

THE EFFECTS OF DIFFERENT PODCASTING  
STRATEGIES ON STUDENT ACHIEVEMENT  
IN A LARGE, COLLEGE LEVEL INQUIRY  
BIOLOGY COURSE

By

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Dedicated to the memory of  
Thelia Shaw  
1943-2005

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## CHAPTER I

### INTRODUCTION

#### **M-learning and today's student**

Contrary to the thinking underlying the teaching strategies of many college instructors, learning is not restricted to the classroom, it can occur anywhere and at anytime. Unfortunately, if students are not receptive to learning during the designated lecture, learning in the classroom may not take place. Today's college students have grown up with technology playing a central role in their lives inside and outside the classroom. Faculty, wishing to appeal to their students' digital lifestyle, have incorporated the latest educational technologies into their curriculum, and thus the electronic landscape of today's university is constantly changing as the latest technology is adapted for educational uses.

One of the latest developments in educational technology is mobile learning, or m-learning. M-learning refers not only to the mobility of the learner, but to the mobility of the information as well. Course content can be accessed anytime and anyplace thanks to a student's mobile computing device and an internet connection to access course content. These devices include portable computers, media players like Apple's iPod™, and most recently, smartphones. There are several m-learning strategies, all with the



same goal; to allow students access to course material anytime, anywhere. At this time, podcasting is the m-learning strategy that has been most widely implemented at universities around the globe because it epitomizes the “anytime, anywhere” nature of m-learning due to the portability and popularity of media players.

Unfortunately, research into the efficacy of podcasting has not kept up with its increasing use on college campuses. While initial research papers focused on student impressions of podcasts and effects of podcasts on class attendance, few studies connected research in cognition with strategies for proper podcast use and development (Deal 2007). As the following review of current literature will show, podcasting has the potential to be a very effective learning tool if used appropriately by faculty and students. However, using podcasts to review a science lecture while at the gym, or other similar venue, which is touted as a benefit of m-learning may not constitute “appropriate” use.

Without connecting cognitive research and analysis of student podcast use, educators cannot adequately answer the question “Is podcasting an effective instructional tool?” To address that question, this study asked several other questions including: Who uses podcasts and when are they used? How are students using podcasts? Are certain podcast types more effective than others? Does podcast use result in increased learning as evidenced by increased test scores?

### **What is podcasting?**

A podcast is a digital recording of an audio broadcast made available on the Internet so that it can be downloaded onto any personal media player or other media playing device. The term podcast developed from the combination of the words *iPod* and

*broadcast* (Farkas 2006). The production of podcasts, or *podcasting*, has gained in popularity because it allows users to decide when and where they listen to the broadcast (Bashford 2006). Podcasting has proven to be a very effective way of distributing news, music, and more recently video content, in what are called vodcasts (VOD stands for video-on-demand). The advantage to podcasting is that it is inexpensive, easy to use, and allows the listener to time-shift access to desired content (Meng 2005). Unlike streaming media, podcasting does not require the recipient to remain connected to the Internet or sit in front of a computer while receiving information, making it ideal for m-learning. The user simply subscribes to the podcast once, and as new podcast episodes become available, they are automatically downloaded or “pushed” to the subscribers computer and onto their media player. A main benefit of this “push” format is that it increases the likelihood that students will use the podcasts often because they do not need to repeatedly check whether new files are available for download from the Web site (Brittain, Glowacki et al. 2006). Once the podcast is on the user’s media player, it can be accessed whenever the user wishes. When courses provide podcasts, students can listen to assignments before class or review a lecture at a time and place of their choosing.

### **Podcasts on campus**

Recording a lecture for podcasting can be very simple. Typically, the instructor speaks into a microphone connected to a digital recording device while presenting a lecture normally. The recording of the lecture is then uploaded to a website where students can download the new podcast (Read 2005b). Currently several software programs are available that automatically record and encode files for podcasting for posting online. Podcasting has proved very popular among students at Purdue

University, which in 2005 already had a library of podcasts from more than 60 courses. Previously, the university library kept cassette tapes from 90 courses that students could check out; however, students rarely did so (Read 2005a). Once recordings of individual lectures were available to download, more than 10,000 recordings of lectures were downloaded during the first semester (Ferguson 2005). Recently, Purdue has expanded on the success of its audio-only podcasts and installed a campus-wide automated lecture capture system in 70 of its classrooms with the potential to podcast hundreds of different courses by making them available as podcasts on iTunesU, a website maintained by Apple (Young 2007). Lecture capture software goes one step beyond audio-only podcasts by combining into a single podcast images from the presenter's slides and audio recorded during the presentation.

Many large universities have been experimenting with integrating podcasts into campus-wide curriculum; Duke even distributed iPods to over 1600 incoming freshmen in 2004 to encourage novel uses of technology in education and campus life (Duke Center for Instructional Technology 2005; Deal 2007). Most courses using podcasts were in the humanities and were predominantly music and language courses. Benefits of podcast use were identified by surveys and focus groups and included convenience of use and creation of podcasts, the ability to listen anywhere, greater student engagement in class discussions, and enhanced individual learning preferences (Duke Center for Instructional Technology 2005). Students remarked that they enjoyed using podcasts because it allowed them to "listen to difficult portions [of lecture] several times" and to "pause the lecture in order to write down more detailed notes." Having the ability to listen to lectures, conversations, and performances outside of class, reportedly increased

student interactions during the class period. However, some students and faculty expressed concern that having lectures available online would encourage students to sleep through class or send the message that paying attention is not important (Duke Center for Instructional Technology 2005).

### **Criticisms of podcasting**

While music and language classes incorporated the iPod for listening assignments, many other courses at Duke University offered podcasts that were recordings of a professor's lecture. In 1981, Stencil outlined how to make use of the then new "portable" technology of cassette tapes for recording lectures and distributing information to Walkman-wearing students. With this in mind, today's enthusiasm for podcasting feels like *de ja vu* as surveys of university podcast websites indicate instructors are using podcasts as nothing more than a high-tech replacement for a tape recorder (Stencil 1981; Ferguson 2005; Read 2005a; Read 2005b; Young 2005; Knight 2006). The majority of the podcasts currently available to students are simply audio recordings of the professor's lecture; however, this doesn't seem to dampen student enthusiasm for the new technology (Read 2005).

