illustrative notecards would yield higher learning gains and retention relative to the descriptive notecard group.

CHAPTER III

METHOD

Human Subjects Training and IRB

The principal investigator and her mentor, Emily McCadden and Dr. Kelly Barry, respectively, in collaboration with the course instructor, Dr. Barbara McCracken, completed the "CITI Course in the Protection of Human Research Subjects" (Appendix A) training since the study involved student learning in three sections of a lower-level biology course. On July 30, 2013, the Southern Illinois University of Edwardsville (SIUE) Institutional Review Board (IRB) approved the application for exempt research (Appendix A).

Demographics and Course Information

The demographics of the group were not collected since the students did not complete an end-of-semester survey specific to this study. There was a total of 253 students enrolled in the three sections of the course. Of the 85 students enrolled in section 003 (control group), 53 students participated in the research study. Of 84 students enrolled in section 004 (illustration group), 43 students participated in the research study. Of 84 students enrolled in section 005 (description group), 42 students participated in the research study.

According to SIUE's Undergraduate Catalog 2013-2014 (2013), BIOL 140 Human Biology is an "[i]ntroduction and application of basic human biology concepts, including cell theory, genetics, systems biology, and evolution." It is set up as a lecture-only course and is not for biological sciences major credit. Exercise Science majors intending to earn a B.S. Degree are required to complete at least 8 courses in the sciences (life, physical, or social) in which they have the option to take BIOL 140 Human Biology as one of their required science courses. Forensic Science minors must complete seven courses from a list of approved courses including one course from the Biological Sciences, and that course option could be BIOL 140 Human Biology. Health Education majors must take a life science course as part of a general education requirement in which they can choose either BIOL 140, Human Biology, or BIOL 203, Human Sexuality. SIUE's School of Nursing requires the completion of BIOL 140 Human Biology as an admission requirement into the SIUE Nursing program. Furthermore, BIOL 140 Human Biology is SIUE's prerequisite course for BIOL 240a Anatomy and Physiology I and BIOL 250 Bacteriology which nursing students must complete to be admitted into the Nursing program. Nursing majors enroll in BIOL 140 Human Biology in their first semester of college unless they are transfer students who already have a higher Biology prerequisite such as BIOL 240a Anatomy and Physiology I or BIOL 250 Bacteriology from another community college or university.

Fall 2013 Research Study

Three course sections of BIOL 140 were selected for the study, where each section of the course was taught by the same instructor, Dr. Barbara McCracken. Before the first day of class, the three sections (section 003, section 004, and section 005) were assigned to different groups. Section 003, a Monday/Wednesday/Friday class with 50 minutes per class period, was selected to be the control group. Section 004, a Tuesday/Thursday class with 75 minutes per class period, was assigned to be the illustration group. Section 005, also a Tuesday/Thursday class with 75 minutes per class period, was assigned to be the description group. Prior to the first day of class, a pre-test and post-test were developed in collaboration with Dr. Kelly Barry, the principal investigator's mentor, and Dr. Barbara McCracken, the course instructor.

On the first day of class, each student in each section was given a unique, five-digit code for anonymity in the study. The control group was assigned five-digit anonymity codes

00301-00386, the illustration group was assigned anonymity codes 00400-00484, and the description group was assigned anonymity codes 00501-00585. All students completed an Informed Consent form (Appendix B) on the first day of class. Emily McCadden, the principal investigator, attended the first class of section 004 (illustration group) and section 005 (description group) while Dr. Kelly Barry, the principal investigator's mentor, attended the first class of section 003 (control group) to briefly discuss the research project in order for the students to understand to what they would be consenting. Only those students who agreed to participate were included in the study (Appendix C). Of the 85 students enrolled in the control group, 53 students agreed to participate in the research study. Of 84 students enrolled in the illustration group, 43 students agreed to participate in the research study. Of 84 students enrolled in the description group, 42 students agreed to participate in the research study. Although there were students in each group who did not choose to participate in the research study, they still completed the assignments from the research study since the assignments were part of their class participation credit as described in their course syllabus (Appendix D).

All of the students (participating and non-participating) completed the same pre-test (Appendix E) to determine the students' level of knowledge prior to the first lecture. The pre-test included 24 multiple-choice questions with four answer choices per question. The questions were devised based on the previous Fall 2012 syllabus for the course in which 24 chapters of the course textbook were taught. Each question on the pre-test corresponded to information from each chapter of the course textbook *Campbell Biology: Concepts and Connections 7th Edition* (2012), co-authored by Jane B. Reece, Martha R. Taylor, Eric J. Simon, and Jean L. Dickey. One question was included for each chapter. Some questions were written by the principal investigator while some were taken from end of chapter review questions found in the textbook. The questions from the end of chapter review questions can be found in Appendix F.

Experimental design and procedures

The students in the control group (n=53) were taught with standard curriculum and no study aids. The illustration group (n=43) and the description group (n=42) utilized a study aid. The illustration group and the description group completed notecard assignments (Table 1), the study aid, while the control group did not. In this study, the independent variable was the type of notecard used as a study aid (illustration or description). The illustration group and the description group were assigned three questions on the Tuesday class periods. The questions were identical in content but differed in phrasing of the question. The illustration group's questions were formatted like "Illustrate…" "Diagram…" or "Draw…" (Appendix G) while the description group's questions were about the same content but were phrased like "Describe…" "Define…" or "Discuss…" (Appendix H). The illustration group and the description group were given three blank notecards for completing each assignment. Both groups answered one question per notecard making a total of three notecards due each Thursday, weekly, excluding exam weeks and holiday vacation (Table 1). The notecards were graded and returned to students on the following Tuesday class period or students could collect them from the instructor at her office the Friday or Monday prior to the Tuesday class period. Each notecard was worth 1 point apiece with a total of 3 points possible per weekly assignment. There were a total of 11 assignments given in the 16-week Fall 2013 semester (Table 1). The total points possible for both the illustration group and the description group equaled a maximum of 33 points and were considered participation points for the class. The illustration group answered the three questions by making a drawing or diagram of the biological concept/process/terminology (Appendix G) while the description group either described or defined the biological concept/process/terminology (Appendix H). The students in the illustration group and the students in the description group received their graded notecards promptly (within 2 days of submission) and had all of their graded notecards available before each exam to help them study.

The control group did not complete notecard assignments. The instructor gave the students in the control group a weekly three-question quiz (part of standard curriculum of course) each Friday, excluding exam weeks and holiday vacation. The course instructor assigned the quizzes in order for each course section to have equal participation points. The instructor did not make the notecard assignments from the illustration group and description group available to the control group. The control group was asked questions on the quiz (Appendix I) that were based on the same chapter content that the illustration group and the description group were asked to complete for their notecard assignments. The format of the quiz varied weekly (Appendix I). Styles of questions asked included multiple-choice and fill-in-the-blank. The weekly quiz was written by the principal investigator, Emily McCadden, for Quiz 1-3 and 9 and were written based on the exact questions the illustration group and the description group were assigned those weeks. The weekly quiz was written by the instructor, Dr. Barbara McCracken, for Quiz 4-8, 10, and 11 and were not the exact questions that the illustration group and description group were assigned but were related to the same chapter content. Each weekly quiz was worth three points except for Quiz 9 which was worth six points due to low student participation that particular week (Table 1). The instructor assigned the control group's Quiz 9 at the start of the lecture, but students were leaving directly after the quiz so she assigned the students a three-point pop quiz at the end of the lecture. Table 1 also shows a comparison of assignments between the control group, description group, and illustration group. There were 11 quizzes assigned in the 16-week semester of Fall 2013 (Table 1). The total points possible for quizzes for the control group equated to 36 points possible. The quiz points were considered participation points for the class.

The notecard assignments were graded not only on completion but also the correctness of the response. The students did not receive points just by completing the assignments. They had to be thorough when completing their illustrations or descriptions. For example, if one notecard only included half the information, then the student would only receive half credit (0.5 points) for that particular notecard. If half or more of the information was incorrect, the student would only receive half credit for that notecard. This grading format was used for both the illustration group and the description group.

Table 1. Course Schedule Portraying Chapter Material for Fall 2013 Research Study and Study Aids Given.

Course Assignment Schedule for Fall 2013 Research Study					
Assignment Number	Chapter(s)	Control Group Quiz	Description Group Notecards	Illustration Group Notecards	Points Possible
1	1: Exploring Life	Quiz, No Study Aid	3 Descriptive Notecard Questions	3 Illustrative Notecard Questions	3
2	3: The Molecules of Cells	Quiz, No Study Aid	3 Descriptive Notecard Questions	3 Illustrative Notecard Questions	3
3	4: A Tour of the Cell	Quiz, No Study Aid	3 Descriptive Notecard Questions	3 Illustrative Notecard Questions	3
Exam 1					
4	5: The Working Cell 6: How Cells Harvest Chemical Energy	Quiz, No Study Aid	3 Descriptive Notecard Questions	3 Illustrative Notecard Questions	3

5	8: The Cellular Basis of Reproduction and Inheritance	Quiz, No Study Aid	3 Descriptive Notecard Questions	3 Illustrative Notecard Questions	3
6	9: Patterns of Inheritance	Quiz, No Study Aid	3 Descriptive Notecard Questions	3 Illustrative Notecard Questions	3
Exam 2					
7	10: Molecular Biology of the Gene	Quiz, No Study Aid	3 Descriptive Notecard Questions	3 Illustrative Notecard Questions	3
8	11: How Genes Are Controlled 12: DNA Technology and Genomics	Quiz, No Study Aid	3 Descriptive Notecard Questions	3 Illustrative Notecard Questions	3
9	13: How Populations Evolve 14: The Origin of Species	Quiz, No Study Aid	3 Descriptive Notecard Questions	3 Illustrative Notecard Questions	3 (Illustration and Description Groups) 6 (Control Group)
Exam 3					
10	20: Unifying Concepts of Animal Structure and Function	Quiz, No Study Aid	3 Descriptive Notecard Questions	3 Illustrative Notecard Questions	3
11	21: Nutrition and Digestion 22: Gas Exchange	Quiz, No Study Aid	3 Descriptive Notecard Questions	3 Illustrative Notecard Questions	3
Exam 4					
Final Exam					

Examples of excellent, satisfactory, and unsatisfactory notecards can be found in Appendix J. Students were able to submit notecards a few days past the due date without any deduction of points. The notecard assignments, generally, were not accepted more than a week after the due date. However, there were a few exceptions to this rule when a few students were permitted by the instructor to turn in notecard assignments assigned in previous weeks during the last week of the semester. Points were not subtracted due to their tardiness since the instructor allowed the late submission. These students were non-participants of the study, so this did not affect the data analysis of the research study.

The control group's quizzes were also graded for correctness. Examples of excellent, satisfactory, and unsatisfactory quizzes can be found in Appendix K. For multiple-choice questions and/or fill-in-the blank questions, the students received one point if the answer was correct and zero points if it was not. These points were all-or-nothing. If the quiz included short answer questions, the answer was worth half credit if a student only partially answered the question, one point if all correct, or zero points if completely wrong. Students were not able to make up the quiz if they missed class.

All students completed a post-test, a separate assessment given immediately prior to the final exam. The post-test included the exact questions from the pre-test (Appendix E).

Statistical tests used in study

Students who did not complete seven or more assignments ($\geq 64\%$) were excluded from data analyses. Forty-one of the original 53 members of the control group completed $\geq 64\%$ of the assignments. Thirty-four of the original 52 members of the description group completed $\geq 64\%$ of the assignments. Thirty-six of the original 43 members of the illustration group completed $\geq 64\%$ of the assignments. Only questions 1 through 18 from the pre-tests and post-tests were assessed with statistical tests since the class sections did not learn about the topics and concepts included in questions 19 through 24.

All statistical tests were conducted using IBM SPSS Statistics and a statistical tutorial program developed by Laerd Statistics (2013) except the calculation of normalized learning gains. Normalized learning gains were calculated utilizing an equation determined by a study by Steinert, Phillips, and Coletta (2007). Excel 2013 was used to develop graphs in all of the figures.

The difference in pre- and post-test scores were evaluated using a paired t-test, $p = 0.05$ (Table 2). The data was shown to be normally distributed by performing a Shapiro-Wilk's test of normality (Table 4), but there was one outlier in the control group (Anonymity Code #00328, Appendix L) which had a 10-point positive difference between the pre-test and the post-test. This outlier was adjusted by basing its value on the second highest difference value of 6. The justification for adjustment of outliers was referred to in the Laerd Statistics tutorial program (One-way ANOVA in SPSS Statisitics, 2013). The outlier was thus changed from 10 to 6.01 to still remain as the highest value in the data set. The description group also had one outlier (Anonymity Code #00522, Appendix L) which had a 9-point positive difference between the pre-test and the post-test. This outlier was adjusted the same way the control group outlier was by basing its value on the second highest difference value of 7. The outlier was changed from 9 to 7.01 to still remain the highest value in the data set. The illustration group did not contain any outliers. A Wilcoxon signed-rank test, $p < 0.05$, was performed to confirm that the paired t-test was appropriate for the data analysis since the paired t-test had a two outliers (Table 3).

A Shapiro-Wilk's test of normality (Table 4) was performed to determine if the data was normally distributed prior to performing the one-way ANOVA. There were two outliers when performing the initial test of normality. These were the same two outliers that were adjusted in the paired t-test. The outliers were adjusted the same way as it was in the paired t-test (One-way ANOVA in SPSS Statisitics, 2013). A one-way ANOVA was conducted in order to determine if there was a significant difference between classes based on pre-test and post-test scores (Table 5). An Effect Size (ω^2) was calculated based on the resulting data gathered from the one-way ANOVA using the following calculation: $\omega^2 = [SSb - (df_b)MS_w] / (SS_t + MS_w)$. The purpose of calculating Effect Size was to determine whether there was a small, medium, large effect or any effect at all by estimating the size of the difference between groups (Nandy, 2012). Following the one-way ANOVA and Effect Size calculation, a Tukey post-hoc test was conducted in order to compare all possible combinations of group differences (Table 6).

The normalized learning gains (*G*) (Figure 1) were calculated [*G* = (postscore % – prescore %) / (100 – prescore %)] to present a legitimate comparison of the pre- and post-tests of students with different pre-test scores (Steinert et al., 2007).

Weekly assignment averages were analyzed to compare assignment scores (quiz or notecard assignment) across the three groups and to assess short-term learning. All participants were included in the first weekly assignment analysis (Figure 2A, Appendix C) while only those participants who completed ≥ 64% (seven) of assignments were analyzed in the second weekly assignment analysis (Figure 2B, Appendix L). The second analysis was conducted to determine whether the amount of participants who did not complete the assignments affected the weekly assignment averages. A Kruskal-Wallis H test was conducted to determine if there was a statistical significance between assignment scores of the three groups. The Kruskal-Wallis H test was followed up by Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons to further analyze any statistical significances between groups' assignment scores.

A Spearman's Correlation test was conducted across all three groups to determine how exam scores correlated with their respective assignments (refer to course schedule in Table 1) as well as how the final exam scores correlated with all eleven assignments (Table 9). A bar graph showing assignment percentages and exam percentages was constructed to visualize comparisons between exam score percentages and assignment score percentages and can be found in Figure 3. Also, the difference of correct answers on pre-tests and post-tests of each group were compared to determine if students gained in learning in certain content areas compared with other content areas as well as whether students from a particular group learned better in certain content areas relative to the other groups (Figure 4).

Finally, a Kruskal-Wallis H test was performed to conclude if there was a significant difference between groups based on scores attained on the five exams, including the final exam of the semester (Table 10). Course evaluations from all sections were assessed for qualitative information of students' experiences (Table 11). A template of the course evaluation can be found in Appendix M.

CHAPTER IV

RESULTS

The paired t-test showed that there was a significant difference *within* the groups from the beginning of the semester to the end of the semester (Table 2). A Wilcoxon signed-rank test confirmed that the paired t-test was appropriate for the data analysis (Table 3), and in this case, the Wilcoxon signed-rank test validated the use of the paired t-test by showing that there was a significant difference *within* the groups from the beginning of the semester to the end of the semester.

Table 2. Pre- and Post-Test Statistical Data Using a Paired t-Test. Values are based on a 95% confidence level ($p < 0.05$).

Pre-/Post-Test Analysis Using Paired t-test 95% Confidence				
	n	df	d	P(T<=t) two-tail
Control	41	40	0.381	0.019
Description	34	33	0.895	0.000
Illustration	36	35	1.253	0.000

After adjusting the outliers (Anonymity Codes #00328 & #00552, Appendix L) and performing a Shapiro-Wilk's test of normality (data is normally distributed when $p > 0.05$), it was determined that the difference scores between the post-tests and the pre-tests for all three classes was normally distributed (Table 4).

Table 3. Pre- and Post-Test Statistical Data Using a Wilcoxon Signed-Rank Test. Values are based on a 95% confidence level (p < 0.05).

Pre-/Post-Test Analysis Using Wilcoxon Signed-Rank Test 95% Confidence			
	n	z (standardized test statistic)	P Value
Control	41	2.221	0.026
Description	34	3.979	0.000
Illustration	36	4.512	0.000

Table 4. Shapiro-Wilk's Test of Normality of Data Distribution. Data is normal if p value is > 0.05.

Shapiro-Wilk's Test of Normality 95% Confidence			
	n	df	P Value
Control	41	40	0.210
Description	34	33	0.172
Illustration	36	35	0.090

The one-way ANOVA showed that, based on the differences between pre-test and post-test scores of each group, there *was* a statistically significant difference between the different assignment groups, $F(2,108) = 3.366$, $p = 0.038$ (Table 5). The Effect Size (ω^2), calculated based on the results of the one-way ANOVA, was found to be 0.044 (Table 5). A small effect equals 0.01, a medium effect equals 0.06, and a large effect equals 0.14 (Field, 2013). Thus, the Effect Size ($\omega^2 = 0.044$) between the three groups in this study was a small-to-medium effect but an effect no less. Because the one-way ANOVA showed a statistical significance, a Tukey post-hoc test was performed to compare all possible combinations of group differences. There was an increase in difference scores from the control group to the description group that *was not* statistically significant ($p = 0.130$). There was an increase in difference scores from the control group to the illustration group which *was* statistically significant ($p = 0.045$). Lastly, there was an increase in difference scores from the description group to the illustration group that *was not* statistically significant ($p = 0.909$) (Table 6).

Table 5. One-Way ANOVA and Effect Size. Values of One-Way ANOVA are based on a 95% confidence level ($p < 0.05$).

One-Way ANOVA 95% Confidence & Effect Size							
	Sum of Squares (SS)	df	Mean Square (MS)	F	P Value	Significantly Different?	Effect Size (ω^2)
Between Groups (b)	45.596	2	22.798	3.366	0.038	YES	0.044
Within Groups (W)	731.504 (t)	108	6.733				

Note: Effect Size calculated with following equation: $\omega^2 = [SSb - (df_b)MS_w] / (SS_t + MS_w)$.

The normalized learning gains, displayed in Figure 1, shows that the description group and the illustration group had twice the learning gains, $G = 0.19$ and $G = 0.20$, respectively, than that of the control group, $G = 0.08$.

Table 6. Tukey Post-Hoc Test for Multiple Comparisons. Values are based on a 95% confidence level ($p < 0.05$). An (*) denotes significance.

	Tukey Post-Hoc Test 95% Confidence			
	Mean (M)	Standard Deviation (SD)	Mean Increase	P Value 95% confidence (CI)
Control	1.15	3.05		
Description	2.32	2.53		
Illustration	2.58	2.06		
Description compared with Control			0.21	0.130
Illustration compared with Control			1.43	0.045*
Illustration compared with Description			0.26	0.909

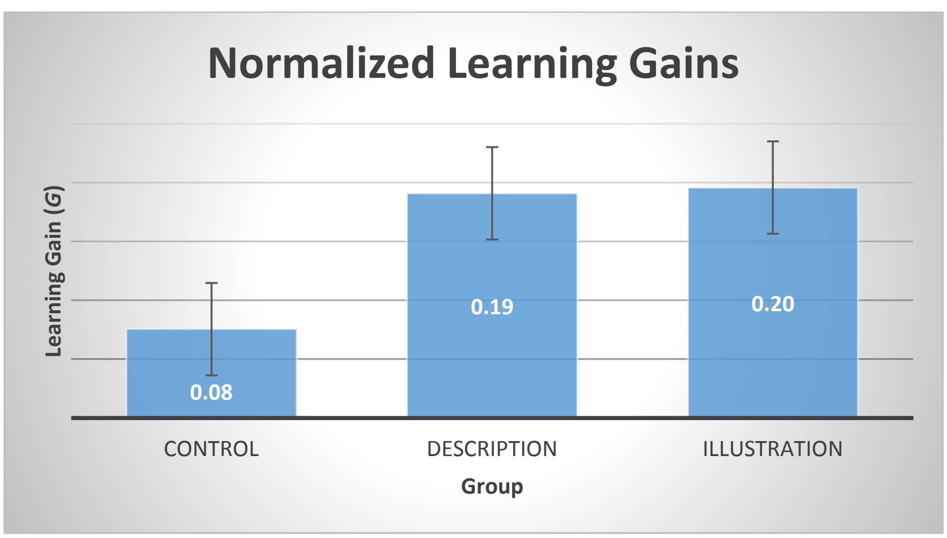
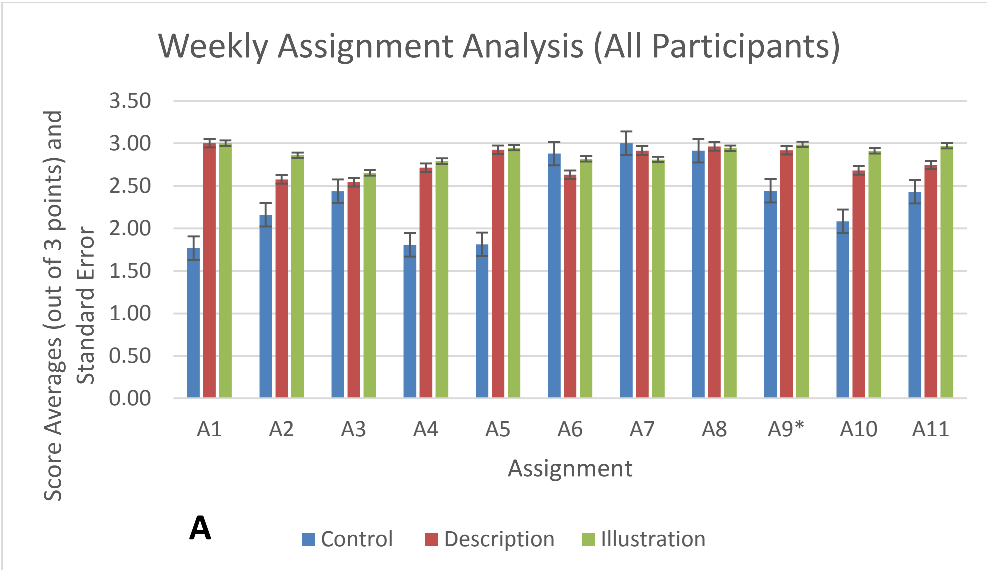


Figure 1. Normalized Learning Gains. Allows for a valid comparison of post-test scores for students with different pre-test scores. Error bars are standard error.