In 2002, Barrett provided students in a cardiology course with CDs containing several recordings of heart murmurs supplemented with clinically relevant commentary. Without the need for human subjects, students could repeatedly study cardiac auscultations on their own, dramatically increasing the number of successful diagnoses (Barrett, Lacey et al. 2004). The opportunity for students to replay the material was useful, and in 2006 Barrett made the same material available as an electronic file that

students could download to an iPod (Barrett, Kuzma et al. 2006). Soon, articles in the popular press appeared with titles like, “Having Heart Surgery? Make Sure Your Doctor Has an iPod”, “iPods Are Good for Your Heart” and “Paging Dr. iPod” (Evans 2007; Gitlin 2007; Weirick 2007). While this certainly seems like a more appropriate use for podcasting technology than recorded lectures, the fact that the same level of success was obtained years earlier using CDs was completely ignored by the media. In fact, it may be enthusiasm for the latest technology that is driving the entire m-learning phenomenon, instead of any measurable pedagogical benefits. Unfortunately, many educators adopt the technology first, and then strive to find an appropriate application for it. This type of development results in ambiguous learning outcomes, which is why controlled research in this area is important.

Critics of podcasting assert that student attendance at lectures will decline if podcasts of the lecture are made available to students (Ferguson 2005). Listening to a podcast could help students take more detailed notes, but hearing the lecture in the same manner repeatedly may not improve conceptualization and critical thinking. Officials from Duke expressed surprise at the results from their study, which found that the campus-wide podcasts had more influence on public perception of the university than on improvement of student learning (Duke Center for Instructional Technology 2005). This study aims to determine if meaningful learning can occur by using podcasts as a study aid for students enrolled in an introductory biology course. More specifically, I tested if different podcast designs, based on current psychological and pedagogical research, can increase student understanding of biological concepts as reflected in student exam scores. I also assessed student use of, and attitudes towards podcasting and podcast use through

the use of a survey.

## CHAPTER II

### REVIEW OF LITERATURE

#### **The potential of podcasting**

Podcasts have the potential to help students learn because podcast technology allows user control of the pace and the frequency at which they encounter information. The flow of new information from a lecture can often be overwhelming to learners, especially when images, written and spoken words are all used simultaneously (Sweller, Merrienboer et al. 1998). This combination can result in extraneous cognitive load thus overloading the learner's working memory, which contributes to student misconceptions (Paas, Renkl et al. 2003; Tabbers, Martens et al. 2004). The development of cognitive load theory encouraged the presentation of information in a way to reduce strain on working memory and increase intellectual performance (Sweller, Merrienboer et al. 1998). Allowing learners simply to pause incoming information gives them a chance to process and integrate new information with existing ideas. This simple user interaction has been shown to reduce the learner's cognitive load thereby enabling them to progressively build a coherent mental model of the concept being covered (Mayer and Chandler 2001).

Meaningful learning is most likely to occur when the cognitive load in working memory is reduced. Working memory, formerly called "short-term memory," consists of

two systems that organize and integrate visual and auditory information for storage into long-term memory (Baddeley 1992). Our knowledge level, or what makes us “experts” at something, can be attributed to our long-term memory stores and how well that information is organized into schemas. Stored as single entities in long-term memory, schemas are formulas or structures that organize information and reduce working memory load. For example, when you go out to eat you access your “restaurant” schema. You know that you should wait to be seated and that a waiter will take your order and bring your food. There are certain behaviors required of you; you pay for the food and leave a tip. This example is one high-level schema that is made of much smaller schemas. If sometime later you were to take a wine tasting class, your “wine” schema would be integrated with the “restaurant” schema, and together they would function as one schema. As long as information is organized into one schema, it can be as large and complex as needed but still easy for the brain to access and modify. According to schema theory, building increased numbers of complex schemas by combining elements of many low-level schemas with those of high-level schemas allows one to develop true understanding (Sweller, Merrienboer et al. 1998; Paas, Renkl et al. 2003; Paas, Tuovinen et al. 2005). However, an instructor’s lesson can end up creating many small low-level schemas that students cannot combine into one high-level schema, thus true understanding of a subject never occurs.

### **Spacing effect contributes to reflective learning**

Because the file format used in podcasting is downloaded to the user’s computer, users can access information from the same podcast multiple times. This could



contribute to a spacing effect, where increased learning occurs when repeated information is spaced out over a relatively longer time, versus studying the information in a single massed presentation (Dempster 1988; Challis 1993). Many podcast users will have already received information firsthand during the course lecture, and using the podcast will provide them with a second or third opportunity to study it again thus contributing to the spacing effect.

Among the traits that expert learners possess is the ability to reflect on what they have just learned. Reflection has been shown to increase a student's ability to observe, critically analyze, interpret and discuss ideas (Costa 2008; Veal, Taylor et al. 2009). Jeong and Lee (2008) found that students who had the opportunity to reflect on information from class produced 44% more responses during class discussions than non-reflective students. Podcasts provide an opportunity to pause the flow of information thus encouraging and enhancing reflection among users (Baird and Fisher 2006). Unfortunately, few students recognize the benefits of reflecting, and most podcasts of lecture are an extension of the traditional didactic model of education where reflection is not encouraged (Lowe, Rappolt et al. 2007; Jeong and Lee 2008). Students report higher levels of reflective thinking if opportunities for this purpose are built into the curriculum (Lowe, Rappolt et al. 2007; Veal, Taylor et al. 2009).

### **Shorter podcasts reduce cognitive load**

The majority of course podcasts offered by universities are recordings of lectures lasting 50 minutes or more. While being able to pause, advance, and review a long lecture podcast should benefit learners, cognitive load theory suggests there should be greater benefit if the learner has this same control over shorter lecture segments that the

learner already knows contain the desired information (Mayer, Moreno et al. 1999; Paas, Renkl et al. 2003). Long lecture podcasts can be segmented into multiple recordings organized by specific topics, each segment lasting from 5 to 15 minutes. Doing so should allow listeners to use their time more efficiently by focusing on the specific topic about which they are interested in learning more. Additionally, a lecture divided and organized in this way provides the listener with an opportunity to stop between segments and reflect on what they have learned, thereby enabling the listener to integrate new information with prior knowledge and progressively build a correct mental model of the concept being covered (Mayer and Chandler 2001).

Two conditions must be met for meaningful learning to occur. First, learners must engage in selecting the relevant information that addresses their needs. Second, learners must activate relevant prior knowledge and integrate new content to construct a new cohesive schema (Moreno and Mayer 2005). These criteria can be met with a recording of a lecture that has been divided into segments with useful and relevant titles. By selecting the relevantly titled segment to listen to, the learner can easily recognize that the segment contains desired information and can then determine with which mental schema the new information should be integrated. This should free up working memory to concentrate more on understanding and integrating the new content into existing mental schemas (Sweller, Merrienboer et al. 1998; Moreno and Mayer 2005).