Short-term learning was assessed through the weekly assignments (Figure 2). Figure 2A is the analysis of weekly assignment score averages based on all participants in the study in order to assess short-term learning (Appendix E). Figure 2B excludes those participants who did not complete ≥ 64% (seven) of assignments during the semester (Appendix L). There is little to no difference in average weekly assignment scores across the three groups when excluding those who did not participate in the study ≥ 64% of the time. Table 7 shows the data represented in Figure 2 and also includes the results of a Kruskal-Wallis H test. The Kruskal-Wallis H test showed that there was a statistically significant difference among the three groups for Assignments 1, 2, 3, 4, 5, 7, 9, 10, and 11 (Table 7). The illustration group had the highest average score for Assignments 2, 3, 4, 9, 10, and 11 whereas the description group had the highest average score for Assignment 5 and the control group had the highest average score for Assignment 7. The description group and the illustration group tied for the highest average score for Assignment 1.

Since the Kruskal-Wallis H test showed a statistical significance between groups with regards to assignment scores, a follow-up post hoc test called Dunn's (1964) procedure with Bonferroni correction for multiple comparisons was performed to pinpoint where the statistical significances resided (Table 8). The description group was statistically significantly different compared to the control group for Assignments 1, 2, 4, 5, 9, and 10 (mean rank and p values reported in Table 8). The illustration group compared to the control group was statistically significantly different with regards to Assignments 1, 2, 3, 4, 5, 9, 10, and 11. Because the control group had a higher mean score on Assignment 7, the control group was statistically significantly different to the illustration group for Assignment 7, $p = 0.000$. There was a statistically significant difference when comparing the description group to the illustration group for Assignment 11, $p = 0.016$.



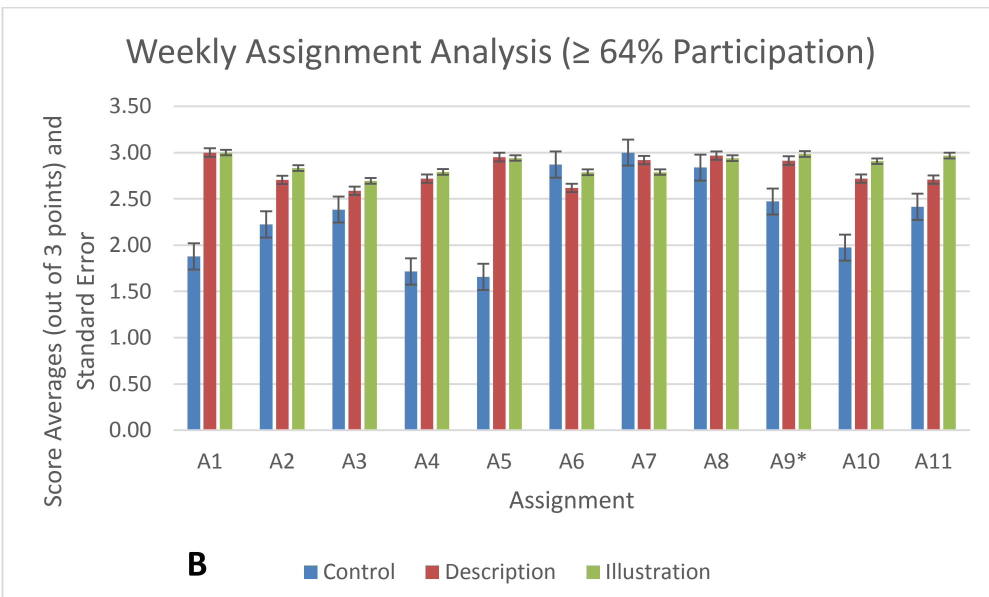


Figure 2. (A) Weekly Assignment Analysis (All Participants). Error bars are standard error. (B) Weekly Assignment Analysis (≥64% Participation). Strictly includes only those participants who completed ≥ 64% (7 out of 11) of the assignments. The Control group (green) had normal class instruction which included normal weekly quizzes. The Description group (blue) completed notecards using descriptions and the Illustration group (yellow) completed notecards using illustrations. Error bars are standard error. An (*) denotes assignment 9 (A9) was originally worth 6 points for group 1. An average of each individual score was taken to equate the data with the illustration and description groups. An overall average for A9 was formulated based on those individual averages.

Table 7. Weekly Assignment Average Score Comparison and Kruskal-Wallis H Test for Significance. Excludes participants who did not complete ≥ 64% (7) assignments. Values are based on a 95% confidence level ($p < 0.05$). An (*) denotes significance.

Assignment Score Comparisons for Fall 2013 With Kruskal-Wallis H Test (95% Confidence)			
Assignment Number	Chapter(s)	Highest Average, to Lowest Average, Out of 3 Points Possible (C=Control, D=Description, I=Illustration)	Kruskal-Wallis H Test Results P Value
1	1: Exploring Life	I=3.00 D=3.00 C =1.88	0.000*
2	3: The Molecules of Cells	I=2.83 D=2.71 C=2.23	0.000*
3	4: A Tour of the Cell	I=2.69 D=2.59 C=2.38	0.020*
4	5: The Working Cell & 6: How Cells Harvest Chemical Energy	I=2.79 D=2.72 C=1.72	0.000*
5	8: The Cellular Basis of Reproduction and Inheritance	D=2.95 I=2.94 C=1.66	0.000*
6	9: Patterns of Inheritance		0.082
7	10: Molecular Biology of the Gene	C=3.00 D=2.92 I=2.79	0.001*
8	11: How Genes Are Controlled & 12: DNA Technology and Genomics		0.257
9	13: How Populations Evolve & 14: The Origin of Species	I=2.99 D=2.91 C=2.47	0.000*
10	20: Unifying Concepts of Animal Structure and Function	I=2.91 D=2.72 C=1.97	0.000*
11	21: Nutrition and Digestion & 22: Gas Exchange	I=2.97 D=2.71 C=2.41	0.000*

Table 8. Pairwise Comparisons Using Dunn's (1964) Procedure with Bonferroni Correction for Multiple Comparisons, a post-hoc test following statistical significance found by Kruskal-Wallis H test. An (*) denotes p < 0.05. MR = Mean Rank, C = Control group, D = Description group, and I = Illustration group.

Pairwise Comparisons Dunn's (1964) Procedure with Bonferroni Correction for Multiple Comparisons (95% Confidence)

Pairwise Comparison		Assignment Number								
		1	**2**	**3**	**4**	**5**	**7**	**9**	**10**	**11**
Control-Description	P value	0.000*	0.026*	0.318	0.000*	0.000*		0.000*	0.000*	0.534
	MR	C = 28.68 D = 72.00	C = 41.15 D = 58.15		C = 33.45 D = 61.92	C = 26.38 D = 68.87		C = 33.59 D = 55.57	C = 29.87 D = 58.31	
Control-Illustration	P value	0.000*	0.000*	0.017*	0.000*	0.000*		0.000*	0.000*	0.000*
	MR	C = 28.68 I = 72.00	C = 41.15 I = 68.94	C = 45.85 I = 63.62	C = 33.45 I = 65.17	C = 26.38 I = 69.85		C = 33.59 I = 60.71	C = 29.87 I = 71.93	C = 35.16 I = 57.94
Description-Illustration	P value	1.000	0.310	0.822	1.000	1.000	0.130	1.000	0.146	0.016*
	MR									D = 42.65 I = 57.94
Description-Control	P value						0.247			
	MR									
Illustration-Control	P value						0.000*			
	MR						I = 40.83 C = 58.00			

Figure 3 shows how the assignment and exam percentages compared. Even if assignment percentage scores were excellent, between 90 percent and 100 percent, the exam scores were generally satisfactory, between 65 percent and 75 percent (Table 9). In other words, even though the illustration group outperformed the other groups on eight assignments (Assignments 1-5 and 9-11) and were statistically significantly different than the control group with regards to those same seven assignments, the illustration group performed as well as the description group and control group on all five exams including the final exam.

Students of all groups achieved the highest scores on the final exam, each group with an 85 percent average (Figure 3, Table 10).

The Spearman's Correlation test found across all three groups, generally, a positive correlation between the assignment scores associated with each exam and the exam score as well as positive correlations between the assignments and the final exam (Table 9). Refer to Table 1 or Figure 3 for exams and their respective assignments. The Spearman's Correlation test coefficient called rho (r_s) represents the strength of the correlation between assignments and exams (Weir, 2015). A very weak correlation is r_s = 0–0.19, a weak correlation is r_s = 0.02–0.39, a moderate correlation is r_s = 0.40–0.59, a strong correlation is r_s = 0.60–0.79, and a very strong correlation is r_s = 0.80–1.0 (Weir, 2015).

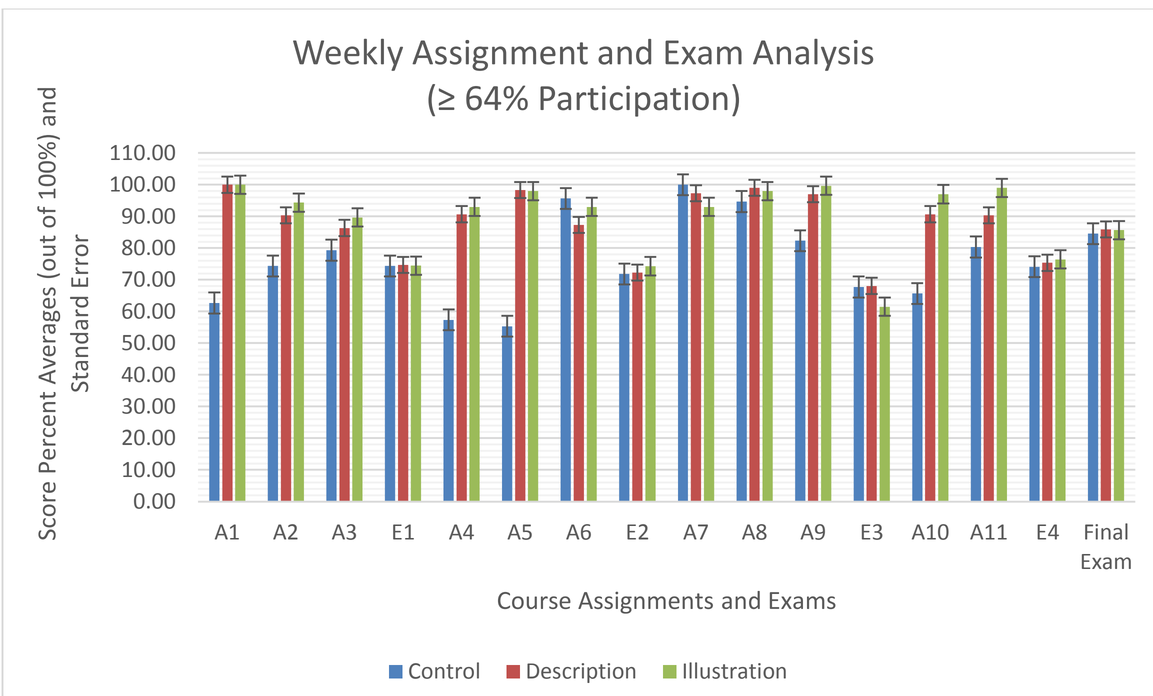


Figure 3. Weekly Assignment and Exam Analysis (≥64% Participation). Strictly includes only those participants who completed ≥ 64% (7 out of 11) of the assignments. The Control group (blue) had normal class instruction which included normal weekly quizzes. The Description group (red) completed notecards using descriptions and the Illustration group (green) completed notecards using illustrations. Error bars are standard error.

There was a moderate, positive correlation between the description group's assignment 6 scores and exam 2 scores, $r_s = 0.445$, $p < 0.01$. There was a moderate, positive correlation between the description group's assignment 9 scores and exam 3 scores, $r_s = 0.462$, $p < 0.05$. There was a weak, positive correlation between the description group's assignment 9 scores and the final exam scores, $r_s = 0.383$, $p < 0.05$. There was a moderate, positive correlation between the description group's assignment 11 scores and the final exam scores, $r_s = 0.409$, $p < 0.05$.

There was a moderate, positive correlation between the illustration group's assignment 2 scores and exam 1 scores, $r_s = 0.400$, $p < 0.05$. There was a moderate, positive correlation between the illustration group's assignment 4 scores and the final exam scores, $r_s = 0.477$, $p < 0.01$. There was a weak, positive correlation between the illustration group's assignment 8 scores and the final exam scores, $r_s = 0.374$, $p < 0.05$.

There was a moderate, positive correlation between the control group's quiz 1 scores and exam 1 scores, $r_s = 0.526$, $p < 0.01$. There was a moderate, positive correlation between the control group's quiz 3 scores and exam 1 scores, $r_s = 0.524$, $p < 0.01$. There was a weak, positive correlation between control group's quiz 5 scores and exam 2 scores, $r_s = 0.392$, $p < 0.05$. There was a weak, positive correlation between control group's quiz 8 scores and exam 3 scores, $r_s = 0.327$, $p < 0.05$. There was a moderate, positive correlation between the control group's quiz 10 scores and exam 4 scores, $r_s = 0.507$, $p < 0.01$. There was a moderate, positive correlation between the control group's quiz 11 scores and exam 4 scores, $r_s = 0.402$, $p < 0.05$. There was a moderate, positive correlation between control group's quiz 1 scores and final exam scores, $r_s = 0.552$, $p < 0.01$. There was a weak, positive correlation between control group's quiz 3 scores and final exam scores, $r_s = 0.389$, $p < 0.05$. Finally, there was a moderate, positive correlation between control group's quiz 5 scores and final exam scores, $r_s = 0.406$, $p < 0.01$. The results of the Spearman's Correlation test can be found in Table 9.

Table 9. Spearman's Correlation Test for correlations between assignments associated with each exam and between all assignments and the final exam. Spearman's Correlation Test coefficient is called rho (r_s). An (*) denotes correlation is significant at $p < 0.05$ and (**) denotes correlation is significant at $p < 0.01$. A (^) denotes a perfect average score on assignment not able to be assessed by correlation test.

Assignment Number	Spearman's Correlation Test					
		Exam 1	Exam 2	Exam 3	Exam 4	Final Exam
1	rho (r_s)	C =0.526** D = undetermined^ I = undetermined^				C = 0.552** D = undetermined^ I = undetermined^
2		C = 0.132 D = -0.68 I = 0.400*				C = 0.189 D = - 0.009 I = 0.206
3		C = 0.524** D = 0.184 I = 0.063				C = 0.389* D = 0.090 I = 0.178
4			C =0.197 D = - 0.146 I = 0.299			C = - 0.063 D = - 0.011 I = 0.477**
5			C = 0.392* D = 0.153 I = - 0.091			C = 0.406** D = 0.037 I = 0.207
6			C = 0.213 D = 0.445** I = -0.019			C = 0.335 D = 0.206 I = - 0.042
7				C = undetermined^ D = 0.305 I = 0.209		C = undetermined^ D = 0.275 I = 0.283
8				C = 0.327* D = 0.276 I = 0.214		C = -0.098 D = 0.184 I = 0.374*
9				C = 0.110 D = 0.462* I = 0.169		C = 0.090 D = 0.383* I = 0.116
10					C = 0.507** D = 0.238 I = 0.104	C = 0.209 D = 0.234 I = 0.290
11					C = 0.402* D = 0.118 I = 0.266	C = 0.136 D = 0.409* I = 0.287

Note: C is control group, D is description group, and I is illustration group. Strength of correlation is: "very weak" r_s = 0.00-0.19, "weak" r_s = 0.02-0.39, "moderate" r_s = 0.40-0.59, "strong" r_s = 0.60-0.79, and "very strong" r_s = 0.80-1.0

By graphing the change in the number of correct answers between the pre-tests and posts-tests of each group shown in Figure 4, it could be determined whether one group benefitted more from their study aid compared to another regarding specific content areas. The pre-test and post-test questions can be found in Appendix E. Figure 4 shows that all groups had large positive changes in the number of correct answers between pre-tests and post-tests for questions 1, 4, 8, 9, 10, 14, 15, and 18. This means that students in all groups achieved long-term learning in the following subject areas: basis of all life, cellular function, molecular biology of a gene, evolution, animal structure and function, the digestive system, and the immune response.

The control group had the best learning results with regards to question 15 about the digestive system. The illustration group had the greatest positive change in correct answers for questions 1, 4, 7, 8, 9, 12, 14, and 16 which means it had better long-term learning outcomes in the following subject areas: the basis of life, cellular function, patterns of inheritance, molecular biology of a gene, the origin of species, the origin and evolution of microbial life, and circulation. The description group had the greatest positive change in correct answers for questions 2, 3, 6, and 11 while the illustration group had the greatest negative change in correct answers for 2, 3, 6, and 11 which means that writing descriptive notecards compared to illustrative notecards and the standard curriculum of the control group enhanced long-term learning in the following subject areas: molecules of the cell, cellular structure, the cellular basis of reproduction and inheritance, and evolution. The description group had the greatest negative change in correct answers for question 17 about gas exchange which means that the standard curriculum and illustrative notecards were more effective for long term learning in that subject area. The control group had the greatest negative change in correct answers for questions 7, 12, and 13 which covered patterns of inheritance, tracing evolutionary history, and the origin and evolution of microbial life, respectively. Because the description group also had a negative change in correct answers for question 12, long-term learning was enhanced by the use of illustrative notecards with regards to tracing evolutionary history and shown by the positive change in correct answers from pre-test to post-test for question 12.

Exam scores for each group (≥ 64% participation, Appendix M) were compared and tested for significance using the Kruskal-Wallis H test (Table 10). Averages of exam 1-5 scores, exam 1-4 being worth 100 points and exam 5 being the final exam worth 200 points, were similar for all groups. The differences *were not* statistically significant.

Assessment of end-of-semester course evaluations illuminated the thoughts of seven students across the three groups. These students were divided when it came to liking or disliking the notecard assignments (Table 11). The course evaluation template can be found in Appendix M.

Table 10. Exam Score Comparisons and Kruskal-Wallis H Test for Significance Between Groups for Exams 1-5. Values are based on a 95% confidence level ($p < 0.05$).

Exam Score Comparisons and Kruskal-Wallis H Test Between Groups				
Exam Number	Highest Average, to Lowest Average, Out of 100 Points Possible, Final Exam worth 200 points (C=Control, D=Description, I=Illustration)	df	P Value	Significant?
1	D = 74.68 I = 74.47 C = 74.34	2	0.976	NO
2	I = 74.28 D = 72.24 C = 71.80	2	0.771	NO
3	D = 68.06 C = 67.71 I = 61.50	2	0.319	NO
4	I = 76.44 D = 75.35 C = 74.10	2	0.587	NO
5 (Final Exam)	D = 171.82 I = 171.28 C = 169.07	2	0.987	NO

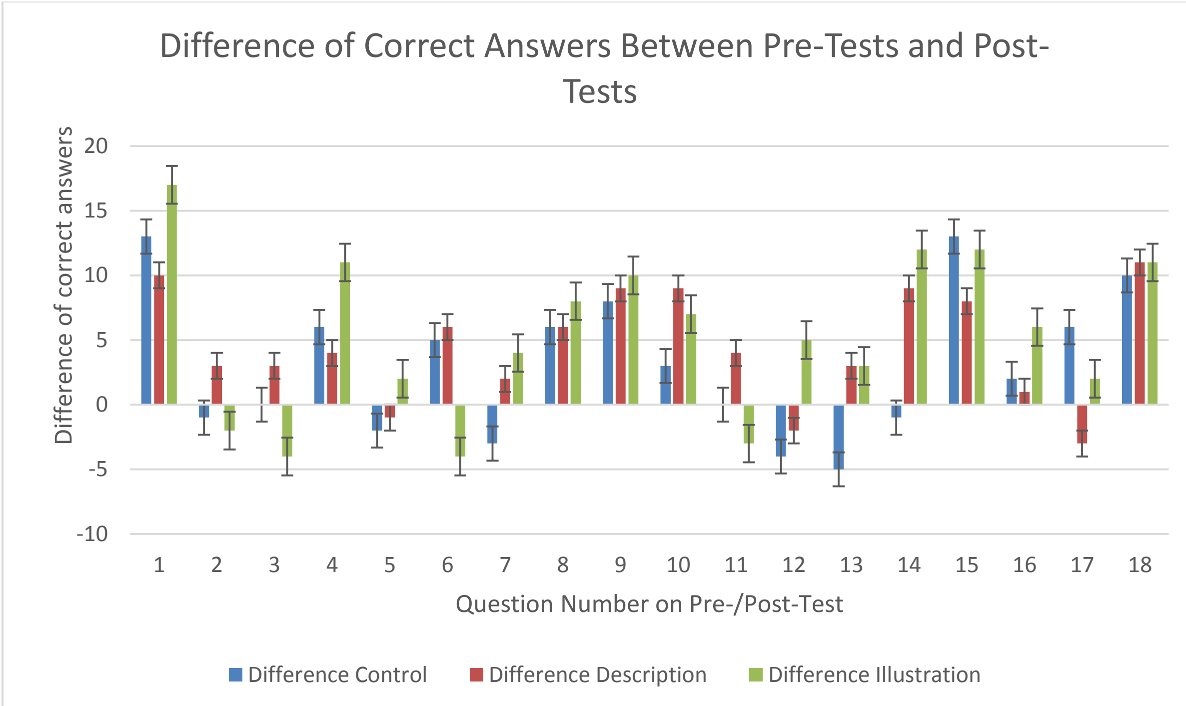


Figure 4. Difference of Correct Answers Between Pre-Tests and Post-Tests of All Groups. Error bars are standard error.

Table 11. Student Feedback of Notecards as Study Aids Based on Questions from Fall 2013 End-of-Semester Course Evaluations. (+) Denotes a positive response while (-) denotes a negative response about the effectiveness of notecards in the course. Control group responses are not labeled (+) or (-).

Course Evaluation Questions and Answers Pertinent to Study			
Question Number	Control Group	Description Group	Illustration Group
1: “What did you like the best about this course, given the subject?”	Student A: “I liked the quiz[ze]s, they were helpful.”		Student D: “The notecards were helpful” (+) Student E: “Flashcards helped w/examples of questions found on exams” (+)
3: “What did you like the least about this course, given the subject? What advice could you give for improving the course in the future?”		Student C: “The notecards” (-)	
4: “What suggestions could you give the instructor for improving his or her teaching of the course in the future?”			Student F: “Try to give a homework sheet w/questions. Not notecards.” (-)
5: “Please add any additional comments or suggestions.”	Student B: “I did not like how the sections were different based on one having quiz[z]es, one doing note cards, I don’t think it was fair and I feel like my grade could have suffered a little from it because of the teaching/learning style.”		Student G: “Keep notecard question to turn in as assignments it was very helpful” (+)

CHAPTER V

DISCUSSION

Analysis of pre-tests and post-tests using a paired t-test, with a 95% confidence ($p < 0.05$), showed a significant difference within the groups from the beginning of the semester to the end of the semester and showed that, indeed, learning occurred in all three groups (control, description, illustration) (Table 2). The Wilcoxon signed-rank test confirmed the results of the paired t-test (Table 3). The difference scores between the post-tests and pre-tests for the three groups were found to be normally distributed by a Shapiro-Wilk's test of normality (Table 4) before proceeding to the one-way ANOVA. A comparison of pre-test and post-test scores between groups when performing the one-way ANOVA (Table 5) showed that while there was a statistically significant difference between groups, that difference was isolated to the statistical significance between the control group and the illustration group according to the results of the Tukey post-hoc test (Table 6). There were no statistically significant differences between the control group and the description group as well as between the description group and the illustration group. The p value, $p = 0.038$, from the one-way ANOVA (Table 5) showed that an effect existed, but it could not show the size of the effect (Sullivan & Feinn, 2012). Therefore, an Effect Size calculation between the three groups was calculated and was determined to be small, $\omega^2 = 0.044$, but an effect no less (Table 5). The findings of the one-way ANOVA go along with the findings of current research studies. One study concluded that students who studied illustrative text rather than only text outperformed readers of only text (Mason et al., 2013). The control group only read their textbook while the illustration group had to create illustrations for their notecard assignments. Because the illustration group had to spend time creating the illustrations, it had more exposure to the illustrated concepts rather than the control group which had the illustrations in the textbook but may have not necessarily referred to them. The findings of the present study are also corroborated by the findings of the learner-generated drawing study that found that students who drew pictures related to the biological process of influenza scored significantly higher on a multiple choice comprehension test than students who only read (Schmeck et al., 2014). Drawing the illustration proved beneficial to the illustration group compared to the control group who had illustrations available to them in their textbooks but did not construct the illustrations themselves.

According the results of the Tukey post-hoc test, the description group and the illustration group were not statistically significantly different (Table 6). A possible reason for this finding is that texts are usually used to comprehend a scientific concept whereas illustrations are referred to when the text needs a further visual explanation so as not to overload the working memory (Hochpochler, et al., 2013). Furthermore, a study by Chen, Hand, and McDowell (2013) showed that fourth grade students who wrote about the concepts of force and motion to eleventh grade students performed better between pre-tests and post-tests than those students who did not participate in the collaborative letter-writing task. In the present study, student understanding of concepts through writing descriptions must have been as sufficient as drawing illustrations.

The analysis of normalized learning gains based on the pre-test and post-test scores showed that the illustration group and the description group, $G = 0.20$ and $G = 0.19$, respectively, had more than twice the learning gains of the control group, $G = 0.08$ (Figure 1). Normalized learning gains have been shown to be a valid and reliable measure of student learning (Meltzer, 2005). Meltzer (2005) points out the fact that through countless studies measuring tens of thousands of students of diverse backgrounds enrolled in hundreds of classes in a wide range of institutions across the world, studies have consistently reproduced values of *G* that fall within relatively narrow bands for traditional courses and interactive-engagement taught courses. After studying the learning gains of students in 62 physics-based courses, Hake (1998) found that traditional lecture-based courses have an average normalized learning gains of $G = 0.23 \pm 0.04$. Interactive-engagement courses which include class activities have average normalized learning gains of $G = 0.48 \pm 0.14$. In the present study, both the normalized learning gains of the illustration group and the description group were within Hake's (1998) average normalized learning gains of a lecture-based course but were expected to be closer to the *G* value of interactive-engagement courses since the notecard groups completed an activity while the control group was the more traditional course in this study. The control group achieved less than half of the average normalized learning gains of a traditional course. Though the normalized learning gains may be lower than a typical activity-based class for the illustration group and description group, there is no arguing that these groups showed a large improvement in learning compared to the control group. These results are consistent with Moore and Ledee's (2006) study that found that supplemental instruction, including study activities, improved students' academic behaviors which could lead to improved academic performance and learning over time.

The weekly assignment analysis represented in Figure 2 shows that there was not much of a discrepancy between including all participants (Figure 2A) or including only those participants who completed ≥ 64 % (seven) of the assignments (Figure 2B) in the short-term learning analysis. It was originally thought that it would make a substantial difference to the data distribution because if the students were not completing the notecards or quizzes, they would not be performing as well. Many participants (111 students) completed seven assignments or more, so the impact of including the fraction (27 students) of students that did not complete seven or more assignments was miniscule as seen in the weekly assignment analysis. Based on Figure 2 as a whole, the weekly assignment analysis of short-term learning showed that the illustration group performed better most of the time on its assignments compared to the control group and the description group. In the assignment score comparison between groups, assignments 1-5, 7, and 9-11 were all statistically significantly different as found through a Kruskal-Wallis H test (Table 7). Most of the time, the illustration group had the highest average out of 3 points possible and the control had the lowest average. However, the description group outperformed the illustration group on assignment 5, and the control group outperformed the description group and the illustration group on assignment 7, the illustration group having the lowest average (Table 7). Comparison of assignment scores showed that the illustration group performed better most of the time on its assignments compared to the control group and the description group.

Since there were statistically significant differences between groups based on weekly assignments, pairwise comparisons, comparing all groups in all combinations, were assessed by Dunn's (1964) procedure with Bonferroni correction for multiple comparisons to further pinpoint where the statistical significances resided (Table 8). Descriptive notecards were superior to the standard curriculum of a weekly quiz for the following assignments and subject matter: Assignments 1-2, and 4 which were about the basis of the cell, molecules of the cell, and cellular communication/cellular respiration, respectively; and Assignments 9-10 which were about evolution, animal structure and function, respectively. Illustrative notecards were superior to the standard curriculum of a weekly quiz for the following assignments and subject matter: Assignments 1-4 which were about the basis of the cell, molecules of the cell, cellular structures and components, and cellular communication/cellular respiration, respectively; and Assignments 9-11 which were about evolution, animal structure and function, and nutrition/digestion/gas exchange, respectively.

The notecard groups, in general, were statistically significantly different than the control group (Table 8) and is in line with current research. A study assessing homework with student achievement showed that achievement was higher in classes assigned frequent homework assignments (Trautwein, Schnyder, Niggli, Neumann, & Ludtke, 2009). The control group's standard curriculum was superior to the illustration group on Assignment 7 which was the molecular biology of a gene. Illustrating molecular genetics may have been more confusing compared to being able to complete the standard weekly quiz of the control group. Venville and Donovan (2008) state that some students aged 14 and higher may not be at the formal operational stage, one of Jean Piaget's stages of learning characterized by understanding abstract thoughts emerging at adolescence (age 14), and not have the visualization skills necessary for using verbal or abstract analogies. One possible reason the control group performed better on Assignment 7, the molecular genetics assignment, is that students in the illustration group could not properly visualize the illustration it was asked to construct based on molecular genetics concepts for Assignment 7. The pairwise comparison of the description group to the illustration group showed a statistically significant difference between groups with regards to Assignment 11 which covered nutrition, digestion, and gas exchange. Illustrating the alimentary canal, gastric glands of the stomach, and inhalation and exhalation led to better scores on Assignment 11 than describing them. Describing these body structures could have been more confusing than just looking at a visual representation of them. According to McTigue and Slough (2010), students understand better when illustrations show both the parts and the processes. Thus, illustrating the digestive system and its processes as well as the process of gas exchange must have led to better comprehension than just writing descriptive text of the structures and processes. Because students were writing descriptions based on the scientific text of their textbooks, they may have used the wording of the author which, in a typical textbook, is a "flat, lifeless tone of a desembodied authority" (McTigue & Slough, 2010, p. 219) with which readers do not engage. The students of the description group may have not been engaged with their written descriptions about the content of nutrition, digestion, and gas exchange.

The Spearman's Correlation test showed that there was generally a positive correlation between exam scores and their respective assignment scores as well as between the final exam scores and assignment scores for all groups (Table 9). It cannot be said that assignments caused better performance on exams just that there was a positive trend between assignment scores and exam scores as well as assignment scores and the final exam scores. Also, the final exam average percentages for each group was about 85 percent, about ten percent higher than all of the groups' exam averages. This shows that all groups had greater long-term learning regardless of using notecards or not, and also shows that the notecard assignments, in general, did not hinder learning for the notecard groups. Homework and quizzes both have been shown to improve student learning. As previously mentioned, the Trautwein et al. (2009) study assessing homework with student achievement showed that achievement was higher in classes assigned frequent homework assignments. In a study conducted by Shafiq and Siddiquah (2011), assigning quizzes yielded better performance on the post-test. The experimental group, 57 students, was given six quizzes between the midterm and final exam while the control group, 58 students, were given no quizzes between the midterm and final exam. The experimental group performed better on the post-test showing that quizzes aid in the learning process and lead to improved performance on exams.

Finally, a Kruskal-Wallis H test of exam scores between groups showed no significant difference of exam scores, including the 200-point final exam, between the three groups (Table 9). Since the control group completed a weekly quiz, it may have been sufficient enough for long-term learning compared with the notecard assignments. Also, time spent studying the notecards could have been a factor. One study found that studying one large set of notecards over a period of days, a study method called spacing, was superior to concentrating on a separate set of notecards each day, a study method called massing (Kornell, 2009). Moreover, spacing is different than cramming since cramming consisted of studying rigorously, eight times, during the final study session (Kornell, 2009). Another study about notecards and timing is a study by Wissman et al. (2012) which found that students do not institute or understand the benefits of longer lags between study sessions. In the present study, participants of the notecard groups (illustration and description) completed three notecards a week, excluding holidays and exam weeks. Since some participants submitted notecards one or two days late, did not collect their graded notecards from the instructor in a timely manner, or submitted three to four notecard assignments at the end of the semester, those students may have either massed or crammed the notecards rather than spacing them when they studied. This can lead to lower long-term learning retention and be a possible reason for no statistically significant difference in exam scores across the three groups (Table10). Another explanation is that the standard weekly quiz of the control group was sufficient and as helpful a learning tool as the notecards to equal the academic performance of the illustration group and the description group. Again, completing quizzes has been shown to lead to improved exam performance (Shafiq & Siddiquah, 2011).

Figure 4 shows all groups achieved long-term learning in the following subject areas: basis of all life, cellular function, molecular biology of a gene, evolution, animal structure and function, the digestive system, and the immune response. The control group had the best learning results with regards to question 15 about the digestive system. The illustration group had better long-term learning outcomes in the following subject areas: the basis of life, cellular function, patterns of inheritance, molecular biology of a gene, the origin of species, the origin and evolution of microbial life, and circulation. Writing descriptive notecards compared to illustrative notecards and the standard curriculum of the control group enhanced long-term learning in the following subject areas: molecules of the cell, cellular structure, the cellular basis of reproduction and inheritance, and evolution. The description group had the greatest negative change in correct answers for question 17 about gas exchange which means that the standard curriculum and illustrative notecards were more effective for long term learning in that subject area (Figure 4, Appendix E). This also goes with the results of the Bonferroni post hoc test (Table 8) in which the illustration group was statistically significantly different than the description group with regards to Assignment 11, nutrition, digestion, and gas exchange. Both the control group and the illustration group had positive changes in the number of correct answers between pre-tests and post-tests for question 17. Again, describing the digestive process and gas exchange may have been more confusing than constructing an illustration or completing the standard curriculum quiz. The control group had poor long-term learning results in the subjects of patterns of inheritance, tracing evolutionary history, and the origin and evolution of microbial life. Because the description group also had a negative change in the subject of tracing evolutionary history, long-term learning was enhanced by the use of illustrative notecards with regards to tracing evolutionary history, shown by the positive change in correct answers from pre-test to post-test for question 12 (Figure 4, Appendix E). There was not any trend between groups or within groups as seen on the graph in Figure 4. Mostly, Figure 4 shows that all groups performed well on certain questions pertaining to similar subject matter.

Student attitudes were assessed to determine whether students thought the use of notecards were beneficial (Table 11). In the description group, one person said they least liked the notecard assignments, while in the illustration group one person would have rather had homework sheets than notecards, and three people thought the notecards were helpful (Table 11). Based on those few comments, it was a divide between students disliking the notecards and students believing the notecards were helpful. Medical students preferred to mass their notecard study time than space their study time on notecards because they considered the practice of spacing to be less successful to their learning (Schmidmaier, et al., 2011). Thus, students in the present study may have felt that the notecard assignments were not aiding in their overall learning because they were not approaching the act of studying notecards appropriately and most effectively.

These student reflections illuminate the idea that everyone has a different learning style, and while one student may learn better with illustrations, another may learn better with writing descriptions. Still, others may prefer a combination of learning styles. Shankar et al. (2014) found that 52.7% of students preferred a multimodal learning approach consisting of multiple learning styles in regards to the VARK model. The present study only included one type of learning style per class (visual for the illustration group and read/write for the description group in regards to the VARK model), so those who preferred the multimodal approach or a different unimodal approach may have not reached their full potential. Also, in regards to the Grasha-Riechman Learning Style Inventory, students in the present study were asked to be independent learners since they completed the notecard assignments outside of class but could have preferred another type of learning including being a dependent learner who relies on the teacher, a collaborative learner who cooperates with others, a competitive learning who competes with others, a contributive learning who participated in class activities, or an avoidant learner who was uninterested in learning (Baykul, et al., 2010). A study by Kinshuk et al. (2009) showed that learners with a strong preference toward a specific learning style struggled in achieving as high of scores as learners who were more flexible in their learning style preferences. The three groups may have had students who had strong preferences toward a specific learning style which could have reduced their academic performance. This may not be the case, however. Two studies investigating learning style preferences of college-educated adults and academic performance, however, showed that academic performance was not influenced by learning style preferences (Wilkinson et al., 2014; Rogowsky et al., 2014).

Limitations of Study

If this study were reproduced, an end-of semester survey should be dispersed to students one or two class periods before the final exam. There would be considerably more qualitative data on student attitudes of notecards as a study aid. While quantitative data of exam scores and pre-tests and post-tests show statistical significance in learning, the experiences of the students actually using or not using the notecards is important in the climate of the classroom environment. Collecting demographics would have been informative with regards to factors such as gender, age, and major concentration in college. This may show a preference in learning styles amongst specific groups.

In this study, it was only possible to compare the control group quizzes to the notecard assignments of the description group and the illustration group for the short-term learning analysis. The quiz was set up as a multiple-choice, fill-in-the-blank, and short answer style of quiz while the notecard assignments were purely short answer questions. All three groups should have had a weekly quiz while the description group and the illustration group complete the notecard assignments in addition to the weekly quiz. It was not set up this way because the instructor wanted to provide an equal opportunity across the three groups with regards to the amount of participation points she offered to the students (Appendix E). If this study were to be reproduced, short-term learning would be better analyzed if all three groups completed a weekly quiz, where one group completes an additional weekly illustrative notecard assignment and another group completes an additional weekly descriptive notecard assignment.

Another limitation of the present study was that students in the control group did not always receive the exact three questions the description group and the illustration group received (Appendices H, I, and J). It would have been better if they all focused on the same ideas. Because the questions of the pre-tests and the post-tests were based on the same concepts of the notecard assignments, the control group may have not had the same advantages when it came to completing the post-test because the control group answered different questions on seven of their weekly quizzes (Appendices H, I, and J). As seen through Figure 4, the control group performed poorly on questions 2, 5, 7, 12, and 13. Questions 5, 7, 12, and 13 were based on topics of assignments that were written by the instructor (Quiz 4-8 and Quiz 10-11, Appendix K) which could mean that those students did not have the same advantages when it came to completing the post-test.

Many students, consistently, did not collect their graded notecards which could have factored into exam score similarity among groups since the students were not necessarily studying them in a spaced manner, the most effective way of studying notecards according to Wissman et al. (2012). If this study were repeated, the instructor could take students' participation points away if they do not collect their notecards before the next exam related to the content on the notecards. This action would put the notecards in the possession of the students, therefore, being more accessible.

Notecard assignments were generally accepted a few days later than the Tuesday due date, but the control group was not permitted to make up quizzes. Because of this difference, the notecard groups had more time to complete their notecards to make them as good as possible, but the control group was quizzed at the beginning of each Friday without any extra time to study. This could explain why notecard assignment grades were superior to the quiz grades of the control group (Figure 2, Table 8).

Moreover, the results may indicate the problem with only incorporating one type of learning style (visual or read/write of the VARK method) in a diverse classroom setting. There may have been students who were successful with the use of illustrative notecards in the illustration group, but in that same group, some students may have performed better by writing descriptions or definitions instead. It would be beneficial to investigate the use of notecards that include both illustrations and text because this would encompass the visual and the read/write learning styles of the VARK model. In fact it has been found that studying text supplemented with an illustration leads to better academic performance than studying only text. In an eye-tracking study, Mason et al. (2013) computed the number of eye fixations students made on text with and without illustrations (concrete or abstract) and found that readers of the illustrated text, either concrete or abstract, outperformed readers of only text, and there was no statistically significant differences between the readers of the abstract text and readers of the concrete text.

Finally, another possible limitation to this study was that the notecard assignments were completed outside the classroom rather than in the classroom like the quizzes. According to Lumpkin, Achen, and Dodd (2015), class lecture periods should be punctuated by a variety of learning activities every 10-15 minutes to promote student focus and engagement, thereby increasing their level of learning. Since the notecard assignments were not in-class activities, learning and academic performance, potentially, could have been reduced compared with their potential academic performance had they completed in-class assignments and may explain why there was not a significant difference on exam scores across the three groups (Table 9).

Implications for Future Research

If this study were reproduced, it would interesting to include a fourth group in which students complete notecard assignments that include both text and illustrations to determine whether having the descriptive text along with the illustration would yield similar or different results from the present study as discovered by Mason et al. (2013) which found that text supplemented with illustrations improved student exam scores.

If the students in the present study had completed the activity within the class periods, both the illustration group's and the description group's learning gains may have had a more dramatic increase. Again, if this study were repeated, it would be interesting to assign the notecard assignments as in-class activities rather than out-of-class homework. Tomanek and Montplaisir (2004) urge instructors to implement frequent in-class exercises because results of their study showed that undergraduate students in a lecture hall setting did not study for deep learning, rather their motivation to study was the exams. Students were only successful on questions about cell division that they had seen before, performing poorly on unfamiliar questions still related to the topic of cell division. Lee and Jabot (2011) studied normalized learning gains of students in an undergraduate sophomore-level genetics class after integrating actively engaging group quizzes in which the students received immediate, in-class feedback on their quizzes as well as discussed key genetics concepts. The group's normalized learning gains were a solid $G = 0.56$ (Lee & Jabot, 2011). Colt, Davoudi, Murgu, and Rohani (2011), too, found that learning gains improved when implementing simulation activities during a one-day bronchoscopy course for 24 first-year pulmonary and critical care fellows across eight training institutions in southern California.

Furthermore, it could be helpful to investigate the different study aids amongst four classes spanning two semesters. Since the control group completed quizzes in this study and exam performance was similar amongst all three groups, it would be interesting to compare quizzes and notecards. Quizzes have been found to aid in learning, leading to improved exam performance. Shafiq and Siddiquah (2011) found that the experimental group, given six quizzes between a midterm and final, performed better on the post-test demonstrating that quizzes aid in the learning process and lead to improved performance on exams. I would have a control group, a quiz group, an illustrative notecard group, and a descriptive notecard group. The quiz and the notecard groups would be switched around in the next semester. Short-term and long-term learning and retention could be compared amongst students utilizing different study aids.

Conclusions

Ultimately, the present study showed that learning occurred in all three groups and learning gains were enhanced with the use of notecards (description or illustration). Even though the illustration group (visual learning style of VARK model) had a statistically significant difference compared to the control group with regards to the difference scores of the pre-tests and post-tests, it could not be determined that illustrations were superior to descriptions because the illustration group was not statistically significant from the description group (read/write learning style of VARK model) with regards to the difference scores of the pre-tests and post-tests. Moreover, the groups were not statistically significantly different based on exam scores.

Even though the results show that students who utilized notecards as a study aid did not outperform the control group on exams, learning gains of the illustration group and the description group doubled compared to the control group. Furthermore, some subject areas were better understood by utilizing notecards, descriptive or illustrative, and sometimes the illustrative notecards were better than descriptive notecards and vice versa for learning about certain subject areas. The illustration group and the description group also had better short-term learning benefits with regards to their weekly assignments. It was also found through correlation tests that notecards did not decrease learning and had a general positive correlation with exam scores just like the control group.

For teachers in the field, the findings of the present study show that using notecards as study aids enhance long-term learning but not exam performance. Therefore, measuring learning based on academic performance may not present the entire scope of learning attained by students.

It is important to continue research regarding notecards, illustrative and descriptive, because notecards are a common learning strategy among many types of students across all grade levels. While it is a popular method of studying, it is important to discover if it is the optimal study aid providing the most meaningful way of learning for not only post-secondary science classes but also secondary science classes. Many students enrolled in lower-level biology courses for nonmajors are freshmen or sophomores, so they are not too far removed from their high school biology experience. Because students in the secondary setting are taught from a variety of perspectives, undergraduate education should accommodate the consumer needs of secondary education by teaching undergraduate students in the most meaningful way, which is not sternly lecture-based or teacher-centered. Including class activities, study aids, and acting as more of a facilitator of learning—the learner-centered approach—should allow the teacher to create a deeper learning experience for the students.

Furthermore, there is little research devoted to utilizing notecards to study biological concepts. With biology for nonmajors courses becoming larger and larger due to high interest in health-related fields as well as being a general education requirement for non-science majors, it is vital that teachers find the best ways for their students to be not only successful in the course itself, but also to have the these learning tools to use in other classes, professional careers, and their possible continuing education.

REFERENCES

Baykul, Y., Gursel, M., Sulak, H., Ertekin, E., Yazici, E., Dulger, O., . . . Buyukkarci, K. (2010). A Validity and Reliability Study of Grasha-Riechmann Student Learning Style Scale. *International Journal of Social, Education, Economics and Management Engineering*, 59-66.

Brewer, C. A., Smith, D., Bauerle, C., DePass, A., Lynn, D., O'Connor, C., . . . Wubah, D. (2009). *Vision and Change in Undergraduate Biology Education: A Call to Action.* Washington, DC: American Association for the Advancement of Science.

Britannica, T. E. (2014, March 26). *Learning: Psychology.* Retrieved from Encyclopaedia Britannica: http://www.britannica.com/EBchecked/topic/333978/learning

Brown, K. L. (2003). From Teacher-Centered To Learner-Centered Curriculum: Improving Learning In Diverse Classrooms. *Education*, 49-54.

Cancela, A., Sanchez, A., & Maceiras, R. (2012). Designing a flashcard with knowledge pills for learning to solve chemistry exercises. *European Journal of Engineering Education*, 366-374.

Carney, R. N., & Levin, J. R. (2002). Pictorial Illustrations Still Improve Students' Learning From Text. *Educational Psychology Review*, 5-25.

Cheang, K. I. (2009). Effect of Learner-Centered Teaching on Motivation and Learning Strategies in a Third-Year Pharmocotherapy Course. *American Journal of Pharmaceutical Education*, 1-8.

Chen, Y.-C., Hand, B., & McDowell, L. (2013). The Effects of Writing-to-Learn Activities on Elementary Students' Conceptual Understanding: Learning about Force and Motion through Writing to Older Peers. *Science Education*, 745-771.

Cole, M., Rogers, L., Clark, M., & Sigrist, L. (2014). Incorporation of learning styles into the graduate program in nutrition curriculum. *U.S. Army Medical Department Journal*, 14-20.

Colt, H. G., Davoudi, M., Murgu, S., & Rohani, N. Z. (2011). Measuring learning gain during a one-day introductory bronchoscopy course. *Surgical Endoscopy*, 207-216.

Cubukcu, Z. (2012). Teachers' Evaluation of Student-Centered Learning Environments. *Education*, 49-66.

Dobson, J. L. (2009). Learning style preferences and course performance in an undergraduate physiology class. *Advances in Physiology Education*, 308-314.

Emes, C., & Cleveland-Innes, M. (2003). A Journey Toward Learner-Centered Curriculum. *The Canadian Journal of Higher Education*, 47-70.

Field, A. (2013). *Discovering statistics using IBM SPSS Statistics 4th Edition.* London: Sage.

Gioka, O. (2007). Assessment "for" Learning in Biology Lessons. *Journal of Biological Education*, 113-116.