A student's working memory can overload if it is required to keep track of large amounts of new information that don't seem to fit into existing schemas (Paas, Tuovinen et al. 2005). Providing students with a podcast that is short and to the point should reduce this load on working memory, making it easier to transfer that information to long

term memory (Baddeley 1992). Being able to listen to shorter segment podcasts in a non-linear fashion should increase the listeners' retention of information (Tabbers, Martens et al. 2004). Listeners who experience less cognitive load will be better able to mentally organize information and relate it to prior knowledge thus contributing to fewer misconceptions. Typically, podcasts are available to students after a lecture has taken place, thus the main role of this type of podcast is for review purposes. Having a podcast comprised of shorter segments of the lecture would aid in reviewing and increase the usability and attractiveness of podcasts to students (Nataatmadja and Dyson 2008). Frydenberg (2006) found that by mid-semester some students stopped using the podcasts of his lecture; students felt the 60-minute length of the podcasts was too long to be useful for reviewing course material. After segmenting the podcasts into portions 6-10 minutes in length, student use of podcasts increased. Frydenberg turned the task of producing shorter podcasts over to students, who edited them to contain only the information that would be relevant and helpful.

### **Social learning and conversational podcasts**

A different type of podcast, conversational, may also increase student understanding. Conversational podcasts are recordings of a group of three to four students discussing biological concepts in a personal manner so that the listeners feel as if they are part of the dialogue, or that the dialogue is directed to them. Studies indicate that by simply directing information to users in a personal manner increases learner interest. For example, changing the word "the" to "your" in a description of how lungs work encourages active cognitive processing of the information during learning and results in long-term conceptual understanding (Mayer, Fennell et al. 2004; Moreno and

Mayer 2004)

Few studies have examined the effect of listening to a podcast produced in a conversational manner. Dlott (2007) worked with other faculty to produce entertaining and informative podcasts for students enrolled in a history course. However, these podcasts were produced as examples for students to follow when they developed podcasts for their peers as part of an assignment. Similarly, Duke University (2005) found that the podcasting technology was uniquely suited for this type of assessment. Several faculty encouraged students to produce their own podcasts in lieu of papers or class presentations. Assessing students through this type of podcast allows instructors to measure critical thinking, analysis and synthesis of new ideas of the student producers easily (Duke Center for Instructional Technology 2005; Dlott 2007). Currently at Clemson University students are developing podcasts for the general public that cover the topic of evolution and creationism. These podcasts are all produced in a conversational manner in the hope that this will make the content of the podcast more engaging and relatable to the listener, who may have little to no background in the biological sciences (Waldvogel and Smith 2009).

### **Social agency theory**

According to the social agency theory (Mayer, Sobko et al. 2003), if the learner feels as if they are involved in a conversation, their brain's social conversation schema becomes activated. During a conversation, working memory keeps track of the facial expression, body language, tone of voice, and vocabulary of the speaker, while at the same time forming possible responses (Lieberman and Rosenthal 2001). Even when

podcasts are audio only, studies suggest that listening to a conversation is enough to activate the social conversation schema. Students may even pay closer attention to what is being said by whom because the information is received by the auditory channel only (Graesser and Bowers 1999; Mayer and Moreno 2003). When this schema is activated, the rules of conversation come into play. Learners work harder to make sense of what is being said because they may feel as if the speaker is trying to communicate with them and the learners may be called on to participate in the conversation (Mayer, Sobko et al. 2003; Mayer, Fennell et al. 2004) Hearing speakers converse in first person instead of third person can increase the salience of what is being said by the speaker (Graesser and Bowers 1999). Deep cognitive processing is more likely to occur when the listener feels as if the speaker is trying to communicate with them, instead of just delivering information (Mayer 2001).

### **Study objectives**

For all the attention that m-learning, and more specifically podcasts, has received from faculty, students, and the media, questions remain with regard to the actual benefits to learning from podcast use. While a great deal of cognitive research supports the use of podcasting as a pedagogical tool, students and faculty must understand how to use this tool for it to be effective. When surveyed, students regularly report feeling that podcasts have a positive effect on their class performance, regardless of their self-efficacy with respect to technology (Hodges, Stackpole-Hodges et al. 2008).

The objective of this study was to measure student use of, and attitudes toward podcasts to determine if podcast use has any effect on student scores over the course of a

semester. While previous studies may have had small sample sizes, lacked control groups for comparison, or only collected qualitative data, this was a quantitative, controlled study performed under naturalistic conditions with a large enrollment biology course. Course resources such as texts and online practice exams were available to both the control and treatment groups to determine how students used podcasts when studying. Similarly, students were not given specific instructions regarding how often or when to use podcasts. Students were only surveyed at the end of the course to avoid any unintentional influence on their use of podcasts. The exam scores of students who used podcasts were compared to the scores of concurrently enrolled students who do not use them. Additionally, comparisons were made among the scores of students using the four available podcasting strategies of video, complete audio, segmented audio, and conversational.

Students who use podcasts have been found to review lecture material more often than non-users (McKinney, Dyck et al. 2009). This led me to expect that podcast users would have higher exam scores than non-users and that students who used podcasting strategies that encouraged reviewing, such as the segmented and conversational podcasts, would have higher scores than those students who used video or complete audio podcasts. Because many students feel comfortable using podcasts, I expected to see a large number of students subscribe to podcasts. During a pilot survey of Biology 1114 students, I collected similar data to the pre-course survey given by Hollandsworth (2007), who reported an estimated 80% of students would subscribe to podcasts if they were made available. Determining whether or not this positive attitude would actually translate to increased learning measured by higher exam scores was an objective of this study.

## **Broader impact**

Podcasting is gaining in popularity among university students and faculty as a simple, popular way to distribute and receive information from class lectures. Nationwide, campuses are spending millions of dollars on equipment and staff for podcast production in a search for an ideal method of reaching today's student. Despite podcasting's growing popularity, studies relating student class performance and podcast use are rare. This leaves many wondering if podcasts are worth the effort and expense. To date, studies on the efficacy of podcasting in science courses have focused mainly on the uses and perceived usefulness of the podcasts by students in upper division or professional level courses (Fose and Mehl 2007). The present study was the first controlled study to utilize naturalistic conditions to compare students' podcast use with exam responses, as well as assessing podcast use habits among students in a first year science course.