Golding, J. M., Wasarhaley, N. E., & Fletcher, B. (2012). The Use of Flashcards in an Introduction to Psychology Class. *Teaching of Psychology*, 199-202.

Goldstein, J., & Flynn, D. F. (2011). Integrating Active Learning & Quantitative Skills into Undergraduate Introductory Biology Curricula. *The American Biology Teacher*, 454-461.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 64-74.

Hochpochler, U., Schnotz, W., Rasch, T., Ullrich, M., Horz, H., McElvany, N., & Baumert, J. (2013). Dynamics of mental model construction from text and graphics. *European Journal of Psychology of Education*, 1105-1126.

Jaeger, A. J., & Wiley, J. (2014). Do illustrations help or harm metacomprehension accuracy? *Learning and Instruction*, 58-73.

Jensen, J. L., Kummer, T. A., & Banjoko, A. (2013). Assessing the Effects of Prior Conceptions on Learning Gene Expression. *Journal of College Science Teaching*, 82-91.

Khanal, L., Shah, S., & Koirala, S. (2014). Exploration Of Preferred Learning Styles In Medical Education Using VARK Modal. *Russian Open Medical Journal*, 1-8.

Kinshuk, Liu, T.-C., & Graf, S. (2009). Coping with mismatched courses: students' behaviour and performance in courses mismatched to their learning styles. *Educational Technology Research and Development*, 739-752.

Kolb, A. Y., & Kolb, D. A. (2005). Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher Education. *Academy of Management Learning & Education*, 193-212.

Kong, S., & Song, Y. (2013). A principle-based pedagogical design framework for developing constructivist learning in a seamless learning environment: A teacher development model for learning and teaching in digital classrooms. *British Journal of Educational Technology*, 209-212.

Kornell, N. (2009). Optimising Learning Using Flashcards: Spacing Is More Effective Than Cramming. *Applied Cognitive Psychology*, 1297-1317.

Kruskal-Wallis H Test in SPSS Statistics. (2013). Retrieved from Laerd Statistics: https://statistics.laerd.com/premium/kwht/kruskal-wallis-test-in-spss.php

Lee, W. T., & Jabot, M. E. (2011). Incorporating Active Learning Techniques Into a Genetics Class. *Journal of College Science Teaching*, 94-100.

Li, Y.-S., Yu, W.-P., Liu, C.-F., Shieh, S.-H., & Yang, B.-H. (2014). An exploratory study of the relationship between learning styles and academic performance among students in different nursing programs. *Contemporary Nurse: A Journal for the Australian Nursing Profession*, 229-239.

Lu, H., Jia, L., Gong, S.-h., & Clark, B. (2007). The Relationship of Kolb Learning Styles, Online Learning Behaviors and Learning Outcomes. *Educational Technology & Society*, 187-196.

Lumpkin, A., Achen, R. M., & Dodd, R. K. (2015). Student Perceptions of Active Learning. *College Student Journal*, 121-133.

Mason, L., Pluchino, P., Tornatora, M. C., & Ariasi, N. (2013). An Eye-Tracking Study of Learning From Science Text With Concrete and Abstract Illustrations. *The Journal of Experimental Education*, 356-384.

McTigue, E. M., & Slough, S. W. (2010). Student-Accessible Science Texts: Elements of Design. *Reading Psychology*, 213-227.

Meltzer, D. E. (2005, August 30). *Addendum to: The relationship between mathematics preparation and conceptual learning gains in physics: a possible "hidden variable" in diagnostic pretest scores.* Retrieved from Physics Education: http://www.physicseducation.net/docs/Addendum_on_normalized_gain.pdf

Moore, R., & LeDee, O. (2006). Supplemental Instruction and the Performance of Developmental Education Students in an Introductory Biology Course. *Journal of College Reading and Learning*, 9-20.

Musante, S. (2011). Upgrading Undergraduate Biology Education. *BioScience*, 512-513.

Nandy, K. (2012, April 9). *Understanding and Quantifying EFFECT SIZES.* Retrieved from UCLA School of Nursing: http://nursing.ucla.edu/workfiles/research/Effect%20Size%204-9-2012.pdf

Nikoopour, J., & Kazemi, A. (2014). Vocabulary Learning through Digitized & Non-digitized Flashcards Delivery. *Social and Behavioral Sciences*, 1366-1373.

One-way ANOVA in SPSS Statisitics. (2013). Retrieved from Laerd Statistics: https://statistics.laerd.com/premium/owa/one-way-anova-in-spss.php

Paired-samples t-test in SPSS Statistics. (2013). Retrieved from Laerd Statistics: https://statistics.laerd.com/premium/pstt/paired-samples-t-test-in-spss.php

Payman, H., Sadeghifar, J., Khajavikhan, J., Yasemi, M., Rasool, M., Yaghoubi, Y. M., . . . Karim, H. (2014). Using VARK Approach for Assessing Preferred Learning Styles of First Year Medical Sciences Students: A Survey from Iran. *Journal of Clinical & Diagnostic Research*, 01-04.

Prajapati, B., Dunne, M., Bartlett, H., & Cubbidge, R. (2010). The influence of learning styles, enrolment status and gender on academic performance of optometry undergraduates. *Ophthalmic and Physiological Optics*, 69-78.

Prithishkumar, I. J., & Michael, S. A. (2014). Understanding your student: Using the VARK model. *Journal of Postgraduate Medicine*, 183-186.

Reece, J. B., Taylor, M. R., Simon, E. J., & Dickey, J. L. (2012). *Campbell Biology: Concepts & Connections.* San Francisco: Pearson Benjamin Cummings.

Religion And Diversity In Schools. (2011). Retrieved from Tannebaum: https://www.tanenbaum.org/sites/default/files/Religion%20and%20Diversity%20in%20Schools%20Fact%20Sheet%20FORMATTED.pdf

Reynolds, J. (2006). Learning-Centered Learning: A Mindset Shift for Educators. *Inquiry*, 55-64.

Rogowsky, B. A., Calhoun, B. M., & Tallal, P. (2014). Effects on Comprehension. *American Psychological Association*, 64-78.

Rutledge, M. L. (2008). Effectiveness of Elements of a Diversified Instructional Approach in an Introductory Biology Course. *Bioscene: Journal of College Biology Teaching*, 24-29.

Sadler-Smith, E., & Smith, P. J. (2004). Strategies for accommodating individuals' styles and preferences in flexible learning programmes. *British Journal of Educational Technology*, 395-412.

Salinas, M. F., & Garr, J. (2009). Effect of Learner-Centered Education on the Academic Outcomes of Minority Groups. *Journal of Instructional Psychology*, 226-237.

Schenck, J., & Cruickshank, J. (2015). Evolving Kolb: Experiential Education in the Age of Neuroscience. *Journal of Experiential Education*, 73-95.

Schmeck, A., Mayer, R. E., Opfermann, M., Pfeiffer, V., & Leutner, D. (2014). Drawing pictures during learning from scientific text: testing the generative drawing effect and the prognostic drawing effect. *Contemporary Educational Psychology*, 275-286.

Schmidmaier, R., Ebersbach, R., Schiller, M., Hege, I., Holzer, M., & Fischer, M. R. (2011). Using electronic flashcards to promote learning in medical students: retesting versus restudying. *Medical Education*, 1101-1110.

Schroeder, S. J. (2012). Infusing Learner-Centered Strategies into the Classroom. *Occupational Therapy In Healthcare*, 218-223.

Shafiq, F., & Siddiquah, A. (2011). Effect of Classroom Quizzes on Graduate Students' Achievement. *International Journal of Academic Research*, 76-79.

Shankar, P. R., Balasubramanium, R., Dwivedi, N. R., Ramireddy, R., & Barton, B. (2014). Learning Styles of Premedical and Basic Science Undergraduate Medical Students in a Caribbean Medical School. *Education in Medicine Journal*, 58-62.

SIUE Undergraduate Catalog 2013-2014. (2013, May). Retrieved from Southern Illinois University Edwardsville: http://www.siue.edu/registrar/archive_catalog.shtml

Smart, K. L., & Csapo, N. (2007). Learning by Doing: Engaging Students through Learner-Centered Activities. *Business Communication Quarterly*, 451-457.

Steinert, J. J., Phillips, J. A., & Coletta, V. P. (2007). Interpreting force concept inventory scores: Normalized gain and SAT scores. *Physical Review Special Topics Physics Education Research*, 010106 (1-5).

Sullivan, G. M., & Feinn, R. (2012). Using Effect Size--or Why the P Value Is Not Enough. *Journal of Graduate Medical Education*, 279-282.

Tanner, K., & Allen, D. (2004). Approaches to biology teaching and learning: learning styles and the problem of instructional selection--engaging all students in science courses. *Cell Biology Education*, 197-201.

Tomanek, D., & Montplaisir, L. (2004). Students' studying and approaches to learning in introductory biology. *Cell Biology Education*, 253-262.

Torcasio, S., & Sweller, J. (2010). The use of illustrations when learning to read: A cognitive load theory approach. *Applied Cognitive Psychology*, 659-672.

Trautwein, U., Schnyder, I., Niggli, A., Neumann, M., & Ludtke, O. (2009). Chemeleon effects in homework research: The homework-achievement association depends on the measures used and the level of analysis chosen. *Contemporary Education Psychology*, 77-88.

U.S. Department of Education, National Center for Education Statistics. (2013). Chapter 3: Postsecondary Education. *Digest of Education Statistics: 2012 (NCES 2014-015)*, Chapter 3.

Venville, G., & Donovan, J. (2008). How pupils use a model for abstract concepts in genetics. *Journal of Biological Education*, 6-14.

Vilppu, H., Mikkila-Erdmann, M., & Ahopelto, I. (2013). The Role of Regulation and Processing Strategies in Understanding Science Text Among University Students. *Scandinavian Journal of Educational Research*, 246-262.

Weir, I. (2015). *Spearman's correlation.* Retrieved from statstutor: http://www.statstutor.ac.uk/resources/uploaded/spearmans.pdf

Wilcoxon signed-rank test in SPSS. (2013). Retrieved from Laerd Statistics: https://statistics.laerd.com/premium/wsrt/wilcoxon-signed-rank-test-in-spss.php

Wilkinson, T., Boohan, M., & Stevenson, M. (2014). Does learning style influence academic performance in different forms of assessment:. *Journal of Anatomy*, 304-308.

Wissman, K. T., Rawson, K. A., & Pyc, M. A. (2012). How and when do students use flashcards? *Memory*, 568-579.

Wyss, V. L., Dolenc, N., Kong, X., & Tai, R. H. (2013). Time on Text and Science Achievement for High School Biology Students. *American Secondary Education*, 49-59.

APPENDIX A

Form 1

SOUTHERN ILLINOIS UNIVERSITY EDWARDSVILLE (SIUE)
APPLICATION FOR APPROVAL OF RESEARCH PROJECT INVOLVING HUMAN SUBJECTS
IRB REGULAR PROTOCOL FORM

IRB #__________

Part I – To be completed by researcher:
Please refer to the instruction sheet at http://www.siue.edu/orp/humansubjectsprotection/irb.shtml
Principal Investigator(s):

Name: Emily McCadden | Department: Biological Sciences | E-Mail: ebermes@siue.edu
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Name: Barbara McCracken | Department: Biological Sciences | E-Mail: bmccrac@siue.edu
Mailing Address: Campus Box 1651, SIUE, Edwardsville, IL 62026 | Phone: (618) 650-2508

Name: ______ | Department ______ | E-Mail: ______
Mailing Address: ______ | Phone: ______

Name: ______ | Department ______ | E-Mail: ______
Mailing Address: ______ | Phone: ______

Faculty Supervisor (if applicable): Kelly Barry | **Department:** Biological Sciences

Faculty Supervisor SIUE Email: kbarry@siue.edu | **Phone:** (618) 650-5245

Project Assessing learning gains through note cards and illustrations

Anticipated **start date** of project: 8/19/2013 | **end date for entire** 12/20/2013

Principal Investigator's Status: ☐ SIUE faculty ☒ SIUE student ☐ SIUE staff

Researcher not affiliated with SIUE: ☐ faculty ☐ student ☐ staff ☐ other

Affiliation: ______ Other: ______

Research Site(s)	Indicate which of the following are expected sites of investigation (check all appropriate sites):
	☒ SIUE Edwardsville Campus ☐ SIUE East St. Louis Campus ☐ SIUE Dental School ☐ SIUE Pharmacy School ☐ SIU Medical School ☐ Other: ______
	If any of the investigation is to be conducted at locations off campus, please list locations below: ______

Project Status (mark as many as appropriate):

- ☐ To be submitted externally for funding (list agency under notes)
- ☐ To be submitted internally for funding (list funding unit under notes)
- ☐ Funded (list unit or agency under notes)
- ☐ Will not be submitted for funding
- ☐ Student independent study (list course title and number under notes)
- ☒ Student thesis proposal
- ☐ Student dissertation proposal
- ☐ Student research project in lieu of thesis
- ☐ Student capstone project
- ☒ Classroom
- ☐ Other (specify)________________________________

Notes:

Funding Information: Check one	Specify Funding Source (include pending): ____________________ ____________________ ______ Internal funding ______ External funding
Other Notes:	

1. **PURPOSE**
(Provide a brief statement of the purpose of the research and how human subject participants are necessary.

This study will assess the effectiveness of note cards as study aids. Moreover, it will assess whether creating illustrative note cards will be more effective or creating descriptive note cards will be more effective. The principal investigator will collect data from BIOL 140 Human Biology sections 003, 004, and 005 during the Fall semester of 2013. The principal investigator will collect exam scores and correlate these scores with the note card assignment results to find out if the note cards have an impact on individual exam scores and final grades. In addition, pre and post test scores will be used to evidence any possible impact from the note card assignments.

2. **SUBJECTS**
Proposed human subject participants are:
(check all that apply)

☐ Under the age of 18 (specify exact age/age group) ______________.

X 18 years of age and/or older (specify exact age/age group) ______________.

☐ Are any of your participants 90 years or older? ____Yes, ___x__No
(Note: Collecting age information from anyone 90 years or older, is considered an identifier under HIPAA regulations when used in conjunction with protected health information (PHI), unless it is aggregated into a single category of age 89 or older.)

Provide a detailed description, including number of subjects, age of subjects and how they are to be selected and recruited.

The principal investigator will distribute an informed consent document at the beginning of the Fall 2013 semester to the selected class population, and participants will be selected and recruited by their own choice. This choice will be indicated by their signature at the bottom of the informed consent document. The number of subjects in the study will be approximately 250. All students are traditional undergraduate students who will be 18 years of age or older. The informed consent form will not be shared with the instructor of the course, so there will be no influence upon the students' grade if they choose to participate or not participate. The names of the participants will not be shared with the instructor until the end of the study and after final grades have been submitted for the semester.

3. PROCEDURES

Check method of data collection: (check all that apply)

☐ Interviews

☐ Interviews using audio or video/digital recordings

(If using audio, video, and/or digital recordings, refer to requirements listed in the instruction sheet @ http://www.siue.edu/research/humansubjectsprotection/irb.shtml). Also complete and submit the Audio/Visual/Digital Recording Release Consent form.

☐ Surveys sent by e-mail or the web

(If using web or email surveys, provide detailed information on how confidentiality will be maintained; removal of identifiers, etc.)

X Surveys (other than e-mail or web)

☐ Observation of public behavior

☐ Collection of unidentifiable, discarded teeth

☐ HIPAA - Collection of participant's protected health information from hospital files and/or insurance files (Check all that apply)

☐ Hospital/medical records for in or out patients	☐ Mental health records
☐ Physician/clinic records	☐ Data previously collected for research purposes
☐ Laboratory, pathology and/or radiology results	☐ Billing records
☐ Biological samples	☐ Pharmacy Records
☐ Interviews or questionnaires/health histories	☐ Other. Please describe:

☐ Retrospective chart reviews with no identifiers (will not collect name, ss#, date of birth, hospital admission date)

☐ (must complete the De-Identification Certification form at: http://www.siue.edu/orp/humansubjectsprotection/hipaa.shtml)

☐ Retrospective chart reviews with identifiers (will collect name, ss#, date of birth, hospital admission date)

X Other: **Pre-tests, post-tests, exam scores, note card s assignment scores, quiz scores**

PROCEDURES Continued:

Give complete description of how human subject participants will be recruited and used in this research.
If subjects will be informed about this study (e.g., through a cover letter, statement, or flyers), please provide a copy of such with this application.

Human participants will be used in this research by attending and participating in all parts of BIOL 140 sections 003, 004, and 005. Subjects will complete a pre-test at the beginning of the semester, participate in the teaching methods offered to their group, then take a post-test and survey at the end of the semester. The group teaching methods and course content will be the same for all three sections of BIOL 140 with the following exception: Section 003 will participate in the standard course format, section 004 will complete weekly note cards with written descriptions, and section 005 will complete weekly note cards with illustrations.

g. How will the identity of subjects and/or their responses be recorded?

☐ **Anonymous** (direct identifiers, such as names of subjects, or indirect identifiers, such as codes, are never recorded with the research data and therefore cannot be linked to the subjects). Describe how the information will be recorded anonymously.

Or

☒ **Confidential** (coding or security measures are in place to protect the privacy of individual subjects). Describe the steps you will take to maintain confidentiality, including the identity of the subjects, their responses, and any data that you obtain from private records and/or capture on audiotape or videotape. If audio or video taping subjects, describe the disposition of the data and/or the tapes once the study has been completed.

It is important to identify the subjects within this study, as their note card assignment results must be correlated with their grades in BIOL 140. However, this information will be kept and maintained by the principal investigator and not shared with the secondary investigator, who is also the course instructor, until the end of the study and after final grades are posted. The individual identity of the participants and the correlation of note card data and grades will be kept in a locked filing cabinet in a secure location.

Research results may be published in professional journals and/or presented at professional conferences. To maintain participant confidentiality, all data will be reported collectively.

h. For what purpose is the information being collected (e.g., publication, thesis)?

The information collected in this study will be for thesis purposes.

i. Data Security

All information must be stored using at least two of the following safeguards: (If you are using both electronic data *and* hardcopy data, you will need two safeguards for each type) (The IRB recommends that data, including Informed Consent Forms be kept centrally in a SIUE Department in a locked cabinet.)

Electronic Data: (mark at least two that apply or select "not applicable")

☐	secure network (e.g. firewall)
☐	password access
☐	data recorded anonymously
☐	coded, with master list kept as a hardcopy or on a secure network (confidential)
☒	not applicable
☐	other. Please specify:

Hardcopy data: (mark at least two that apply or select "not applicable")

☐	locked suite at SIUE
☒	locked office at SIUE
☒	locked file cabinet at SIUE
☐	data recorded anonymously
☒	data coded by PI or research team with a master list secured and kept separately (confidential)
☐	24 Hour personal supervision
☐	not applicable
☐	other. (Please specify):

I have reviewed this proposed research for ethical considerations and scientific merit. I recommend that it be:

☒ approved ☐ not approved. (check one)

Signature of Department Chair/Head: [signature]

Date: 7/23/13

School/College/Department: Biological Sci.

****

PART III – To be completed by the IRB:

For IRB Office Use Only

IRB#: ____________

The proposed research has been reviewed by the Institutional Review Board (IRB). According to the Federal common rule regulation.

This project meets the criteria for:

_____exempt
_____expedited
_____full-board

research under 45 CFR 46._______ category(ies): __( )_______

Signature of IRB Chairperson or IRB Designee: ______________________________

Date: ______________________________

CITI Collaborative Institutional Training Initiative

Human Research Curriculum Completion Report
Printed on 7/16/2013

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Group 1 faculty, staff, or student conducting research involving human subjects: SIUE faculty, staff, or student conducting research involving human subjects having direct contact with human subjects and/or subjects records

Stage 1. Basic Course Passed on 07/16/13 (Ref # 10812552)

Required Modules	Date Completed	
International Studies	06/15/13	2/3 (67%)
Students in Research	06/25/13	7/10 (70%)
Avoiding Group Harms: U.S. Research Perspectives	06/26/13	3/3 (100%)
Introduction	06/26/13	no quiz
History and Ethical Principles - SBE	07/08/13	4/5 (80%)
Defining Research with Human Subjects - SBE	07/08/13	5/5 (100%)
The Regulations - SBE	07/11/13	5/5 (100%)
Basic Institutional Review Board (IRB) Regulations and Review Process	07/16/13	5/5 (100%)
Assessing Risk - SBE	07/16/13	5/5 (100%)
Informed Consent - SBE	07/16/13	5/5 (100%)
Privacy and Confidentiality - SBE	07/16/13	4/5 (80%)
Records-Based Research	07/16/13	2/2 (100%)
Research With Protected Populations - Vulnerable Subjects: An Overview	07/16/13	4/4 (100%)
Research with Children - SBE	07/16/13	2/4 (50%)
Research in Public Elementary and Secondary Schools - SBE	07/16/13	4/4 (100%)
Internet Research - SBE	07/16/13	5/5 (100%)
FDA-Regulated Research	07/16/13	5/5 (100%)

Research and HIPAA Privacy Protections	07/16/13	4/5 (80%)
Hot Topics	07/16/13	no quiz
Conflicts of Interest in Research Involving Human Subjects	07/16/13	3/5 (60%)
Cultural Competence in Research	07/16/13	4/5 (80%)
Southern Illinois University Edwardsville	07/16/13	no quiz

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI participating institution. Falsified information and unauthorized use of the CITI course site is unethical, and may be considered scientific misconduct by your institution.

Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Course Coordinator

Return

CITI Collaborative Institutional Training Initiative

Human Research Curriculum Completion Report
Printed on 7/9/2013

Learner: Kelly Barry (username: kbarry@siue.edu)
Institution: Southern Illinois University Edwardsville
Contact Information Biological Sciences
8 Circle Dr
Southern Illinois University Edwardsville
Edwardsville, Il 62026 USA
Department: Biological Sciences
Phone: 618-650-5245
Email: kbarry@siue.edu

Group 1 faculty, staff, or student conducting research involving human subjects: SIUE faculty, staff, or student conducting research involving human subjects having direct contact with human subjects and/or subjects records

Stage 1. Basic Course Passed on 07/09/13 (Ref # 10716603)

Required Modules	**Date Completed**	
International Studies	07/01/13	2/3 (67%)
Students in Research	07/01/13	9/10 (90%)
Avoiding Group Harms: U.S. Research Perspectives	07/01/13	3/3 (100%)
Introduction	07/02/13	no quiz
History and Ethical Principles - SBE	07/02/13	5/5 (100%)
Defining Research with Human Subjects - SBE	07/02/13	5/5 (100%)
The Regulations and The Social and Behavioral Sciences - SBE	07/02/13	5/5 (100%)
Basic Institutional Review Board (IRB) Regulations and Review Process	07/02/13	5/5 (100%)
Assessing Risk in Social and Behavioral Sciences - SBE	07/04/13	5/5 (100%)
Informed Consent - SBE	07/04/13	3/5 (60%)
Privacy and Confidentiality - SBE	07/06/13	4/5 (80%)
Records-Based Research	07/09/13	2/2 (100%)
Research With Protected Populations - Vulnerable Subjects: An Overview	07/09/13	4/4 (100%)
Research with Children - SBE	07/09/13	4/4 (100%)
Research in Public Elementary and Secondary Schools - SBE	07/09/13	4/4 (100%)
Internet Research - SBE	07/09/13	5/5 (100%)
FDA-Regulated Research	07/09/13	5/5 (100%)

CITI Collaborative Institutional Training Initiative

Human Research Curriculum Completion Report
Printed on 7/17/2013

Learner: Barbara McCracken (username: bmccrac@siue.edu)
Institution: Southern Illinois University Edwardsville
Contact Information 6986 Gushing Springs Drive
Edwardsville, IL 62025 USA
Department: Biological Sciences
Phone: 6186503907
Email: bmccrac@siue.edu

Group 1 faculty, staff, or student conducting research involving human subjects: SIUE faculty, staff, or student conducting research involving human subjects having direct contact with human subjects and/or subjects records

Stage 1. Basic Course Passed on 07/10/13 (Ref # 10684843)

Required Modules	Date Completed	
International Studies	06/27/13	1/3 (33%)
Students in Research	06/27/13	8/10 (80%)
Avoiding Group Harms - U.S. Research Perspectives	07/05/13	2/3 (67%)
Introduction	07/05/13	no quiz
History and Ethical Principles - SBE	07/05/13	4/5 (80%)
Defining Research with Human Subjects - SBE	07/05/13	4/5 (80%)
The Regulations - SBE	07/08/13	5/5 (100%)
Basic Institutional Review Board (IRB) Regulations and Review Process	07/08/13	5/5 (100%)
Assessing Risk - SBE	07/08/13	5/5 (100%)
Informed Consent - SBE	07/08/13	5/5 (100%)
Privacy and Confidentiality - SBE	07/08/13	5/5 (100%)
Records-Based Research	07/08/13	1/2 (50%)
Research With Protected Populations - Vulnerable Subjects: An Overview	07/08/13	4/4 (100%)
Research with Children - SBE	07/08/13	3/4 (75%)
Research in Public Elementary and Secondary Schools - SBE	07/10/13	4/4 (100%)
Internet Research - SBE	07/10/13	5/5 (100%)
FDA-Regulated Research	07/10/13	4/5 (80%)
Research and HIPAA Privacy Protections	07/10/13	3/5 (60%)

Hot Topics	07/10/13	no quiz
Conflicts of Interest in Research Involving Human Subjects	07/10/13	4/5 (80%)
Cultural Competence in Research	07/10/13	4/5 (80%)
Southern Illinois University Edwardsville	07/10/13	no quiz

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI participating institution. Falsified information and unauthorized use of the CITI course site is unethical, and may be considered scientific misconduct by your institution.

Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Course Coordinator

Return

Emily McCadden
Example Note Card Questions

Chapter 1: Exploring Life

Illustrative Note Card Group Sample Questions

1. Illustrate an example of emergent properties.
2. Draw each of the three domains of life and use arrows to illustrate their relationship to each other.
3. Illustrate how a raccoon interacts with its environment including matter and energy exchange.

Written Description Note Card Group Sample Questions

1. What is meant by emergent properties? Write an example.
2. In what three domains can life be classified? Describe each domain.
3. Describe how a raccoon interacts with its environment including matter and energy exchange.

Emily McCadden
Pre-Test/Post-Test

1. An example of emergent properties is
   a. Atoms.
   b. Molecules.
   c. The cell.
   d. A test tube full of organelles.
2. All of the following are polymers EXCEPT
   a. Protein.
   b. Glycogen.
   c. DNA.
   d. Glucose.
3. What is the function of the rough endoplasmic reticulum?
   a. Modifies a protein
   b. Synthesizes and packages a protein
   c. Synthesizes lipids
   d. Makes ATP for cellular energy
4. Tonicity refers to
   a. The ability of a surrounding solution to cause a cell to gain or lose water.
   b. When a cell engulfs a particle.
   c. The amount of energy needed for reactant molecules to move to a higher-energy, unstable state.
   d. The tendency of particles of any kind to spread out evenly in an available space.
5. How is cellular respiration distinguished from fermentation?
   a. Only respiration oxidizes glucose.
   b. NADH is oxidized by the electron transport chain in respiration only.
   c. Substrate-level phosphorylation is unique to fermentation; cellular respiration uses oxidative phosphorylation.
   d. Fermentation is the metabolic pathway found in prokaryotes; respiration is unique to eukaryotes.
6. During mitosis, all of these stages occur EXCEPT
   a. Anaphase.
   b. Interphase.
   c. Telophase.
   d. Prophase.
7. Sam has parents who are heterozygous for a recessive disorder called cystic fibrosis. What are the chances that Sam has cystic fibrosis?
   a. 25%
   b. 50%
   c. 75%
   d. 100%

Emily McCadden
Pre-Test/Post-Test

8. Translation occurs
    a. In the mitochondria.
    b. In the nucleus.
    c. In the cytoplasm.
    d. In the Golgi apparatus.
9. Why do cells contain proto-oncogenes that can change into cancer-causing genes?
    a. Cells produce proto-oncogenes as a by-product of mitosis.
    b. Viruses infect cells with proto-oncogenes.
    c. Proto-oncogenes are "junk" genes without a known function.
    d. Proto-oncogenes normally control cell division.
10. The process in which individuals with certain inherited traits are more likely to survive and reproduce than are individuals that do not have those traits is called
    a. Genetic drift.
    b. Evolution.
    c. Natural selection.
    d. Microevolution.
11. In ______________________________, a new species arises within the same geographic area as its parent species.
    a. Reproductive isolation
    b. Sympatric speciation
    c. Adaptive radiation
    d. Punctuated equilibria
12. The bacteria that cause tetanus can be killed only by prolonged heating at temperatures considerably above boiling. This suggests that tetanus bacteria
    a. Have cell walls that contain peptidoglycan.
    b. Protect themselves by secreting antibiotics.
    c. Are autotrophic.
    d. Produce endospores.
13. Proteins that bacterial cells secrete into their environment are called
    a. Endotoxins.
    b. Endospores.
    c. Biofilms.
    d. Exotoxins.
14. Negative-feedback mechanisms are
    a. Found only in birds and mammals.
    b. Most often involved in maintaining homeostasis.
    c. Analogous to a furnace that produces heat.
    d. All of the above.

Emily McCadden
Pre-Test/Post-Test

15. What acid does the stomach produce during digestion?
    a. Sulfuric acid
    b. Pepsin
    c. Hydrochloric acid
    d. Phosphoric acid
16. The three phases of gas exchange include all of the following EXCEPT
    a. The production of surfactant.
    b. Transported gases by the circulatory system.
    c. Breathing.
    d. Exchange of gases with body cells.
17. When the heart is relaxed during the phase called ______ blood flows into all four of its chambers.
    a. Systole
    b. Cardiac output
    c. Diastole
    d. Heart rate
18. What type of cell is humoral immune response (antibody)?
    a. Cytotoxic T Cells
    b. Natural killer cells
    c. Macrophages
    d. B cells
19. Filtration in the kidneys starts where in the nephron?
    a. Distal tubule
    b. Loop of Henle
    c. Proximal Tubule
    d. Bowman's capsule
20. The function of the hypothalamus is to
    a. Function as the main control center of the endocrine system.
    b. Stimulate contractions of uterus during labor.
    c. Stimulate and maintain metabolic processes.
    d. Stimulate growth.
21. Spermatogenesis and oogenesis both produce ______ cells.
    a. Diploid
    b. Haploid
    c. Octoploid
    d. Tetraploid

Emily McCadden
Pre-Test/Post-Test

22. The difference between an axon and a dendrite of a neuron is that an axon ____________________ a signal while a dendrite ____________________ a signal.
    a. receives; transmits
    b. transmits; receives
    c. mediates; transmits
    d. receives; mediates
23. Which is NOT a part of the ear?
    a. Aqueous humor
    b. Hair cells
    c. Ossicles
    d. Cochlea
24. In a muscle contraction, a myosin head attaches to a(n)
    a. Actin filament
    b. Myosin filament
    c. Sarcomere
    d. M line

Classroom Exit Survey **Classroom Student ID #: _____**

Please circle the best response for each statement.
1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree

1 2 3 4 5 1. I am interested in biology.

1 2 3 4 5 2. I am interested in nursing.

1 2 3 4 5 3. I am a motivated student.

1 2 3 4 5 4. I am familiar with basic biology concepts.

1 2 3 4 5 5. Study aids enhance my learning process.

1 2 3 4 5 6. Creating illustrations helped me better learn biology concepts.

1 2 3 4 5 7. Writing out descriptions of biology concepts aided my learning.

1 2 3 4 5 8. Study aids are not helpful to my learning.

1 2 3 4 5 9. I feel more prepared for a quiz/test when I use note cards.

Additional Comments:

APPENDIX B

Acknowledgment of Informed Consent

Section I: **Identification of Project and Responsible Investigator:**

I hereby agree to participate in a research project entitled "Assessing learning gains through note cards and illustrations" to be conducted by Emily McCadden as principal investigator.

Section II: **Participant Rights and Information:**

1. **Purpose of the Project:**

It is my understanding that the study that will be conducted in BIOL 140 Human Biology will be looking at the effectiveness of supplemental note card study aids to the main curriculum. You will be a part of the study for the duration of the Fall 2013 semester which begins August 19th. If you do not choose to participate, you are still required to complete the assignments as part of a course requirement, but your data will not be included in the study.

2. Description of Risks:

There are no foreseeable risks outside the normal risks associated with enrollment in a university course.

3. Description of Benefits:

There is no direct benefit to you. However, college instructors may benefit from the results of this research.

4. **Disclosure of Alternative Procedures:**

If you choose not to participate, you will do the same classroom assignments but your materials and grades will not be included in the research study. Whether you decide to participate or not participate in this study, your grade will not be affected by this decision.

5. Confidentiality of Records:

We will keep a record of your scores and grades during your human biology course at SIUE. The record will include your age, year in school, major, minor, and gender. However, the record will NOT include your name, address, social security number, school ID number or any other personal information. Your instructor will NOT have information regarding your participation in the project. After our work with your class is complete, the confidential records will be kept in a locked file cabinet and on computer files at our SIUE offices. They will be open only to members of our research team.

6. Contact Information:

If you have any questions about our research project or about your rights and activities as a participant, then please contact the project's principal investigator, Emily McCadden at (618) 402-0605 or email at ebermes@siue.edu. You may also contact her faculty supervisor, Dr. Kelly Barry, at (618) 650-5245 or kbarry@siue.edu. If you are a participant and become worried about your emotional and physical responses to the project's activities, then we encourage you to immediately notify your instructor and Mrs. McCadden. They will work with you to help identify the problem and solve it. You can also seek assistance from SIUE Counseling Services (at 618-650-2197). If you have any questions about your rights or any other concerns, you may also contact Linda Skelton with the SIUE Institutional Review Board at (618) 650-2958 or lskelto@siue.edu.

7. Statement of Voluntary Participation:

If you choose to join our research project, your participation will be voluntary. You can ask to withdraw from the study at any time by contacting the principal investigator at the contact information above, and your data will be withdrawn from the participant pool in a way that does not draw any special attention to you. The instructor of the course will not know who is participating and who is not participating in this study, and should you choose to withdraw from the study, you will not be penalized in any way. If you do choose to withdraw from the study, you should continue to fully participate in the course, as you did prior to withdrawing from the study.

Section III: Signatures

☐ I will participate in this study.

☐ I will not participate in this study.

1. Participant: ________________________________ Date: ______________

2. Principal Investigator: Emily McCadden Date: 22-July-2013

3. Principal Investigator's address: Box 1651, SIUE, Edwardsville, IL 62026

4. Principal Investigator's phone number: (618) 402-0605

5. E-Mail: ebermes@siue.edu

Updated 05/02/12 PGC

APPENDIX C

PARTICIPANTS IN STUDY

Biology 140 Section 003—Control Group

Anonymity Code	Participation Status
00301	P
00302	P
00303	P
00305	P
00307	P
00308	P
00309	P
00310	P
00311	P
00312	P
00315	P
00317	P
00318	P
00319	P
00322	P
00323	P
00324	P
00325	P
00326	P
00327	P
00328	P
00329	P
00330	P
00331	P
00332	P
00333	P
00335	P
00336	P
00337	P
00338	P
00339	P
00341	P
00342	P
00343	P
00345	P
00349	P
00350	P
00351	P
00352	P
00353	P
00354	P
00357	P
00358	P
00359	P
00360	P
00361	P
00362	P
00363	P
00364	P
00365	P
00366	P
00367	P
00368	P
00369	P
00370	P
00371	P

Biology 140 Section 004—Illustration Group

Anonymity Code	Participation Status		
00400	P	00422	P
00401	P	00426	P
00402	P	00428	P
00403	P	00429	P
00404	P	00431	P
00405	P	00432	P
00406	P	00434	P
00407	P	00435	P
00408	P	00436	P
00409	P	00437	P
00410	P	00439	P
00412	P	00440	P
00413	P	00442	P
00414	P	00443	P
00415	P	00444	P
00416	P	00445	P
00417	P	00446	P
00418	P	00447	P
00419	P	00449	P
00420	P	00450	P
00421	P	00451	P
		00452	P

Biology 140 Section 005—Description Group

Anonymity Code	Participation Status
00503	P
00504	P
00505	P
00506	P
00507	P
00509	P
00512	P
00514	P
00515	P
00517	P
00519	P
00521	P
00522	P
00523	P
00524	P
00525	P
00526	P
00527	P
00528	P
00529	P
00530	P
00531	P
00532	P
00533	P
00534	P
00535	P
00536	P
00537	P
00538	P
00539	P
00540	P
00541	P
00542	P
00543	P
00544	P
00545	P
00547	P
00548	P
00549	P
00551	P
00552	P
00553	P
00554	P
00555	P
00556	P
00557	P

APPENDIX D

COURSE SYLLABUS

Biology 140 – Section 003
Human Biology

Department of Biological Sciences - Southern Illinois University Edwardsville

Syllabus – Fall Semester 2013

Instructor: Dr. Barbara McCracken
Office: Room 1245 Science Laboratory West
Phone: 650-3907
E-mail: bmccrac@siue.edu (preferred form of communication, include Bio 140-003 in subject line)
Office Hours: Monday from 1:00 – 2:00 pm and Thursday 2:00 – 3:00 (or by appointment)
Lectures: 12:00 pm - 12:50 pm MWF Peck Hall 0306
Textbook (available at textbook services):

- *Campbell Biology Concepts and Connections*, Reece et al. 7th Edition.

Course Description

Introduction and application of basic human biology concepts, including cell theory, genetics, systems biology, and evolution.

Course Objectives

- For students to gain knowledge and understanding of human biology with respect to:
  - Biological molecules that dictate life at the cellular level
  - Cellular classification, structure and function
  - Genetics and the transmission of molecular information
  - Evolution and the natural history of mankind
  - The form (anatomy) and function (physiology) of the organ systems of the body
- To introduce students to critical thinking skills in applying biological information in real-life situations
- To increase knowledge of the scientific method as a process for improving our understanding of the natural world and how it functions

Assessment

Your grade in this course will be determined by a straight curve based on the percentage of points you earn from a fixed number of points using the following grading scale:

Grade	Percentage Range
A	90 - 100.0%
B	80 - 89.9%
C	70 - 79.9%
D	60 - 69.9%
F	less than 59.9 %

The course instructor reserves the right to curve final grades in the favor of the students. Individual exams and quizzes will not be curved. There will be four lecture exams and a final exam. Each lecture exam is 100 points and the lowest of these scores will be dropped. The final is cumulative and is 200 points. Throughout the semester there will be quizzes and/or other assignments (TBD). The combined total points of the quizzes and assignments will be up to 100 points. Thus, the number of points for this class will be 500 - 600.

Summarizing the point breakdown:

Lecture Exam 1	100 points
Lecture Exam 2	100 points
Lecture Exam 3	100 points
Lecture Exam 4 (drop lowest)	100 points
Final Exam	200 points
Quizzes and/or Assignments	(100 points)
TOTAL	**500 - 600 points**

Attendance, Exams, and Behavior

Attendance in lecture is not mandatory. Students will be responsible for learning the material as presented in lecture and in the textbook. However, it is my personal experience that class attendance is important for doing well in this type of course. Hearing the material and writing it down in the form of notes generally improves comprehension and retention.

Exams: Because we will be dropping the lowest exam score, there will generally be no make-up exams. If you need to miss an exam, for any reason, that will be considered your "drop" exam. The only exception to this rule is for student athletes missing an exam for a university-sponsored event. Please see me prior to the event. After an exam is given back, please check for accuracy in grading. At times, a scantron exam may be graded by the wrong key or some other technical error may occur. If there is a problem with your exam, you will have one week to talk with me about it. Otherwise, the grade will stand. **The Final Exam is scheduled for Monday, December 9th, at 10:00am.** There is no make-up for the Final Exam. Please bring a new Scantron (blue form) to each exam and the final.

Quizzes, worth from 10 – 20 points each, will either be written in class or accessed via Blackboard. Please see section below for information on using Blackboard. Blackboard quizzes will be timed. If you go over the allotted time, Blackboard will not give you a grade for your quiz.

I discourage the use of computers during my lecture. However, I understand that some students prefer to take notes on a laptop or tablet. This will only be permitted if you are not a distraction to students around you. Updating your Facebook status, watching YouTube videos, and playing games are distracting to students around you. And despite your confidence in your abilities to be stealth about your activities, it is more noticeable to me than you may think. I will not hesitate to call you out and ask you to put your computer away if you are distracting me from my lecture. Other forms of electronic communication are not permitted during lecture. Please be sure your phone is off and your iPod is put away.

Please minimize class disruptions. If you need to exit the room during a lecture, please sit near the door. Please do not hold extracurricular conversations during lecture. Excessive or frequent tardiness will also not be tolerated. Students that repeatedly disrupt the class will be asked to leave.

Academic misconduct (such as cheating on exams, assignments, quizzes and any form of plagiarism) will not be tolerated in this course. Such instances will result in a failing grade on the assignment or course and will be brought to the attention of the Dean, following the guidelines associated with the Student Academic Code. The Student Academic Code can be found at http://www.siue.du/policies/3c2.shtml

Blackboard

Students should be familiar with Blackboard. I will post any course announcements and updates through this site. Blackboard will also be your portal to some reading assignments, quizzes, lecture PowerPoints and your current grade. You may access Blackboard by going to http://bb.siue.edu/. Your Blackboard login is your email username and your Blackboard password is your email password. Additional Blackboard resources include:

- Blackboard Student Orientation Site: http://www.siue.edu/its/bb/index.shtml
- Blackboard Help Line: 618-650-5500

Students with Disabilities

Please notify me no later than the end of the first week of class concerning any academic accommodations you will need. You must have a documented disability and an ID CARD from Disability Support Services. Disability Support Services is located in the Student Success Center and is available by phone at 618-650-3782 if you have any questions.

Any student in this course with a disability that requires assistance during emergency room or building evacuations will be accommodated, and provided with a written evacuation plan. Students must identify themselves to me and by contacting Dr. Kelly Barry (kbarry@siue.edu, 650-5245, SLW 1080) for an appointment as soon as possible in the semester.

Strategies for Success

1. Come to class!!
2. Take your own notes. I will post my PowerPoint lectures on the course Blackboard site, but you should be taking your own notes. I cannot emphasize the importance of writing down your own thoughts and explanations. I will try to post the PowerPoint in a timely fashion, however there may be times that they will not be available until after the lecture.
3. Keep up with the reading assignments. This course is not inherently difficult, but there is a lot of material to cover. Stay on top of studying and don't cram for the exams. Cramming is not a successful way to study.
4. Do not give up! Learning is a journey and I want everyone to be successful in this course and within the curriculum. If you are falling behind and need help, please see me. I have an open door policy and I am always willing to help students. If you can't make my office hours, please contact me to arrange for another time.
5. I believe that it is the student's responsibility to learn the material in this course. I do not give grades… I assign a grade that corresponds to the grade breakdown listed on the front page. Please do not ask for individual extra credit. I do, on rare occasions, provide opportunities for extra credit to the entire class. But do not count on these to make a significant difference in your grade. The best way to get a good grade in the class is to come to class and see me if you are having trouble.

Schedule for Fall 2013

(Subject to change at the discretion of the Instructor)

Lecture Date	Lecture Topic	Reading Assignment
Monday, August 19	Course introduction, study techniques & time management	None
Wednesday, August 21	*Biology*: Exploring Life	Ch 1
Friday, August 23	The Molecules of Cells	Ch 3
Monday, August 26	The Molecules of Cells (cont.)	
Wednesday, August 28	A Tour of the Cell	Ch 4
Friday, August 30	The Working Cell / How Cells Harvest Energy	Ch 5/6
Monday, September 2	Labor Day – No Class	
Wednesday, September 4	The Cellular Basis of Reproduction and Inheritance	Ch 8
Friday, September 6	(cont.)	
Monday, September 9	Patterns of Inheritance	Ch 9
Wednesday, September 11	Patterns of Inheritance (cont.)	
Friday, September 13	**Exam I**	
Monday, September 16	Molecular Biology of the Gene	Ch 10
Wednesday, September 18	Molecular Biol (cont.)/ How Genes are Controlled	Ch 10/11
Friday, September 20	How Genes are Controlled	Ch 11
Monday, September 23	DNA Technology and Genomics	Ch 12
Wednesday, September 25	How Populations Evolve	Ch 13
Friday, September 27		
Monday, September 30	The Origin of Species	Ch 14
Wednesday, October 2		
Friday, October 4	Tracing Evolutionary History	Ch 15
Monday, October 7		
Wednesday, October 9	The Origin and Evolution of Microbial Life	Ch 16
Friday, October 11	**Exam II**	
Monday, October 14	Unifying Concepts of Animal Structure & Function	Ch 20
Wednesday, October 16	(cont.) and Nutrition and Digestion	Ch 20/21
Friday, October 18	Nutrition and Digestion (cont.)	Ch 21
Monday, October 21	Gas Exchange	Ch 22
Wednesday, October 23	Gas Exchange / Circulation	Ch 22/23
Friday, October 25	Circulation	Ch 23
Monday, October 28	The Immune System	Ch 24
Wednesday, October 30	The Immune System (cont.)	Ch 24
Friday, November 1	**Exam III**	
Monday, November 4	Control of Body Temperature and Water Balance	Ch 25
Wednesday, November 6	(cont.) / Hormones and the Endocrine System	Ch 25/26
Friday, November 8	Hormones and Endocrine System	Ch 26
Monday, November 11	Reproduction and Embryonic Development	Ch 27
Wednesday, November 13	Reproduction (cont.) / Nervous System	Ch 27/28
Friday, November 15	Nervous System (cont.)	Ch 28
Monday, November 18	The Senses	Ch 29
Wednesday, November 20	The Senses (cont.) / How Animals Move	Ch 29/30
Friday, November 22	How Animals Move	Ch 30

November 25 - 29	Thanksgiving Break – No Class
Monday, December 2	Catch up and review
Wednesday, December 4	
Friday, December 6	**Exam IV**
Monday, December 9, 10:00 am	**Final Exam**

Biology 140 – Section 003
Fall Semester 2013

Memo of Understanding

I have read the syllabus for Biology 140 (Human Biology) Fall 2013 Section 003. I understand, accept, and agree to abide by all of the course policies, as detailed in the syllabus.

Signed ____ Date ___________

Name (please print clearly) ____

Intended Major or Degree Program ________________________________

Biology 140 – Section 004
Human Biology

Department of Biological Sciences - Southern Illinois University Edwardsville

Syllabus – Fall Semester 2013

Instructor: Dr. Barbara McCracken
Office: Room 1245 Science Laboratory West
Phone: 650-3907
E-mail: bmccrac@siue.edu (preferred form of communication, include Bio 140-004 in subject line)
Office Hours: Monday from 1:00 – 2:00 pm and Thursday 2:00 – 3:00 (or by appointment)
Lectures: 9:30 – 10:45 am Tuesday and Thursday in SLB 3114
Textbooks (available at textbook services):

- *Campbell Biology Concepts and Connections*, Reece et al. 7th Edition.