## CHAPTER III

### METHODOLOGY

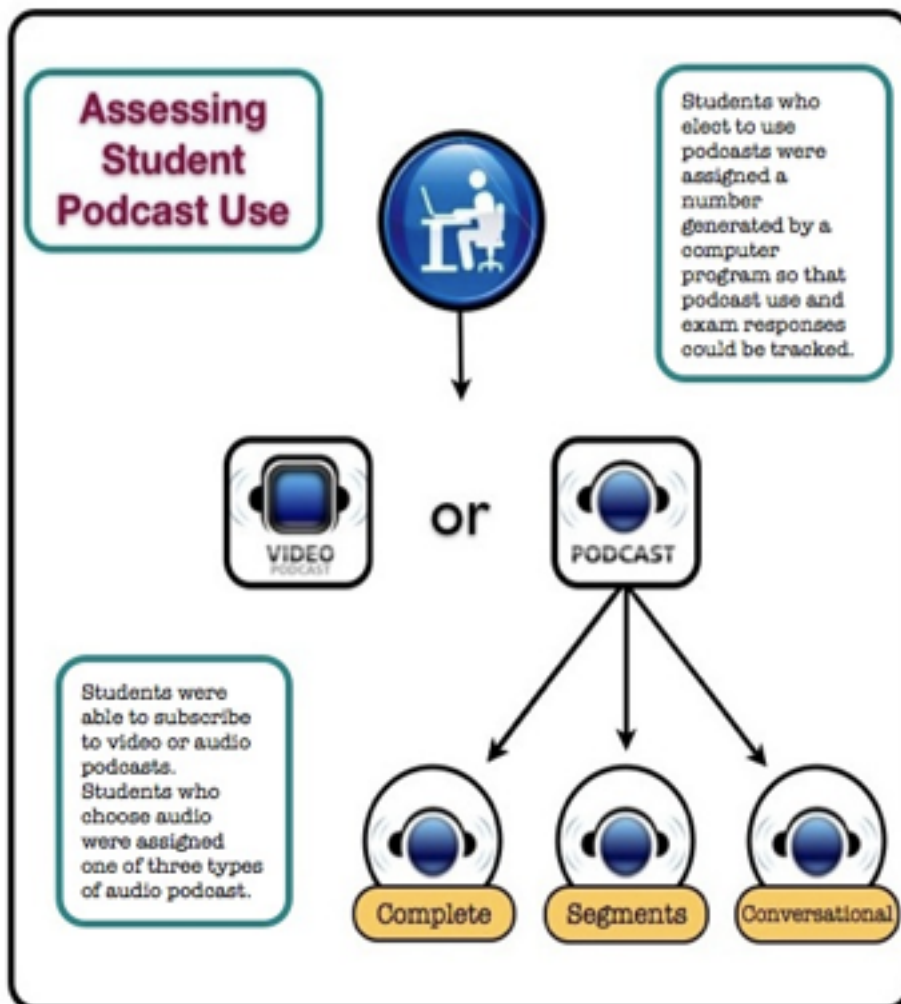
To determine the efficacy of podcasting with respect to student understanding and conceptualization, student responses to exam questions were evaluated by utilizing a mixed-design study. This study used a pretest-posttest design, with a within-groups and between-groups comparison (Mitchell and Jolley 2007). Based on data collected during a pilot study, I found that not all students subscribe to podcasts and that it was possible for a small percentage of students to subscribe to podcasts, but use them infrequently. A end of semester survey was used to determine how often students used the podcasts.

#### **The Podcast Tracking Program**

To track student podcast use and compare it with exam responses, students were required to log in to the course website with their user IDs to subscribe to podcasts. Each student was assigned a podcast subscription and a unique code number generated by the Podcast Tracking Program (PTP). A computer programmer, who had no relation to this study, developed the system to track this. Although students logged into the system using their user ID, the PTP recorded and tracked data by the assigned code number only. Pilot studies indicated that a large percentage of students used portable media players that played audio files, while a smaller percentage of students reported owning portable



devices that also played video. Students had the opportunity to choose between video or audio podcast formats to best match their portable device and preference. Students who selected audio podcasts were randomly assigned one of three types of audio podcasts; complete, segmented, or conversational. The PTP associated the assigned code number with the user ID allowing student podcast choice, exam score and survey responses to be compared without revealing the identity of the students. Figure 1 summarizes the subject selection process.



**Figure 1.** Graphical depiction of study design.

## **Treatments**

Four types of podcasts were available to all Biology 1114 students; podcasts or vodcasts that were complete recordings of class lectures, podcasts that were 5-15 minute segments of lecture titled and organized by topic, and lighthearted but informative conversational podcasts. The latter were conversations between a male and female student that included lecture topics, student questions, and study tips.

Students enrolled in Biology 1114 could subscribe to only one of the podcasts described above. While there were three separate types of audio podcast, only one type of video podcast was available. Our pilot studies had shown that students who used the video format podcasts reported little trouble finding specific information within the podcast, as they used visual cues from the video to quickly find the segment of lecture that contained desired information. However, students in the pilot studies who used audio podcasts did report having trouble locating specific information within the lecture podcasts, which prompted the development of segmented audio recordings.

Conversational podcasts were offered in an audio-only format. To achieve the production values necessary to make a video version of the conversational podcasts that would appear professional and engage students, a camera operator, producer and actors would need to be hired, in addition to the need for a dedicated set and equipment. Since the trend in podcasting formats is decidedly audio-biased, it was decided that a video production of this magnitude was outside the scope of this project.

A goal of the project was to make the podcasts available to students as soon after class as possible. Lecture audio was recorded directly from the instructors' microphone onto a 60 GB Apple iPod™ and edited using Garage Band® on a Macintosh™ computer.

This allowed the investigator to begin editing the lecture audio as soon as class ended and provide it to students within two hours from the end of class. The video footage of lecture was recorded separately by the university's Institute for Teaching and Learning Excellence (ITLE) to achieve the highest quality possible. While filming the class, the camera operator made an effort to pan across the projector screen as well as occasionally zoom in on the instructor, which created a visual experience similar to what one would see if seated in the lecture hall. However, involving the ITLE had the unintended consequence of delaying the time it took to post video podcasts by several hours. Because video files were not edited in the same way as audio files, the video podcasts were distributed by the end of the workday in most cases.

### **Assessments and surveys**

Summative assessments in Biology 1114 consisted of cumulative multiple-choice exams four times a semester. On each exam, students read descriptions of novel scenarios and applied knowledge to answer the questions that followed. This type of questioning reduces a reliance on rote memorization and rewards critical analysis and application of concepts taught in the course. Appendix A contains a list of all questions asked on exams used for this study.

I compared students' scores on exams to those on previous exams, and to responses from students from other treatments. Information regarding student study habits and attitudes towards the usefulness of podcasts was collected via a survey made available through the Podcast Tracking Program at the end of the semester (see Appendix B). This survey was linked to other student data through each student's code

number, allowing comparisons to the student's exam responses.