Course Description

Introduction and application of basic human biology concepts, including cell theory, genetics, systems biology, and evolution.

Course Objectives

- For students to gain knowledge and understanding of human biology with respect to:
    - Biological molecules that dictate life at the cellular level
    - Cellular classification, structure and function
    - Genetics and the transmission of molecular information
    - Evolution and the natural history of mankind
    - The form (anatomy) and function (physiology) of the organ systems of the body
- To introduce students to critical thinking skills in applying biological information in real-life situations
- To increase knowledge of the scientific method as a process for improving our understanding of the natural world and how it functions

Assessment

Your grade in this course will be determined by a straight curve based on the percentage of points you earn from a fixed number of points using the following grading scale:

Grade	Percentage Range
A	90 - 100.0%
B	80 - 89.9%
C	70 - 79.9%
D	60 - 69.9%
F	less than 59.9 %

The course instructor reserves the right to curve final grades in the favor of the students. Individual exams and quizzes will not be curved. There will be four lecture exams and a final exam. Each lecture exam is 100 points and the lowest of these scores will be dropped. The final is cumulative and is 200 points. Throughout the semester there will be quizzes and/or other assignments (TBD). The combined total points of the quizzes and assignments will be up to 100 points. Thus, the number of points for this class will be 500 - 600.

Summarizing the point breakdown:

Lecture Exam 1	100 points
Lecture Exam 2	100 points
Lecture Exam 3	100 points
Lecture Exam 4 (drop lowest)	100 points
Final Exam	200 points
Quizzes and/or Assignments	(100 points)
TOTAL	**500 - 600 points**

Attendance, Exams, and Behavior

Attendance in lecture is not mandatory. Students will be responsible for learning the material as presented in lecture and in the textbook. However, it is my personal experience that class attendance is important for doing well in this type of course. Hearing the material and writing it down in the form of notes generally improves comprehension and retention.

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Schedule for Fall 2013

(Subject to change at the discretion of the Instructor)

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Thursday, August 29	A Tour of the Cell	Ch 4
Tuesday, September 3	The Working Cell	Ch 5/6
Thursday, September 5	The Cellular Basis of Reproduction and Inheritance	Ch 8
Tuesday, September 10	Patterns of Inheritance	Ch 9
Thursday, September 12	**Exam I**	
Tuesday, September 17	Molecular Biology of the Gene	Ch 10
Thursday, September 19	How Genes are Controlled	Ch 11
Tuesday, September 24	DNA Technology and Genomics	Ch 12
Thursday, September 26	How Populations Evolve	Ch 13
Tuesday, October 1	The Origin of Species	Ch 14
Thursday, October 3	Tracing Evolutionary History	Ch 15
Tuesday, October 8	The Origin and Evolution of Microbial Life	Ch 16
Thursday, October 10	**Exam II**	
Tuesday, October 15	Unifying Concepts of Animal Structure & Function	Ch 20
Thursday, October 17	Nutrition and Digestion	Ch 21
Tuesday, October 22	Gas Exchange	Ch 22
Thursday, October 24	Circulation	Ch 23
Tuesday, October 29	The Immune System	Ch 24
Thursday, October 31	**Exam III**	
Tuesday, November 5	Control of Body Temperature and Water Balance	Ch 25
Thursday, November 7	Hormones and the Endocrine System	Ch 26
Tuesday, November 12	Reproduction and Embryonic Development	Ch 27
Thursday, November 14	Nervous System	Ch 28
Tuesday, November 19	The Senses	Ch 29
Thursday, November 21	The Senses / How Animals Move	Ch 29/30
November 25 - 29	Thanksgiving Break – No Class	
Tuesday, December 3	How Animals Move	Ch 30
Thursday, December 5	**Exam IV**	
Monday, December 9, 8:00am	**Final Exam**	

Biology 140 – Section 004
Fall Semester 2013

Memo of Understanding

I have read the syllabus for Biology 140 (Human Biology) Fall 2013 Section 004. I understand, accept, and agree to abide by all of the course policies, as detailed in the syllabus.

Signed ____ Date ___________

Name (please print clearly) ____

Intended Major or Degree Program __________________________________

Biology 140 – Section 005
Human Biology

Department of Biological Sciences - Southern Illinois University Edwardsville

Syllabus – Fall Semester 2013

Instructor: Dr. Barbara McCracken
Office: Room 1245 Science Laboratory West
Phone: 650-3907
E-mail: bmccrac@siue.edu (preferred form of communication, include Bio 140-005 in subject line)
Office Hours: Monday from 1:00 – 2:00 pm and Thursday 2:00 – 3:00 (or by appointment)
Lectures: 12:30 – 1:45 pm Tuesday and Thursday in EB 1033
Textbooks (available at textbook services):

- *Campbell Biology Concepts and Connections*, Reece et al. 7th Edition.

Course Description

Introduction and application of basic human biology concepts, including cell theory, genetics, systems biology, and evolution.

Course Objectives

- For students to gain knowledge and understanding of human biology with respect to:
  - Biological molecules that dictate life at the cellular level
  - Cellular classification, structure and function
  - Genetics and the transmission of molecular information
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Thursday, November 21	The Senses / How Animals Move	Ch 29/30
November 25 - 29	Thanksgiving Break – No Class	
Tuesday, December 3	How Animals Move	Ch 30
Thursday, December 5	**Exam IV**	
Wednesday, December 11 at 12:00 PM	**Final Exam**	

Biology 140 – Section 005
Fall Semester 2013

Memo of Understanding

I have read the syllabus for Biology 140 (Human Biology) Fall 2013 Section 005. I understand, accept, and agree to abide by all of the course policies, as detailed in the syllabus.

Signed ____ Date ___________

Name (please print clearly) ____

Intended Major or Degree Program _______________________________

APPENDIX E

PRE-TEST/POST-TEST

Emily McCadden
Pre-Test/Post-Test

1. An example of emergent properties is
    a. Atoms.
    b. Molecules.
    c. The cell.
    d. A test tube full of organelles.
2. All of the following are polymers EXCEPT
    a. Protein.
    b. Glycogen.
    c. DNA.
    d. Glucose.
3. What is the function of the rough endoplasmic reticulum?
    a. Modifies a protein
    b. Synthesizes and packages a protein
    c. Synthesizes lipids
    d. Makes ATP for cellular energy
4. Tonicity refers to
    a. The ability of a surrounding solution to cause a cell to gain or lose water.
    b. When a cell engulfs a particle.
    c. The amount of energy needed for reactant molecules to move to a higher-energy, unstable state.
    d. The tendency of particles of any kind to spread out evenly in an available space.
5. How is cellular respiration distinguished from fermentation?
    a. Only respiration oxidizes glucose.
    b. NADH is oxidized by the elctron transport chain in respiration only.
    c. Substrate-level phosphorylation is unique to fermentation; cellular respiration uses oxidative phosphorylation.
    d. Fermentation is the metabolic pathway found in prokaryotes; respiration is unique to eukaryotes.
6. During mitosis, all of these stages occur EXCEPT
    a. Anaphase.
    b. Interphase.
    c. Telophase.
    d. Prophase.
7. Sam has parents who are heterzygous for a recessive disorder called cystic fibrosis. What are the chances that Sam has cystic fibrosis?

a. 25%
b. 50%
c. 75%
d. 100%

8. Translation occurs
    a. In the mitochondria.
    b. In the nucleus.
    c. In the cytoplasm.
    d. In the Golgi apparatus.
9. Why do cells contain proto-oncogenes that can change into cancer-causing genes?
    a. Cells produce proto-oncogenes as a by-product of mitosis.
    b. Viruses infect cells with proto-oncogenes.
    c. Proto-oncogenes are "junk' genes without a known function.
    d. Proto-oncogenes normally control cell division.
10. The process in which individuals with certain inherited traits are more likely to survive and reproduce than are individuals that do not have those traits is called
    a. Genetic drift.
    b. Evolution.
    c. Natural selection.
    d. Microevolution.
11. In ____________________________________, a new species arises within the same geographic area as its parent species.
    a. Reproductive isolation
    b. Sympatric speciation
    c. Adaptive radiation
    d. Punctuated equilibria
12. The bacteria that cause tetanus can be killed only by prolonged heating at temperatures considerably above boiling. This suggests that tetanus bacteria
    a. Have cell walls that contain peptidoglycan.
    b. Protect themselves by secreting antibiotics.
    c. Are autotrophic.
    d. Produce endospores.
13. Proteins that bacterial cells secrete into their environment are called
    a. Endotoxins.
    b. Endospores.
    c. Biofilms.
    d. Exotoxins.
14. Negative-feedback mechanisms are
    a. Found only in birds and mammals.
    b. Most often involved in maintaining homeostasis.
    c. Analogous to a furnace that produces heat.
    d. All of the above.

15. What acid does the stomach produce during digestion?
    a. Sulfuric acid

   b. Pepsin
   c. Hydrochloric acid
   d. Phosphoric acid
16. The three phases of gas exchange include all of the following EXCEPT
   a. The production of surfactant.
   b. Transported gases by the circulatory system.
   c. Breathing.
   d. Exchange of gases with body cells.
17. When the heart isrelaxed during the phase called _______ blood flows into all four of its chambers.
   a. Systole
   b. Cardiac output
   c. Diastole
   d. Heart rate
18. What type of cell is humoral immune response (antibody)?
   a. Cytotoxic T Cells
   b. Natural killer cells
   c. Macrophages
   d. B cells
19. Filtration in the kidneys starts where in the nephron?
   a. Distal tubule
   b. Loop of Henle
   c. Proximal Tubule
   d. Bowman's capsule
20. The function of the hypothalamus is to
   a. Function as the main control center of the endocrine system.
   b. Stimulate contractions of uterus during labor.
   c. Stimulate and maintain metabolic processes.
   d. Stimulate growth.
21. Spermatogenesis and oogenesis both produce ________ cells.
   a. Diploid
   b. Haploid
   c. Octoploid
   d. Tetraploid
22. The difference between an axon and a dendrite of a neuron is that an axon ______________________ a signal while a __________________________ a signal.
   a. receives; transmits
   b. transmits; receives
   c. mediates; transmits
   d. receives; mediates
23. Which is NOT a part of the ear?
   a. Aqueous humor
   b. Hair cells
   c. Ossicles
   d. Cochlea

24. In a muscle contraction, a myosin head attaches to a(n)
    a. Actin filament
    b. Myosin filament
    c. Sarcomere
    d. M line

Pre-Test/Post-Test Answers

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b. Myosin filament
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d. M line

APPENDIX F

END OF CHAPTER QUESTIONS USED ON PRE/POST TEST

- Pre-Test/Post-Test Question 5 taken from Chapter 6 Review Questions, p. 105 (Reece, Taylor, Simon, & Dickey, 2012)
- Pre-Test/Post-Test Question 9 taken from Chapter 11 Review Questions, p. 229 (Reece, Taylor, Simon, & Dickey, 2012)
- Pre-Test/Post-Test Question 12 taken from Chapter 16 Review Questions, p. 339 (Reece, Taylor, Simon, & Dickey, 2012)
- Pre-Test/Post-Test Question 14 taken from Chapter 20 Review Questions, p. 427 (Reece, Taylor, Simon, & Dickey, 2012)

APPENDIX G

ILLUSTRATION GROUP NOTECARD QUESTIONS

Assignment 1 (Chapter 1: Exploring Life)

1. What is meant by emergent properties? Draw an example.
2. In what three domains can life be classified? Illustrate each domain.
3. Illustrate how a raccoon interacts with its environment including matter and energy exchange.

Assignment 2 (Chapter 3: The Molecules of Cells)

1. Illustrate and draw an example of a monosaccharide, disaccharide, and polysaccharide.
2. Draw a dehydration reaction of glycerol and a fatty acid.
3. Illustrate primary, secondary, tertiary, and quaternary structures of a protein.

Assignment 3 (Chapter 4: A Tour of the Cell)

1. Draw the structure of the plasma membrane of an animal cell. What would be found directly inside and outside the membrane?
2. Illustrate the synthesis and packaging of a secretory protein by the rough endoplasmic reticulum.
3. Illustrate the three types of cell junctions found in animal tissue.

Assignment 4 (Chapter 5 & 6: The Working Cell/How Cells Harvest Chemical Energy)

1. Illustrate hypotonic, isotonic, and hypertonic solutions in regards to an animal cell.
2. Illustrate phagocytosis, pinocytosis, and receptor-mediated endocytosis.
3. Illustrate three main stages of cellular respiration including the start and end products.

Assignment 5 (Chapter 8: The Cellular Basis of Reproduction and Inheritance)

1. Illustrate the eukaryotic cell cycle including the mitotic phase and the three parts of interphase.
2. Illustrate crossing over and how the steps that lead to genetic recombination.
3. Illustrate nondisjunction and what syndromes it can lead to.

Assignment 6 (Chapter 9: Patterns of Inheritance)

1. Illustrate the F1 and F2 generations of a P (parent) generation that consists of a dominant green (GG) flower and a recessive white (gg) flower.
2. Illustrate the law of independent assortment and draw an example.
3. Draw the phenotype and genotype of a child whose parents (Cc) who are carriers for cystic fibrosis, a recessive disorder.

Assignment 7 (Chapter 10: Molecular Biology of the Gene)

1. Illustrate the functions of DNA polymerase and DNA ligase in DNA replication and in what direction on the parental DNA they replicate. What is the overall direction of replication?
2. Illustrate transcription including the three main steps, the ingredients needed, and the end result.
3. Illustrate the steps of translation including the mRNA, its start codon, tRNAs and their anticodons, ribosomal subunits, P site, A site, and the stop codon.

Assignment 8 (Chapter 11: How Genes Are Controlled & Chapter 12: DNA Technology and Genomics)

1. Illustrate the main levels of DNA packing.
2. Draw the structure of a transcription factor and illustrate how they bend the DNA to allow RNA polymerase to attach.
3. Illustrate nuclear transplantation as it is applied to the creation of Dolly the sheep.

Assignment 9 (Chapter 13: How Populations Evolve & Chapter 14: The Origin of Species)

1. Illustrate stabilizing, directional, and disruptive natural selection to compare the three.
2. Diagram the prezygotic and postzygotic reproductive barriers that keep species separate.
3. Illustrate allopatric speciation in snapping shrimp.

Assignment 10 (Chapter 20: Unifying Concepts of Animal Structure and Function)

1. Draw five types of epithelial tissue including shape, size, and location.
2. Illustrate three types of muscle tissue and their locations.
3. Illustrate the negative feedback system when a person’s body temperature is above 37°C.

Assignment 11 (Chapter 21: Nutrition and Digestion & Chapter 22: Gas Exchange)

1. Illustrate the alimentary canal as well as the accessory digestive glands of the human digestive system.
2. Depict a gastric gland of the stomach, and explain how it produces gastric juice.
3. Illustrate inhalation and exhalation including the contraction and relaxation of the diaphragm.

APPENDIX H

DESCRIPTION GROUP NOTECARD QUESTIONS

Assignment 1 (Chapter 1: Exploring Life)

1. What is meant by emergent properties? Write an example.
2. In what three domains can life be classified? Describe each domain.
3. Describe how a raccoon interacts with its environment including matter and energy exchange.

Assignment 2 (Chapter 3: The Molecules of Cells)

1. Define and give an example of a monosaccharide, disaccharide, and polysaccharide.
2. Describe a dehydration reaction of glycerol and a fatty acid.
3. Describe primary, secondary, tertiary, and quaternary structures of a protein.

Assignment 3 (Chapter 4: A Tour of the Cell)

1. Describe the structure of the plasma membrane of an animal cell. What would be found directly inside and outside the membrane?
2. Describe the synthesis and packaging of a secretory protein by the rough endoplasmic reticulum.
3. Describe the three types of cell junctions found in animal tissue.

Assignment 4 (Chapter 5 & 6: The Working Cell/How Cells Harvest Chemical Energy)

1. Describe hypotonic, isotonic, and hypertonic solutions in regards to an animal cell.
2. Define phagocytosis, pinocytosis, and receptor-mediated endocytosis.
3. Explain three main stages of cellular respiration including the start and end products.

Assignment 5 (Chapter 8: The Cellular Basis of Reproduction and Inheritance)

1. Describe the eukaryotic cell cycle including the mitotic phase and the three parts of interphase.
2. Describe crossing over and how the steps that lead to genetic recombination.
3. Describe nondisjunction and what syndromes it can lead to.

Assignment 6 (Chapter 9: Patterns of Inheritance)

1. Describe the F1 and F2 generations of a P (parent) generation that consists of a dominant green (GG) flower and a recessive white (gg) flower.
2. Describe the law of independent assortment and give an example.
3. Describe the phenotype and genotype of a child whose parents (Cc) who are carriers for cystic fibrosis, a recessive disorder.

Assignment 7 (Chapter 10: Molecular Biology of the Gene)

1. Describe the functions of DNA polymerase and DNA ligase in DNA replication and in what direction on the parental DNA they replicate. What is the overall direction of replication?
2. Describe transcription including the three main steps, the ingredients needed, and the end result.
3. Describe the steps of translation including the mRNA, its start codon, tRNAs and their anticodons, ribosomal subunits, P site, A site, and the stop codon.

Assignment 8 (Chapter 11: How Genes Are Controlled & Chapter 12: DNA Technology and Genomics)

1. Describe the main levels of DNA packing.
2. Describe transcription factors and how they bend the DNA to allow RNA polymerase to attach.
3. Describe the nuclear transplantation as it is applied to the creation of Dolly the sheep.

Assignment 9 (Chapter 13: How Populations Evolve & Chapter 14: The Origin of Species)

1. Compare stabilizing, directional, and disruptive natural selection.
2. List the prezygotic and postzygotic reproductive barriers that keep species separate.
3. Describe allopatric speciation in snapping shrimp.

Assignment 10 (Chapter 20: Unifying Concepts of Animal Structure and Function)

1. Describe five types of epithelial tissue including shape, size, and location.
2. Describe three types of muscle tissue and their locations.
3. Describe the negative feedback system when a person’s body temperature is above 37°C.

Assignment 11 (Chapter 21: Nutrition and Digestion & Chapter 22: Gas Exchange)

1. Describe the alimentary canal and then list the accessory digestive glands of the human digestive system.
2. Describe a gastric gland of the stomach, and explain how it produces gastric juice.
3. Define inhalation and exhalation including the contraction and relaxation of the diaphragm.

APPENDIX I

CONTROL GROUP QUIZ QUESTIONS

Quiz 1 (Chapter 1: Exploring Life)

1. What is meant by emergent properties?

2. In what three domains can life be classified?

    a. Eukarya, Prokarya, and Archaea

    b. Eukarya, Bacteria, and Prokarya

    c. Eukarya, Bacteria, and Archaea

    d. Bacteria, Animalia, Protists

3. Which of the following is the deductive reasoning statement?

    a. She's a witch because she looks like one.

    b. If she weighs the same as a duck, then she is made of wood.

    c. Witches burn because they are made of wood.

    d. She's a witch because she turned me into a newt.

Quiz 2 (Chapter 3: The Molecules of Cells)

1. Which one of the following is a storage polysaccharide in animal cells?

    a. glucose

    b. cellulose

    c. glycogen

    d. lactose

2. A ______________ is formed and ____________ is released following dehydration reactions between 3 fatty acids and a glycerol molecule.

    a. fatty acid; H2O

    b. triglyceride; H2O

    c. H2O; triglyceride

    d. H2O; fatty acid

3. The primary structure of a protein is defined as:

    a. the sequence of amino acids.

b. coiling and folding of the polypeptide.

c. the three-dimensional shape.

d. an association of multiple polypeptides.

Quiz 3 (Chapter 4: A Tour of the Cell)

1. The plasma membrane of an animal cell is composed of a __________________

a. protein bilayer

b. phospholipid bilayer

c. single layer of protein

d. single layer of phospholipid

2. Which is NOT a step in synthesizing and packaging of a secretory protein by the rough endoplasmic reticulum?

a. A ribosome synthesizes a polypeptide following instructions of mRNA.

b. Short chains of sugars are added to polypeptide forming glycoprotein.

c. Molecule is packaged in a transport vesicle.

d. A vesicle buds off from ER membrane and goes to the mitochondrion.

3. A ______________________ junction is a channel that allows small molecules to flow through protein-lined pores between cells.

a. anchoring

b. tight

c. gap

Quiz 4 (Chapter 5 & 6: The Working Cell/How Cells Harvest Chemical Energy)

1. An enzyme lowers the ________ of a reaction and increases the ________.
2. Where on the enzyme does the substrate bind?
3. What is the difference between competitive and non-competitive inhibition in enzymes?

Quiz 5 (Chapter 8: The Cellular Basis of Reproduction and Inheritance)

1. The eukaryotic cell cycle consists of two major phases: _______________________________ and _______________________________.
2. Once the chromosome has been copied, the two copies are stuck together at the centromere. What are the two copies called? ____
3. What are the functions of the mitotic spindle?

a. To help copy the chromosomes during the S phase.

b. To pull the chromosomes apart during anaphase of mitosis

c. To help elongate the cell during mitosis

d. Both B and C

e. A, B, and C are all functions of the mitotic spindle

Quiz 6 (Chapter 9: Patterns of Inheritance)

1. What are the F1 and F2 generations of a P (parent) generation that consists of a dominant green (GG) flower and a recessive white (gg) flower?
2. What is the law of independent assortment? Give an example.
3. What are the phenotype and genotype of a child whose parents (Cc) who are carriers for cystic fibrosis, a recessive disorder?

Quiz 7 Answers (Chapter 10: Molecular Biology of the Gene)

1. Promoter
2. Anticodon
3. Codon recognition, peptide bond formation, translocation

Quiz 8 (Chapter 11: How Genes Are Controlled & Chapter 12: DNA Technology and Genomics)

1. How can we get two different gene products from one mRNA transcript?
    a. By X chromosome inactivation
    b. By alternative RNA splicing
    c. By DNA packing
    d. By signal transduction
2. What mechanism is behind the calico coloring in cats?
    a. X chromosome inactivation
    b. Alternative RNA splicing
    c. DNA packing
    d. Signal transduction
3. How can a cell cause the activation of transcription in another cell that may be at a location very far away in the body?
    a. By X chromosome inactivation
    b. By alternative RNA splicing
    c. By DNA packing
    d. By signal transduction

Quiz 9 (Chapter 13: How Populations Evolve & Chapter 14: The Origin of Species)

1. An example of stabilizing selection would be
    a. A trend toward darker fur color on mice if a fire darkened the landscape
    b. When mice have light and dark fur because they colonized a patchy habitat where a background of light soil was studded with areas of dark rocks.
    c. When the extremely light and dark mice are eliminated thus resulting in intermediate phenotypes, which are best suited for an environment with medium gray rocks.
    d. The contribution and individual makes to the gene pool of the next generation relative to the contributions of other individuals.
2. All of the examples below are of postzygotic barriers except
    a. Reduced hybrid viability.
    b. Hybrid breakdown.
    c. Reduced hybrid fertility.
    d. Habitat isolation.
3. Fifteen pairs of snapping shrimp are separated by the isthmus of Panama. This is an example of
    a. Reproductive isolation.
    b. Adaptive radiation.
    c. Allopatric speciation.
    d. Punctuated equilibria.