### Experimental Design

The subjects for the treatment group were self-selecting. Students that would typically spend the time to seek out and subscribe to podcasts could be students who were more motivated to study. To control for any bias that might exist between group selection and motivation to study, I used multiple assessments. For the first exam, students did not have access to any type of podcasts. The responses to questions on this exam were used to establish a baseline response of all students for comparison. If the students who went on to use podcasts were initially more prepared, motivated, or possessed better study habits than their non-podcast using peers, there should have been a difference between the exam scores for these two groups on the first exam.



**Figure 2.** The availability of podcasts for each in-class exam. No podcasts are available during the first exam to control for bias in student achievement.

All types of podcasts were made available to students immediately after the first exam so that there was ample time for students to utilize podcasts before taking subsequent exams. Figure 2 illustrates the design timeline. To determine if any effect on student score occurred as a result of podcasting, a percent gain score was calculated using

scores from exam 1 and exam 4. Percent gain scores have the advantage that they correlate highly with post-test scores, and allow accurate comparisons between students who have initial high scores and those that have initial low scores (Rathvon 2008). Exam 4 was selected for comparison because it contained questions from all topic areas covered by the course and podcasts and allowed the maximum sample size of podcast users. If podcasts were used effectively, the percent correct on Exam 4 should be higher than the percent correct on exam 1, which was given before podcasts were available. As part of the normal course protocols, the treatment and control groups were assessed with exams 2 and 3 in addition to exams 1 and 4. Any temporal or course-related effect would have been present in both groups, eliminating it as a variable in comparisons.

The percentages scored on exam 1 (E1) and exam 4 (E4) were used to calculate the percent gain (PG). When the score on E4 was higher than the score on E1, resulting in a positive score, the  $PG = [(E4-E1)/R_p] * 100$  where  $R_p$  is the highest possible percentage available (100%) minus the percentage from E1. In cases where the E4 score was lower than the E1 score, resulting in a negative score, the  $PG = [(E4-E1)/R_n] * 100$  where  $R_n$  is the E1 score minus the lowest possible score (0%) (Rathvon 2008). The calculation for PG takes into account the fact that higher scores on E1 resulted in a narrower range for improved change. A student who received a 90% on E1 had a range of 10% for improvement. If this student earned a score of 95% on E4 it would result in a PG of 50 since this student increased their score by 50% of the remaining 10%. Similarly, a student who scored a 70% on E1 and a 76% on E4 would have a PG of 20 because they increased their score by 20% of the remaining 30% that was available for improvement.

This study collected data over two semesters, which could affect the outcome of

the podcast treatment. I performed a two-way ANOVA with semester as a random effect and podcast type as a fixed effect to determine if any interactions existed between the semesters in which data were collected and the treatment. If no interactions were identified, data from both semesters can be combined when used for the planned comparisons. This design allowed comparisons to be made between the exam scores of podcast using and non-using groups, as well as comparisons within the group of podcast users. Two types of comparisons were used to produce confidence intervals; Dunnett's procedure and Tukey's procedure. Dunnett's procedure is best suited for comparing multiple treatment groups against a control, while Tukey's procedure is useful for comparing multiple treatment groups against each other (Hsu, 1996).

### **Questions examined**

The primary interest of this study was to determine if students who used podcasts earned higher scores on exams than students who chose not to use podcasts. This was assessed by testing the following statistical hypotheses:

#### **Test 1:**

$H_1$ : Students who use any podcasts will earn higher percent gain scores than students who do not use podcasts.

$H_0$ : There will be no difference between percent gain scores of either group of students.

For this test, a Multiple Comparisons with a Control, or Dunnett's analysis was used to compare the following groupings:

- Control group vs. Video podcast group
- Control group vs. Complete Audio podcast group
- Control group vs. Segmented Audio podcast group
- Control group vs. Conversational podcast group

While all podcasts contained the same information, the format in which it was presented may have impacted how students used podcasts, thus influencing their percent gain scores. Thus I attempted to answer the question “Will students who used one type of podcast format perform better than students using another?” as follows:

**Test 2:**

H<sub>1</sub>: Students who use certain podcast formats will earn higher percent gain scores on exam questions than students using other types of podcasts.

H<sub>0</sub>: There will be no difference between student percent gain scores regardless of podcast type.

For this test Tukey’s procedure was used to compare all podcast formats against each other. The following comparisons were made:

- Video podcasts vs. Complete Audio podcasts
- Video podcasts vs. Segmented Audio podcasts
- Video podcasts vs. Conversational podcasts
- Complete Audio podcasts vs. Segmented Audio podcasts
- Complete Audio podcasts vs. Conversational podcasts
- Segmented Audio podcasts vs. Conversational podcasts

The Dunnett and Tukey procedures produced confidence intervals for the previously mentioned comparisons. Confidence intervals with limits outside the value of 0 were interpreted as significant differences (Hsu 1996). However, with a study of this scope it was recognized that a podcasting effect could be obscured by unknown factors. Therefore, upper or lower confidence limits within  $\pm 5.0$  of 0 were considered indicative of podcasting having an effect on student achievement after all, one which might have been detected if the control and treatment populations were similar in size, if student podcast use were closely regulated, or if the amounts of time between exams were not as great; conditions which were not possible under the naturalistic conditions of this study.

This study also examined student attitude toward podcasts and their use. Questions

were developed through pilot studies, and were designed to assess study habits, frequency of podcast use, and perceived benefits of podcast type. Students who did not use podcasts were also asked about study habits and the reason behind their decisions to not use podcasts. These data were assessed through the use of anonymous surveys made available through the PTP. The PTP kept track of which treatment students had received and linked these students to a survey specific for their treatment type. Surveys were available to students at the end of the semester, which gave students maximum time to utilize podcasts and form opinions. The questions asked in surveys can be seen in Appendix B.

### **Sample size estimates**

I predicted that the effects of podcasting on student responses would be modest because several factors played a role in the outcome of the study. Subjects' experience in previous science courses, inexperience using podcasts, the number of hours spent studying, and attending class could contribute to differences in student responses that may be falsely attributed to the effects of podcast use. Therefore a smaller effect size (ES) was used when the sample size required for a statistically valid study was considered. For the trial to have statistical power and reduce the chance of a Type I error where the null hypothesis is falsely rejected, an estimated ES of  $>.30$  was used with a Power of  $<.80$  at  $\alpha = .05$ . This *a-priori* estimate required a minimum sample size of about 175 to 200 subjects for both the treatment and control groups (Lipsey 1990; Soper 2007). Groups of this size were possible with this study because the total population included all students enrolled in the spring, plus those enrolled in the fall semesters of



Biology 1114, which typically has a mean size of 600 students each semester. The exam score variance from the previous spring semester of this course, and values from a Dunnett's table for multiple comparisons were used to calculate the confidence interval for differences between groups, and the desired treatment group sizes. A confidence interval of >10% difference on scores was desired and achieved with treatment groups similar in size to those described above.

## CHAPTER IV

### FINDINGS

#### Sample sizes

This study was performed during the spring and fall semesters of 2008. In the spring semester, 514 students completed the course, while 800 completed the course in the fall semester (See Table 1). Of those enrolled, 201 (39%) and 227 (28%) subscribed to podcasts in the spring and fall respectively. Most subscribed to video podcasts, while about 1/3 of students subscribed to various audio formats.

**Table 1.** The number of students who were enrolled at the conclusion of the course, and the number subscribed to podcasts by semester.

	<b>Total Enrollment</b>	<b>Non-users</b>	<b>Video</b>	<b>Full Audio</b>	<b>Segmented Audio</b>	<b>Conversation</b>
<b>Spring 08</b>	514	313	133	20	22	26
<b>Fall 08</b>	800	573	156	20	25	26

#### Statistical analysis of exam scores

To control for any possible differences in study habits or prior knowledge among the sample populations, I compared scores on Exam 1, which preceded any use of podcasts. An ANOVA analysis of Exam 1 scores indicated no significant pre-existing difference between the control and treatment populations,  $F_{(1, 1241)} = 0.23$   $p > 0.05$ .

Podcasts were made available to students immediately after Exam 1, so that scores on subsequent exams should show the effects, if any, of podcast use on exam scores when

compared against the control group of non-podcast using peers. Analysis of percent gain scores and survey responses for the 4 treatment groups and the control group were performed using SAS v9.

Student performance was evaluated by comparing percent gain scores as described in the Methods section against course semester and treatment type. The following ANOVA table (see Table 2) confirmed that there was no interaction between course semester and podcast treatment, while the variable of semester did have a significant effect ( $p < 0.05$ ) on student scores. Students in the fall semester scored significantly higher on exams than students enrolled in the spring semester.

**Table 2.** ANOVA analysis returned no significant interaction between factors.

Source	df	SSs	MS	F
<b>Semester (A)</b>	1	2531.653	2531.653	4.88
<b>Podcast Type (B)</b>	4	2282.610	570.652	1.16
<b>Interaction (A*B)</b>	4	1964.306	491.076	0.91
<b>Error</b>	1233	667886	541.675	
<b>Total</b>	1242	674664.569		

With no significant interaction effect found, both semester's percent gain scores were combined when analyzed by the planned Dunnett and Tukey comparisons. Rather than using an ANOVA to calculate an overall F statistic, the Dunnett and Tukey tests were selected *a priori* to calculate confidence intervals for only those comparisons of interest. This is beneficial because not only does performing an ANOVA first not guarantee the probability of an incorrect assertion to be less than alpha, it might guarantee this probability to be greater than alpha if multiple comparison results are only reported when the F statistic rejects the null hypothesis (Hsu 1996). It is possible that the ANOVA fails to reject the null hypothesis, but a planned comparison method, such as

the Dunnett or Tukey test, detects significant differences (Hsu 1996; Mitchell and Jolley 2007).

### **Results of hypothesis testing**

The following planned comparisons were performed to determine the extent of any effects on exam score due to podcasting.

#### **Test 1:**

H<sub>1</sub>: Students who used any podcasts earned higher percent gain scores than students who do not use podcasts.

H<sub>0</sub>: There was no difference between percent gain scores of either group of students.

For this test, a Multiple Comparisons with a Control, or Dunnett's procedure, was used to compare the following groupings:

- Control group vs. Video podcast group
- Control group vs. Complete Audio podcast group
- Control group vs. Segmented Audio podcast group
- Control group vs. Conversational podcast group

The confidence intervals returned by the Dunnett's procedure all encompass the value 0, which would indicate a 95% certainty that there was no difference between the percent gain scores of podcast users and the control resulting in a failure to reject the null hypothesis (See Appendix C, Table 2).

#### **Test 2:**

H<sub>1</sub>: Students who used certain podcast formats earned higher percent gain scores than students using other types of podcasts.

H<sub>0</sub>: There was no difference between student percent gain scores regardless of podcast type.

For this test, Tukey's procedure was used to compare all podcast formats against each other. The following comparisons were made:

- Video podcasts vs. Complete Audio podcasts
- Video podcasts vs. Segmented Audio podcasts

Video podcasts vs. Conversational podcasts  
Complete Audio podcasts vs. Segmented Audio podcasts  
Complete Audio podcasts vs. Conversational podcasts  
Segmented Audio podcasts vs. Conversational podcasts

Similar to the results from Test 1, the confidence intervals for the Tukey's procedure in Test 2 all encompass the value 0, which would indicate a 95% certainty that there is no difference between the percent gain scores of one group of podcast users and another, resulting in a failure to reject the null hypothesis (See Appx C, Table 3). Neither of the previous comparisons contain a upper or lower confidence limit within  $\pm 5.0$  of 0 to indicate a possible significant difference masked by factors discussed previously.

### **Analysis of survey results**

The Podcast Tracking Program (PTP) developed to number and track students anonymously was used to distribute and collect survey data regarding student perceptions and use of podcasting. A student first had to log in to the course website before taking the optional survey, which allowed their responses to the survey to be linked to their podcast subscription type as well as their exam scores via the PTP. Students who did not choose to subscribe to podcasts were also given an opportunity to respond to a survey. 237 students responded to the survey during the two trial semesters accounting for 18% of the total population. Almost 30% (127) of podcast users responded to the online survey while just 8% (110) of non-users responded (see Table 3).

**Table 3.** Number of responses for each type of podcast and control

	<b>Control</b>	<b>Video</b>	<b>Full Audio</b>	<b>Segmented Audio</b>	<b>Conversational</b>
<b># of respondents</b>	110	91	8	11	17
<b>% of group responding</b>	8%	31%	20%	23%	32%

I analyzed survey results across the treatment group surveys with a chi-square test to determine if any significant differences existed between responses. Only two questions were found to have significantly different responses between groups, the responses to those questions are reported separately in figures 3 and 4. Finding no other significant differences, I combined the remaining responses to simplify further analysis.

### **Survey results: Podcast use and study habits**

70% of the podcast-using respondents indicated that they were female, and the majority (62%) were science majors. Due to the subscription-based nature of podcasting, I had no way of directly assessing the extent to which podcasts were used by each student who subscribed to podcasts, or user. Instead, users were asked on the survey to indicate the percent of podcasts that they thought they used. Since users received all podcasts, they should have had an accurate idea as to how many podcasts were available throughout the semester, as well as the perceived percentage that they used. When it came to study habits and podcast use, 63% reported using less than half of the available podcasts during the semester, while 54% of users indicated that they waited until the day before the exam before studying (see Table 4). Half responded that they were reviewing or adding to class notes while using podcasts, and 73% of students felt that they were

studying while using podcasts. This survey found that only 25% of users indicated using podcasts on their portable media player with many (64%) opting to use their computer instead (see Table 5).

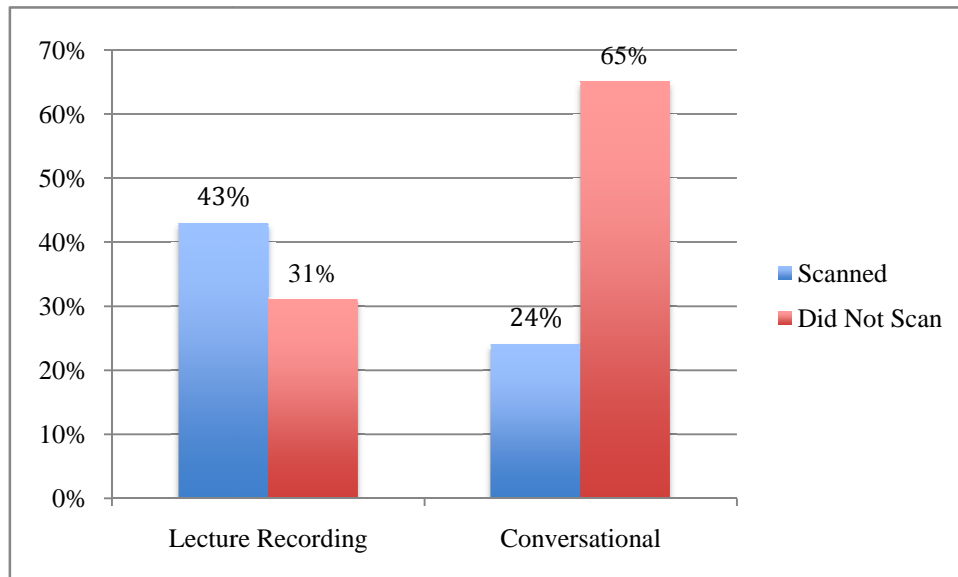
However, when these podcast using students begin to study, they are not necessarily using podcasts. Just 6% reported relying on podcasts most when they study, and all who responded this way were subscribed to the video podcast. The majority of podcast users (79%) relied on the online practice exams when preparing for class exams (see Table 4). Of those surveyed, 38% responded that podcasts did not fit with their study habits, leading to eventual disuse (see Table 5).

Each podcast episode was descriptively titled to aid students in selecting useful episodes. However, only 22% responded that they used only the podcasts that had titles perceived as containing useful information. There was concern that users may have trouble finding desired information within the podcasts, but only 31% responded that this was the case (see Table 5). While most responses were generalizable across all podcast types, users of the Conversational podcasts were significantly less likely to skip through the podcast in search of needed information than users of other podcast types,  $\chi^2_{(1, N=97)} = 5.18, p < 0.05$ . 65% of Conversational podcast users indicated that they did not skip through podcasts, compared to 31% of all other podcast users (see Table 6 and Figure 3).

**Table 4**  
**Survey Questions with Responses from Podcast Users**  
The number of responses are stated in parentheses

1. My gender is
  - a) Male **30% (38)**
  - b) Female **70% (88)**
  - c) Prefer not to say **0%**
  
2. My major is
  - a) Science oriented **62% (78)**
  - b) Non-science **33% (43)**
  - c) Undecided **5% (7)**
  
3. Which of the following **best describes** your regular study habits for Biology lecture?
  - a) Studying after or before every lecture **5% (7)**
  - b) Studying every week **34% (43)**
  - c) Studying only when the instructor tells me what to study **6% (8)**
  - d) Studying the day before an exam **55% (68)**
  
4. What resource do you rely on most when you study for Biology?
  - a) Text readings **4% (6)**
  - b) My notes from class **9% (11)**
  - c) Podcasts **6% (8)**
  - d) On-line practice exams **79% (99)**
  - e) Classmates or review sessions **2% (2)**
  
5. Which of the following **best describes** how often you used podcasts?
  - a) Listened to/watched all new podcasts as they became available **9% (11)**
  - b) Used the podcasts about once a week **10% (12)**
  - c) Used podcasts every time I studied **27% (34)**
  - d) Used multiple podcasts the day before an exam **54% (69)**
  
6. What percentage of Bio podcasts do you think you've used so far this semester?
  - a) 0-25% **35% (44)**
  - b) 25%-50% **28% (35)**
  - c) 50%-75% **18% (23)**
  - d) 75%-100% **15% (19)**
  - e) not sure **4% (5)**





**Figure 3.** Percentage of lecture and conversational podcast users who indicated if the user scanned for information or used the podcast without scanning.  $\chi^2_{(1, N=97)} = 5.18, p < 0.05$ . Users who did not indicate either choice were not included in the comparison.

### Survey results: Attitudes towards podcasts

Although student podcast use was lower than expected, student attitudes toward podcasts were generally positive (see Table 5). 68% of respondents found the podcasts to be a valuable resource for Biology, and 84% liked having podcasts available. However, when asked if they did better because of podcasts, 39% could neither agree nor disagree, while a slightly larger percentage (41%) felt that podcasts did contribute to their success in the course.

Given an opportunity to comment on their experience with podcasts, the number and attitude of the comments appeared influenced by the type of podcast that each student used. Students who used audio podcasts were less likely to offer comments, and those comments were mostly critical of the podcasts, such as “[The podcasts] were disorganized.” and “The gaps of silence made [podcasts] hard to follow.” Video podcast users on the other hand were more likely to offer positive comments with “[Podcasts]

were great for reviewing my notes.” and “[Podcasts] really helped me study!” as common responses. Surprisingly, there were students who had issue with the navigation of iTunes, and others who requested that the complete lecture podcasts be edited to remove student in-class discussions so that podcasts would contain only information “that would be helpful for the exam.”

While assessing student study habits and attitudes towards podcasts was the primary objective of this survey, students were also asked how they felt about the specific podcast type they had used. Almost half (47%) of the Conversational podcast users thought that they learned more by listening to their peers converse than by listening to a lecture, while only 14% disagreed. 45% of Segment podcast users indicated that they would have rather listened to hour long podcasts of lecture, while a similar percentage (46%) of Complete lecture podcast users indicated that they would rather have used Segment podcasts (see Table 7).