Quiz 9—Pop Quiz

1. What does the study of dendrology mean?
2. What are the three cell shapes of epithelial cells?
3. Where do you find epithelial tissues?

Quiz 10 (Chapter 20: Unifying Concepts of Animal Structure and Function)

1. Animals that live in or on their food source are called
    a. Suspension feeders
    b. Substrate feeders
    c. Fluid feeders
    d. Bulk feeders
2. Which of the following is not released by the salivary glands?
    a. Amylase to start starch digestion
    b. Buffers to neutralize acid

c. Glycoprotein to moisturize and lubricate food

d. Nucleases to start digestion of nucleic acids

e. Antibacterial agents

3. What protective mechanisms keep the epithelial cells in the stomach from becoming damaged?

   a. Mucus from specialized epithelial cells coats the surface of the epithelial layer

   b. Pepsin is made and secreted in an inactive form (pepsinogen) so that it doesn't digest the cells that make it.

   c. The epithelial cells of the stomach are constantly being replaced by new cells so that any cells that do get damaged are quickly replaced.

   d. All of the above

Quiz 11 (Chapter 21: Nutrition and Digestion & Chapter 22: Gas Exchange)

1. What are the grape-like clusters of air sacs where gas exchange occurs in the human body called?

   a. Trachea

   b. Bronchi

   c. Bronchioles

   d. Alveoli

2. What is the cause of 90% of lung cancers, increased risk of other cancers, emphysema, cardiovascular disease, and increased aging of the skin, among other things?

   a. Smoking

   b. Smoking

   c. Smoking

3. In humans, inhalation occurs when the chest cavity opens up and the air pressure inside becomes lower than the outside air pressure. What is this called?

   a. Positive-pressure breathing

   b. Negative-pressure breathing

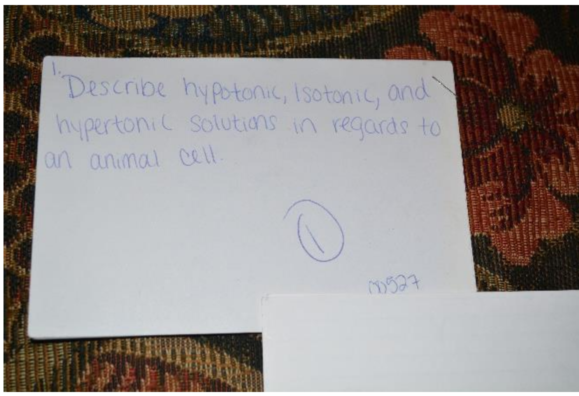
   c. Peer-pressure breathing

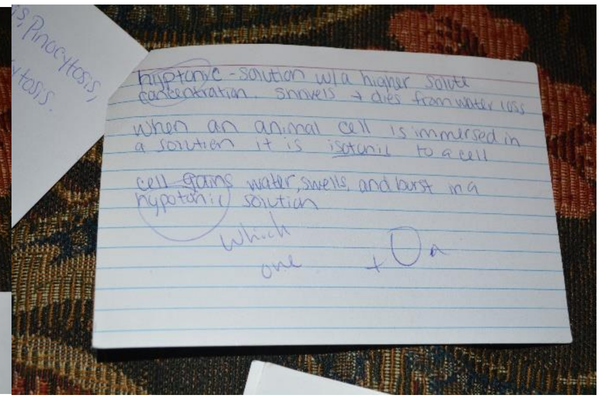
   d. Constant-pressure breathing

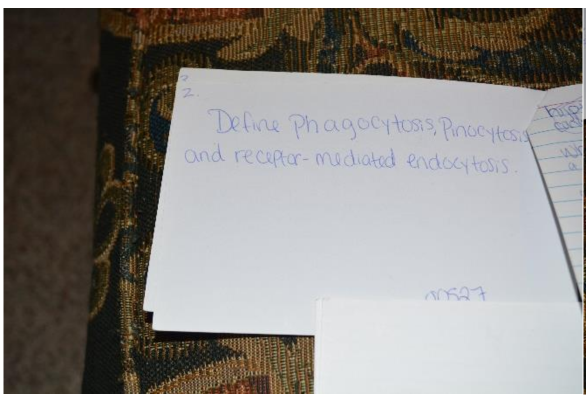
APPENDIX J

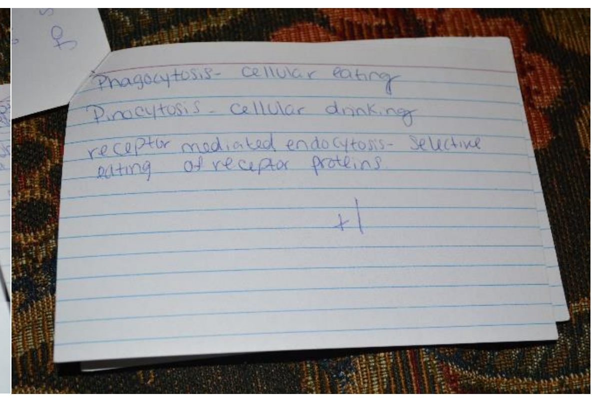
EXAMPLES OF NOTECARD COMPLETION

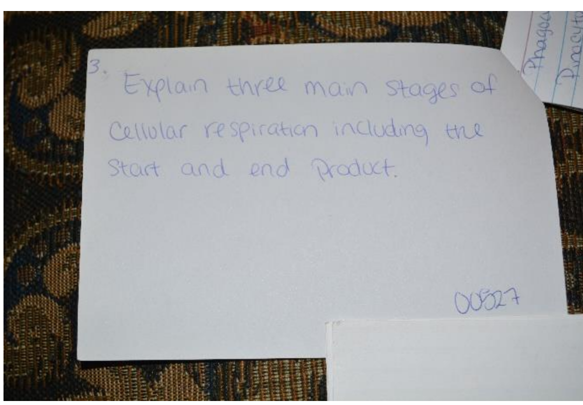
Unsatisfactory—Description Group

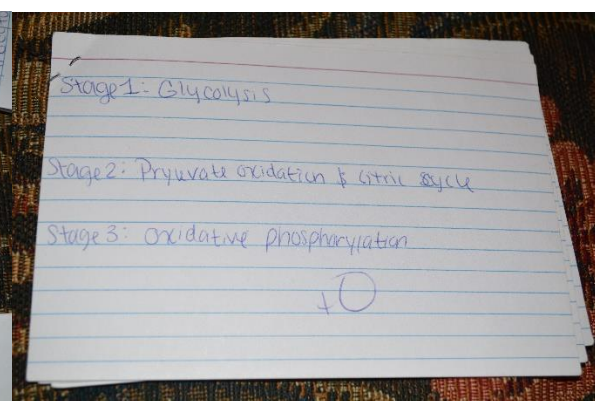




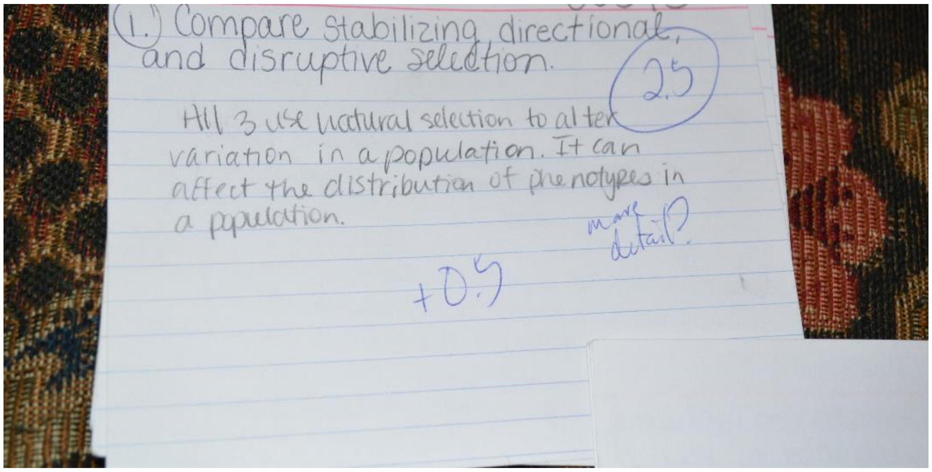








Satisfactory—Description Group

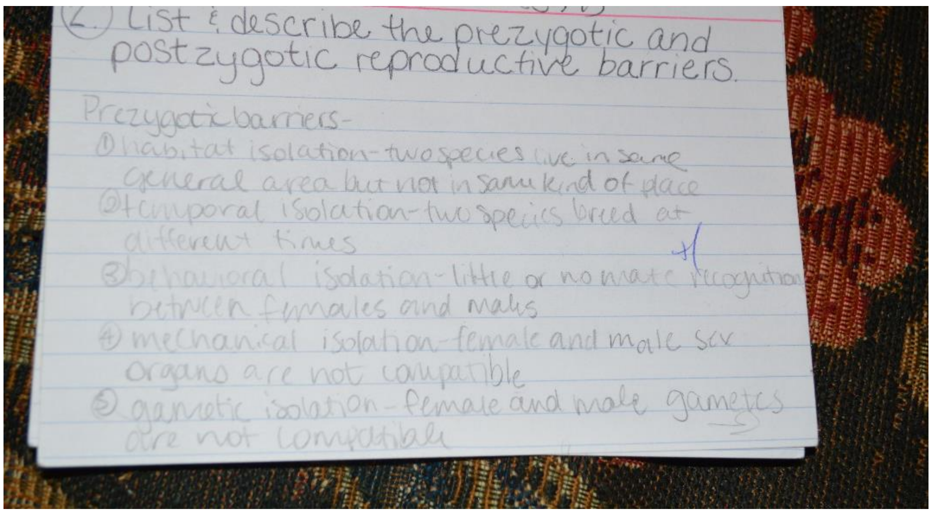

1.) Compare stabilizing, directional, and disruptive selection.

2.5

All 3 use natural selection to alter variation in a population. It can affect the distribution of phenotypes in a population.

more detail?

+0.5


2.) List & describe the prezygotic and postzygotic reproductive barriers.

Prezygotic barriers-

① habitat isolation- two species live in same general area but not in same kind of place

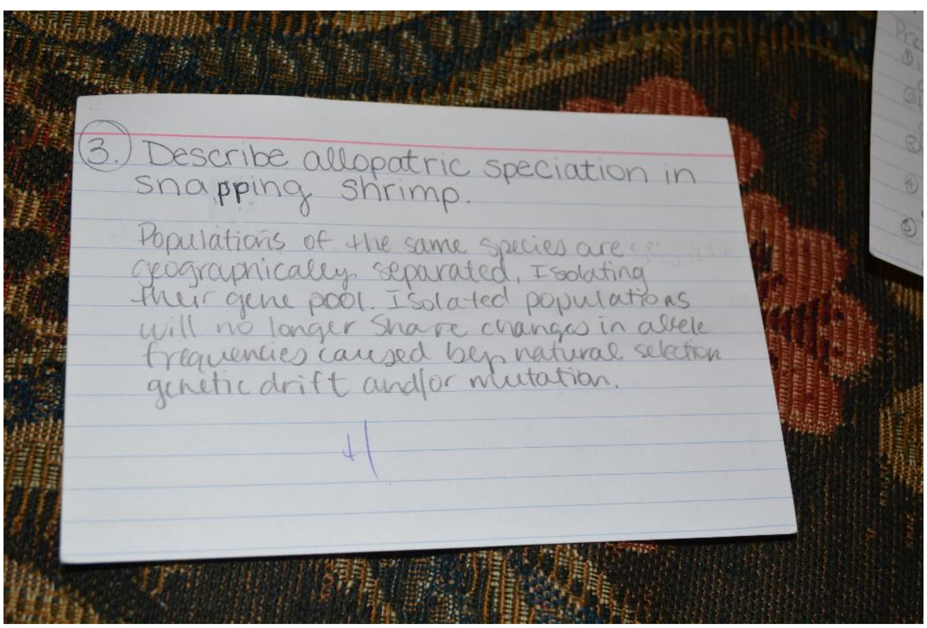
② temporal isolation- two species breed at different times

+1

③ behavioral isolation- little or no mate recognition between females and males

④ mechanical isolation- female and male sex organs are not compatible

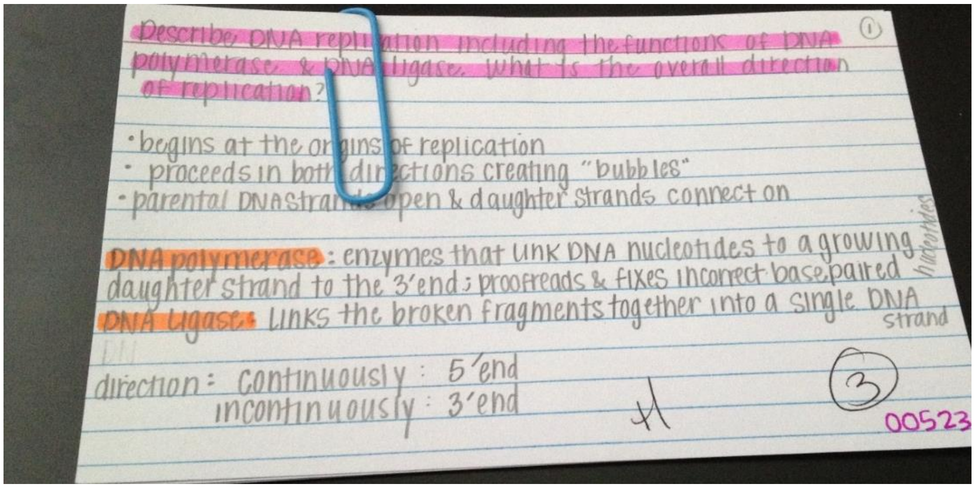
⑤ gametic isolation- female and male gametes are not compatible

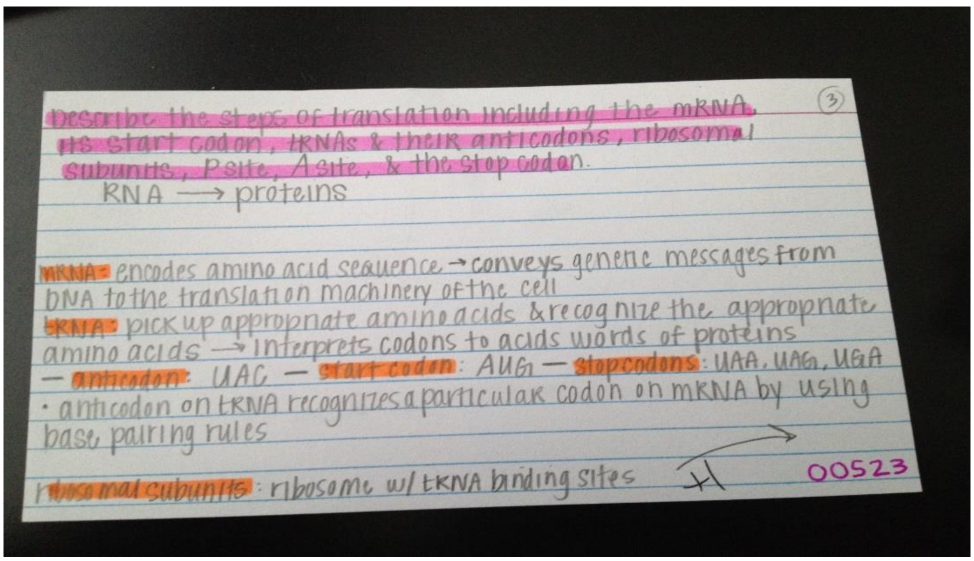

3.) Describe allopatric speciation in snapping shrimp.

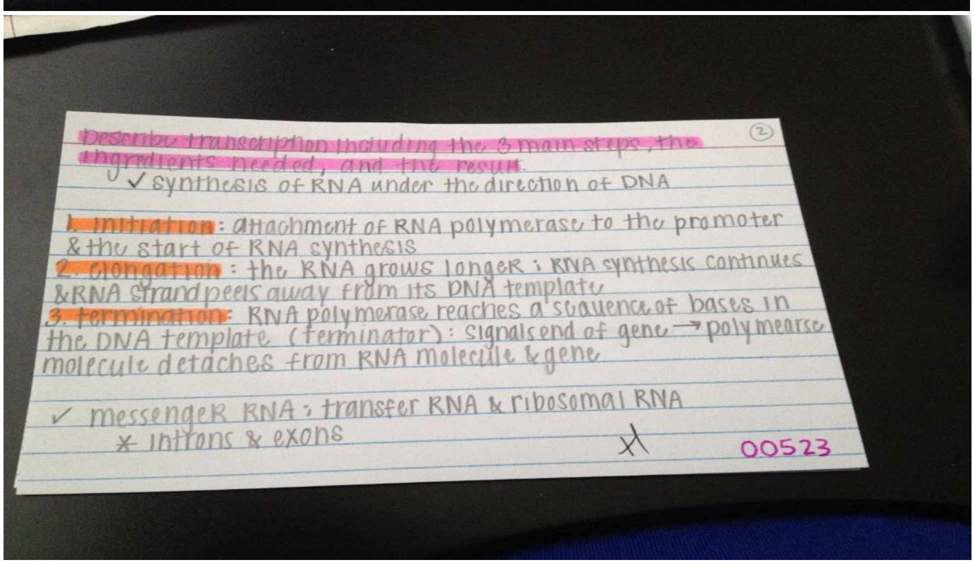
Populations of the same species are geographically separated, isolating their gene pool. Isolated populations will no longer share changes in allele frequencies caused by natural selection genetic drift and/or mutation.