**Table 5.** Podcast user responses to survey questions. Values are Percent of respondents to select the response heading of each column. The actual number of responses is in parentheses.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
<b>I found the podcasts to be a valuable resource for this course.</b>	30% (37)	38% (48)	14% (18)	10% (13)	8% (9)
<b>I had trouble finding the information I needed in the podcast</b>	6% (7)	25% (31)	27% (34)	27% (33)	15% (20)
<b>I listened to podcasts on my portable mp3 player instead of on my computer</b>	18% (23)	7% (9)	11% (13)	14% (18)	50% (62)
<b>I liked having podcasts available for my use.</b>	60% (75)	24% (30)	6% (7)	5% (6)	6% (7)
<b>I did better in this class because I used podcasts.</b>	23% (29)	18% (22)	39% (49)	11% (14)	9% (11)
<b>I take additional notes, or follow along with my notebook when I use podcasts.</b>	20% (25)	30% (38)	26% (32)	14% (17)	10% (13)
<b>The podcasts didn't fit with my regular study habits so I quit using them.</b>	16% (19)	22% (28)	23% (29)	22% (28)	17% (21)
<b>I only used the podcasts that had titles describing the information I needed.</b>	11% (14)	11% (14)	24% (30)	24% (30)	30% (37)
<b>I feel that I am studying when I use podcats.</b>	35% (44)	38% (48)	7% (8)	12% (15)	8% (10)

**Table 6.** Podcast user responses to statements regarding method of podcast use.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
<b>Instead of listening to/viewing the entire lecture, I skipped around to find the information I needed.</b>	16% (18)	27% (30)	26% (28)	24% (26)	7% (8)
<b>Instead of listening to the entire conversation, I skipped around to find the information I needed.</b>	12% (2)	12% (2)	12% (2)	30% (5)	35% (6)

**Table 7.** Podcast user response to questions regarding their podcast type.  
The podcast type is italicized.

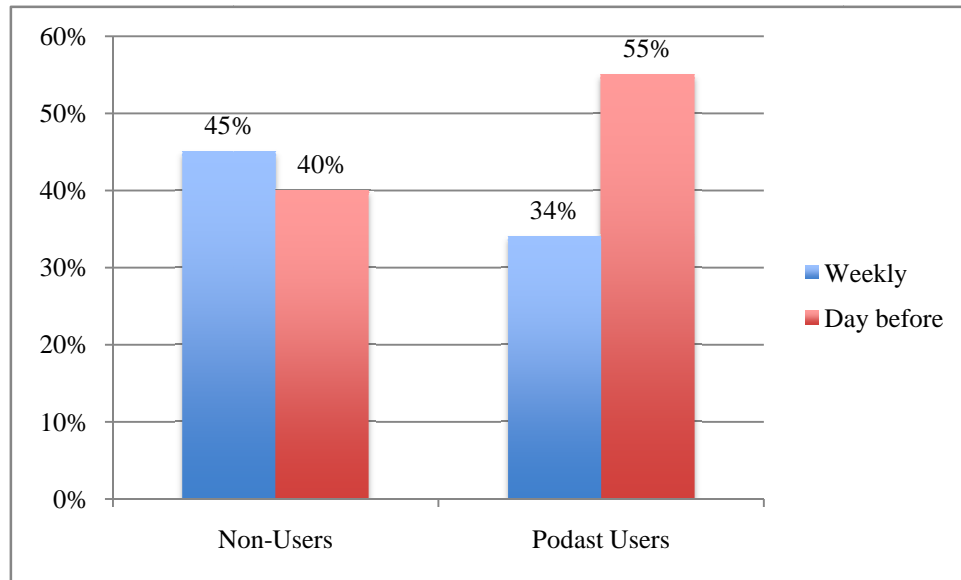
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
<b><i>Conversational: I think I learned more listening to students conversing about biology than if I had listened to a lecture.</i></b>				
12% (2)	35% (6)	29% (5)	6% (1)	18% (3)
<b><i>Segment: I would have rather listened to an hour long podcast of lecture than the shorter lecture segments.</i></b>				
27% (3)	18% (2)	36% (4)	9% (1)	9% (1)
<b><i>Complete: I would have preferred using a podcast where the complete lecture was divided into several shorter segments.</i></b>				
16% (16)	30% (29)	19% (18)	27% (26)	8% (8)

### Survey responses of non-users

Student respondents who did not use any podcasts were similar to podcast using students; most (61%) were female science majors who rely on the on-line practice exams when studying for Biology. Of those surveyed, 96% knew podcasts were available but chose not to use them. When given the opportunity to select a reason for not using podcasts, students selected “My regular study methods already work fine” most often (35%) while 19% “didn’t think podcasts would help” them (see Table 8). Unlike podcast users, non-users did not see the benefit of using podcasts as a tool for note revision. When given an opportunity to elaborate on their decision to eschew podcast use, many commented that podcasts would “only be useful to make up missed lectures.”

A chi-square comparison of the responses to the survey item regarding study habits of the control and treatment groups indicated there was a significant difference,  $\chi^2_{(1, N=115)} = 4.97, p < 0.05$ . Of students who did not subscribe to podcasts, 45% indicate studying once a week, while 40% wait until the day before the exam compared to 34% of

podcast using students studying once a week and 55% waiting until the day before an exam to study (see Figure 4 and Table 8).



**Figure 4.** Percentage of podcast users and non-users who indicated their studying frequency for Biology exams.  $\chi^2_{(1, N=115)} = 4.97, p < 0.05$ . Users who did not indicate either choice were not included in the comparison.

**Table 8**  
Survey Questions with Responses from the Control Group  
The number of responses are stated in parentheses

1. My gender is
  - a) Male **39% (43)**
  - b) Female **61% (67)**
  - c) Prefer not to say **0%**
  
2. My major is
  - a) Science oriented **69% (76)**
  - b) Non-science **29% (32)**
  - c) Undecided **1% (2)**
  
3. Which of the following **best describes** your regular study habits for Biology lecture?
  - a) Studying after or before every lecture **8% (9)**
  - b) Studying every week **45% (49)**
  - c) Studying only when the instructor tells me what to study **7% (8)**
  - d) Studying the day before an exam **40% (44)**
  
4. What resource do you rely on most when you study for Biology?
  - a) Text readings **5% (6)**
  - b) My notes from class **17% (19)**
  - c) On-line practice exams **75% (82)**
  - d) Classmates or review sessions **3% (3)**
  
5. Were you aware that podcasts of this course were available for you to use?
  - a) yes **97% (106)**
  - b) no **3% (4)**
  
6. Which one of the following **best describes** the reason why you decided not to use podcasts?
  - a) I don't have an mp3 player/iTunes. **14% (15)**
  - b) Listening to podcasts seemed too time consuming. **17% (19)**
  - c) I didn't think they would help me. **19