+1

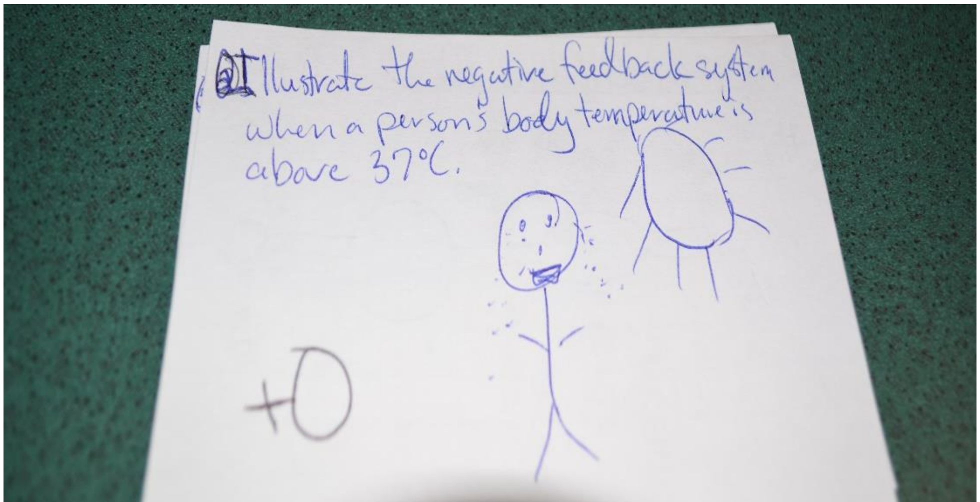
Excellent—Description Group

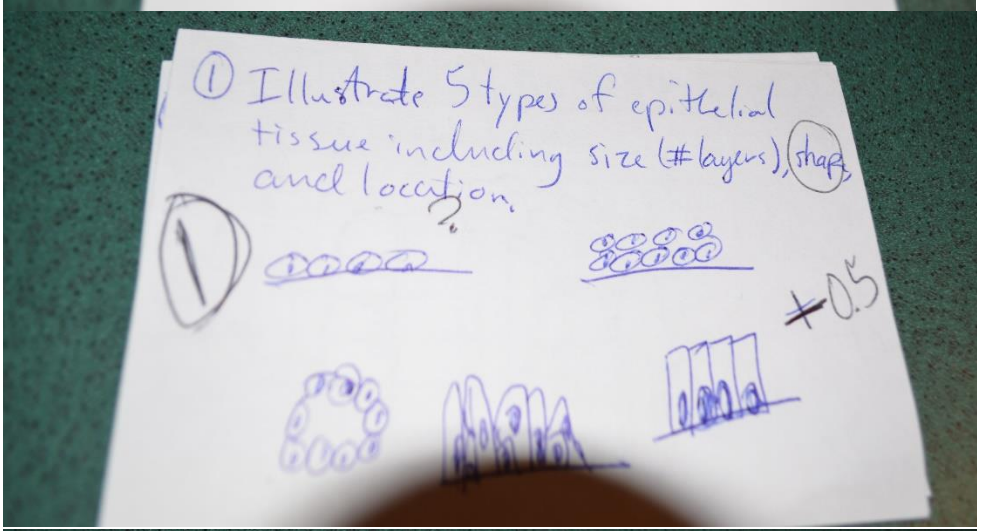


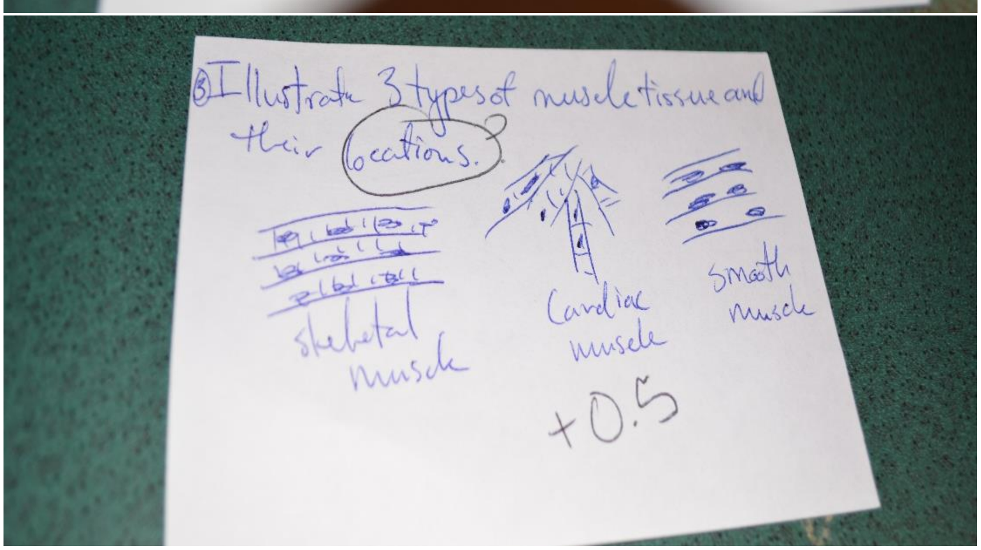




Unsatisfactory—Illustration Group







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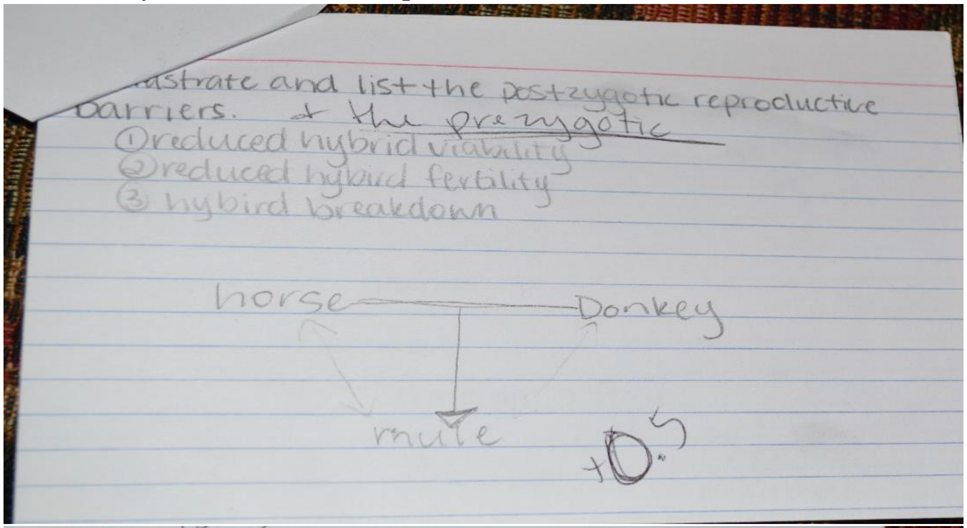
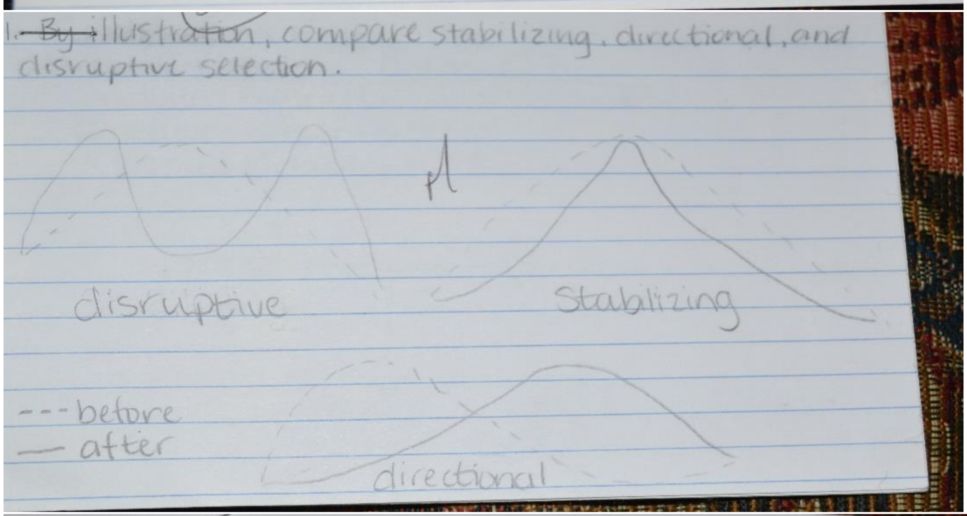
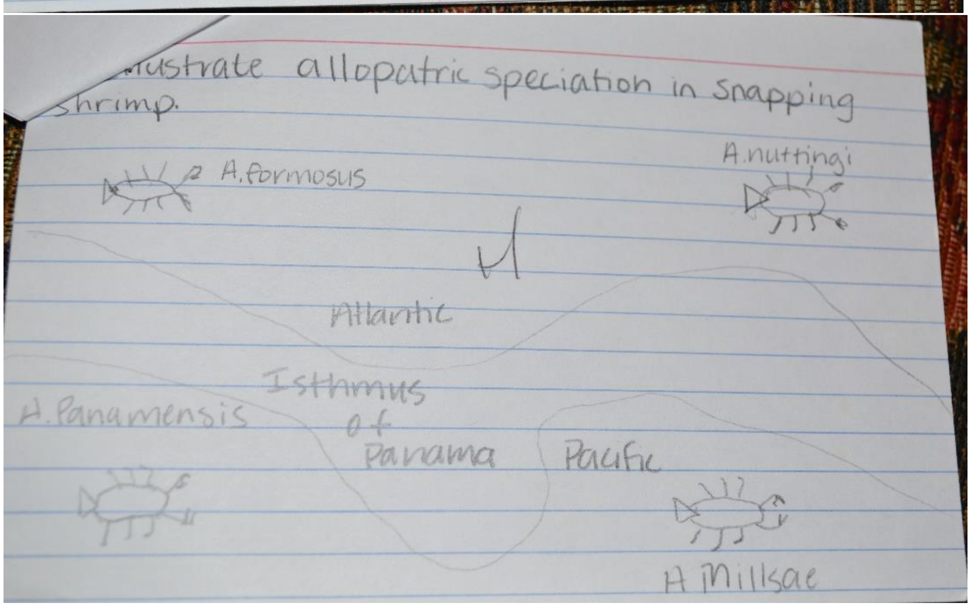
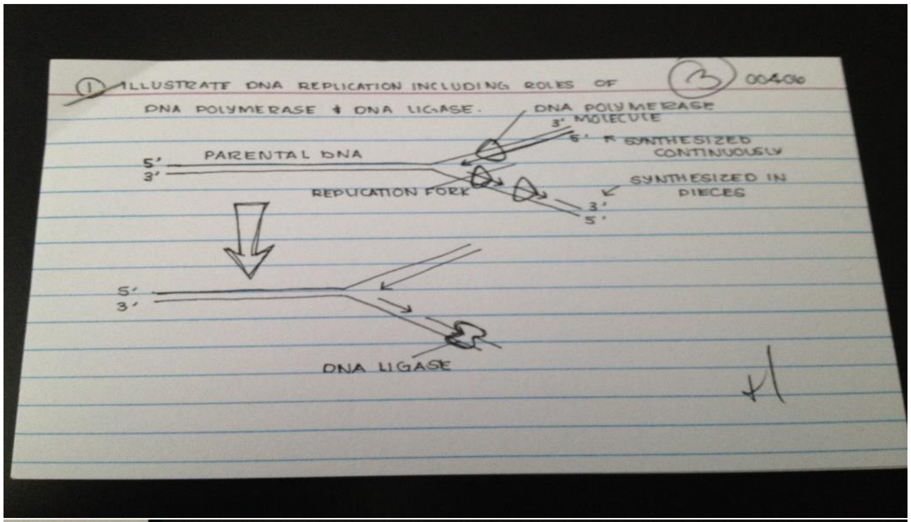
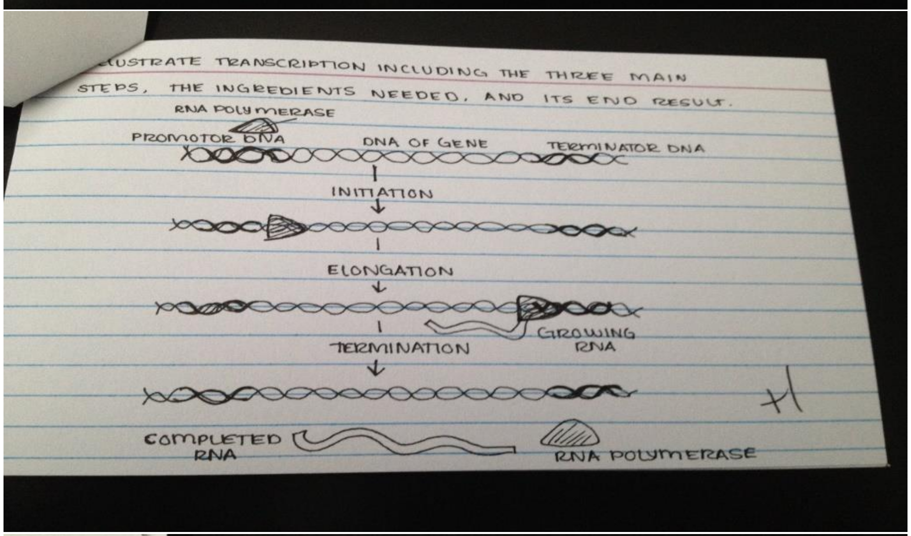


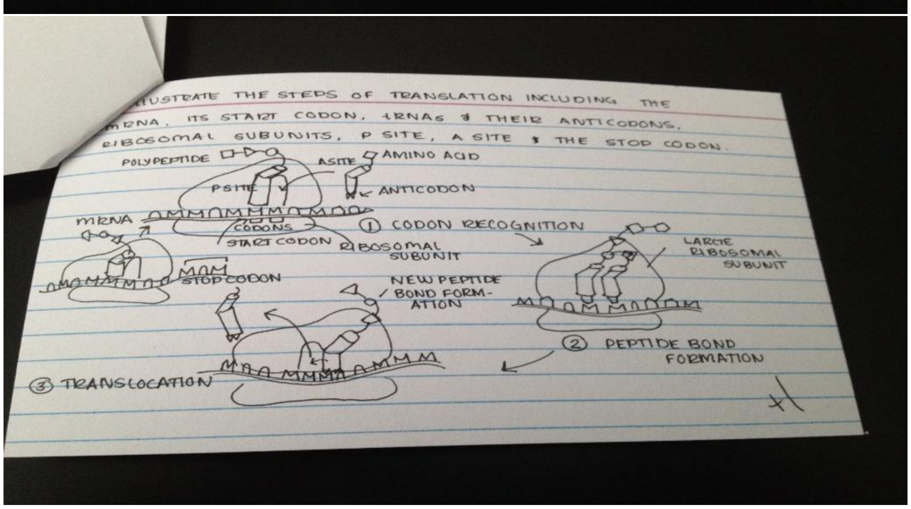




Excellent—Illustration Group



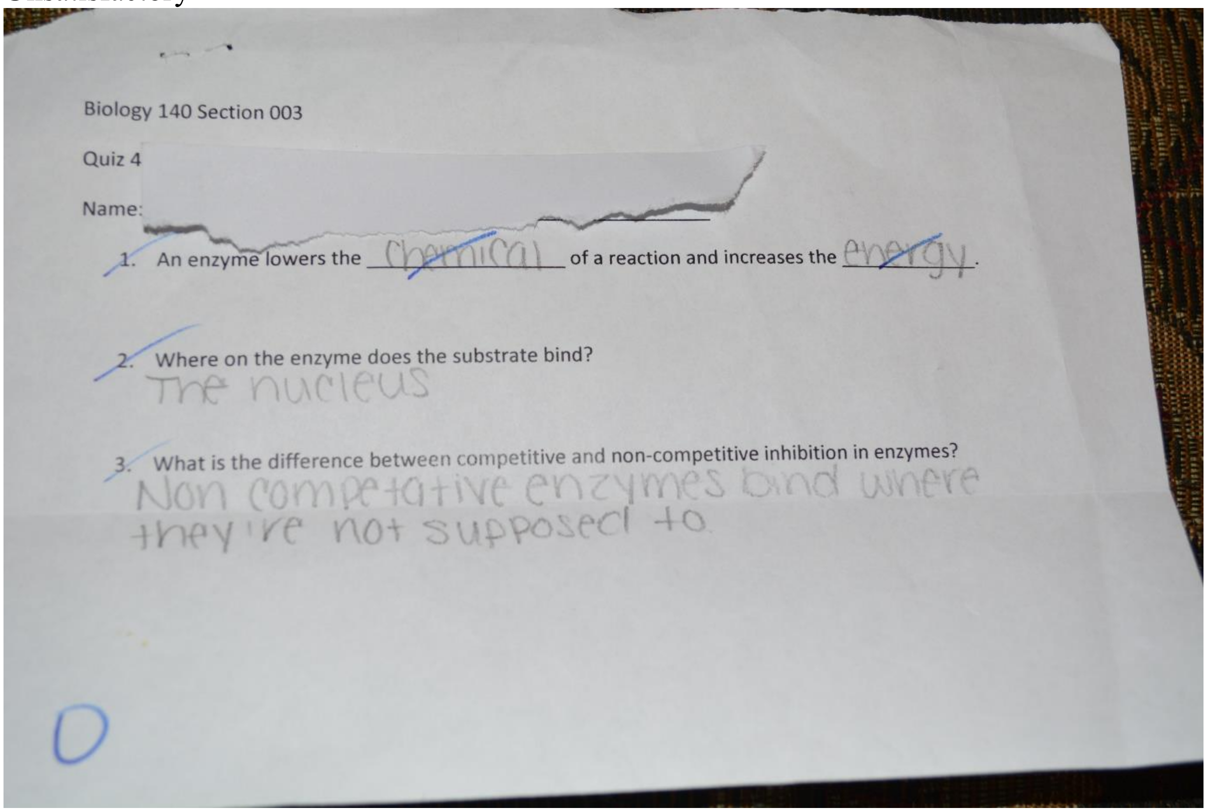




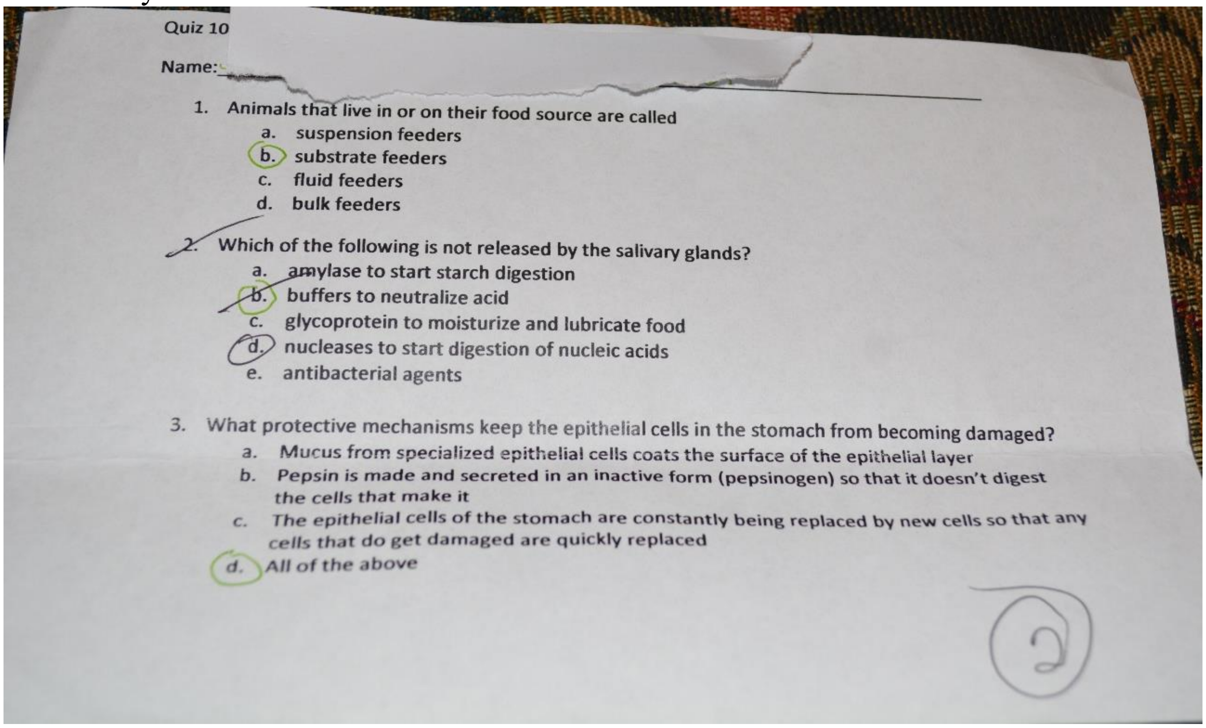
APPENDIX K

EXAMPLES OF QUIZ COMPLETION

Unsatisfactory



Satisfactory



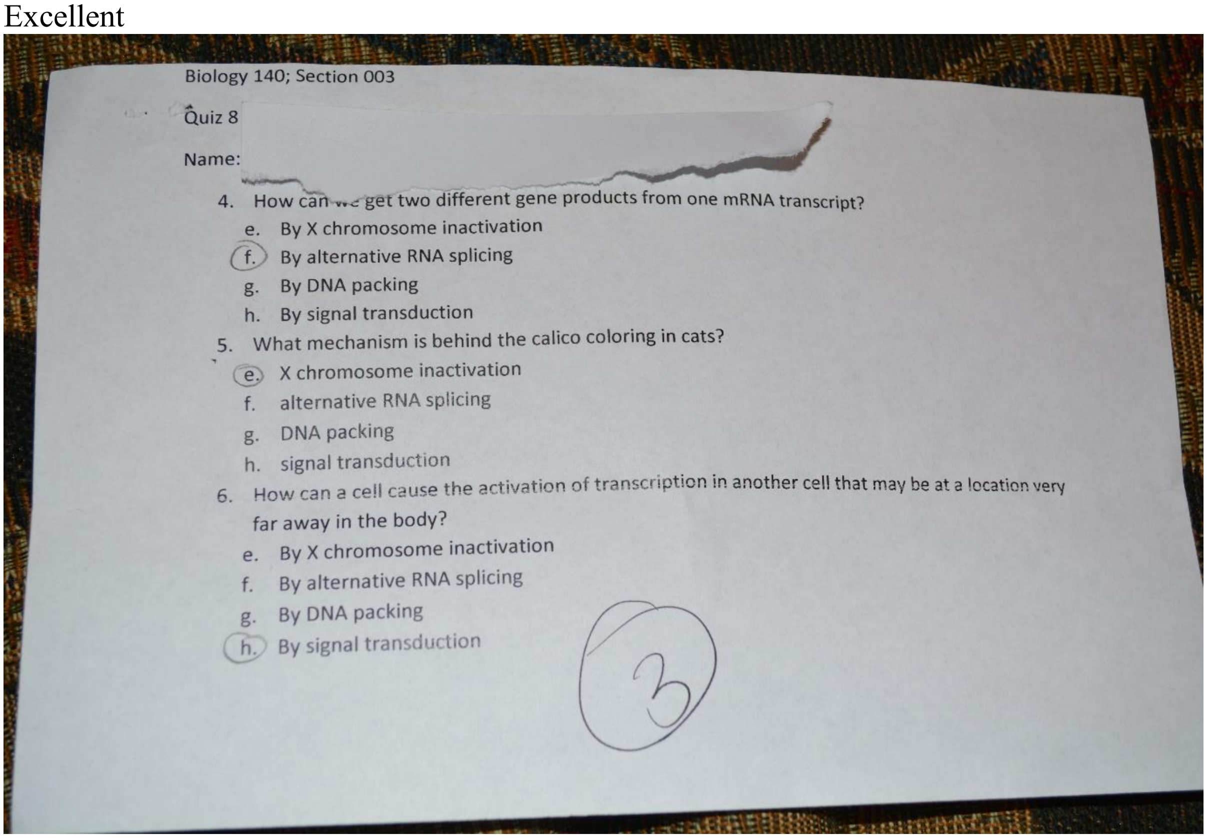
Quiz 10

Name:

1. Animals that live in or on their food source are called
   a. suspension feeders
   b. substrate feeders
   c. fluid feeders
   d. bulk feeders
2. Which of the following is not released by the salivary glands?
   a. amylase to start starch digestion
   b. buffers to neutralize acid
   c. glycoprotein to moisturize and lubricate food
   d. nucleases to start digestion of nucleic acids
   e. antibacterial agents
3. What protective mechanisms keep the epithelial cells in the stomach from becoming damaged?
   a. Mucus from specialized epithelial cells coats the surface of the epithelial layer
   b. Pepsin is made and secreted in an inactive form (pepsinogen) so that it doesn't digest the cells that make it
   c. The epithelial cells of the stomach are constantly being replaced by new cells so that any cells that do get damaged are quickly replaced
   d. All of the above

2

Excellent



Biology 140; Section 003

Quiz 8

Name:

4. How can we get two different gene products from one mRNA transcript?
   e. By X chromosome inactivation
   f. By alternative RNA splicing
   g. By DNA packing
   h. By signal transduction
5. What mechanism is behind the calico coloring in cats?
   e. X chromosome inactivation
   f. alternative RNA splicing
   g. DNA packing
   h. signal transduction
6. How can a cell cause the activation of transcription in another cell that may be at a location very far away in the body?
   e. By X chromosome inactivation
   f. By alternative RNA splicing
   g. By DNA packing
   h. By signal transduction

3

APPENDIX L

GREATER THAN 64% PARTICIPATION / 7 ASSIGNMENTS COMPLETED FOR WEEKLY ASSIGNMENTS

Biology 140 Section 003—Control Group

Anonymity Code	Participation Status
00301	P
00302	P
00303	P
00305	P
00311	P
00312	P
00315	P
00318	P
00319	P
00323	P
00324	P
00325	P
00327	P
00328	P
00329	P
00330	P
00331	P
00332	P
00333	P
00335	P
00336	P
00337	P
00341	P
00342	P
00343	P
00345	P
00349	P
00350	P
00351	P
00352	P
00353	P
00357	P
00358	P
00359	P
00364	P
00366	P
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00368	P
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00371	P

Biology 140 Section 004—Illustration Group

Anonymity Code	Participation Status
00401	P
00402	P
00403	P
00404	P
00405	P
00406	P
00408	P
00410	P
00412	P
00413	P
00414	P
00415	P
00416	P
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00435	P
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00440	P
00442	P
00443	P
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00445	P
00446	P
00447	P
00449	P
00450	P
00451	P

Biology 140 Section 005—Description Group

Anonymity Code	Participation Status
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00505	P
00506	P
00507	P
00512	P
00514	P
00515	P
00517	P
00519	P
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00522	P
00523	P
00526	P
00528	P
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00531	P
00532	P
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00534	P
00536	P
00537	P
00539	P
00540	P
00541	P
00542	P
00543	P
00544	P
00547	P
00548	P
00551	P
00552	P
00553	P
00556	P

APPENDIX M

COURSE EVALUATION TEMPLATE

Standard Course Form for Department of Biological Sciences Instructors and Lecturers
Dr. Barbara McCracken
Biol 140 Sections 003, 004, 005 [redacted]

Please evaluate the course and your instructor for the following questions. Record your answers on a scantron sheet using the following scale:
1 (A) poor
2 (B) below average
3 (C) satisfactory
4 (D) above average
5 (E) excellent
(If you are not able to evaluate a specific aspect of the course/instructor, or if you feel the question does not apply, leave that question blank.)

Section 1: Instructor and Course: Please rate your instructor and the course using the 1-5 (A-E) scale presented above for the following:

1. The course requirements were clearly communicated in the syllabus.□
2. The instructor was available to help students outside of class.
3. The instructor provided timely feedback on student work (exams, assignments, creative activities, etc.).
4. The instructor provided useful feedback on student work (exams, assignments, creative activities, etc.).
5. The class was well-organized.
6. The instructor was prepared for class.
7. The instructor was responsive to student questions.
8. The instructor explained difficult material clearly.
9. The instructor used teaching strategies that enhanced my understanding of course content.
10. The activities/assignments were useful in helping me learn.□
11. Overall, the instruction in this course enhanced my learning of the course content.

Section 2: Learning Objectives: Please indicate how well you think the following course objectives were met during this course.

12. For students to gain knowledge and understanding of human biology with respect to:
    a. Biological molecules that dictate life at the cellular level
    b. Cellular classification, structure and function
    c. Genetics and the transmission of molecular information
    d. Evolution and the natural history of mankind
    e. The form (anatomy) and function (physiology) of the organ systems of the body
13. To introduce students to critical thinking skills in applying biological information in real-life situations
14. To increase knowledge of the scientific method as a process for improving our understanding of the natural world and how it functions

Standard Course Form for Department of Biological Sciences Instructors and Lecturers
Dr. Barbara McCracken
Biol 140 Sections 003, 004, 005
Section 3: Additional questions

Please evaluate the course and your instructor with regard to the following questions by writing in the space provided.

1) What did you like the best about this course, given the subject?

2) What strengths do you feel the instructor has for teaching this course?

3) What did you like the least about this course, given the subject? What advice could you give for improving the course in the future?

4) What suggestions could you give the instructor for improving his or her teaching of the course in the future?

5) Please add any additional comments or suggestions: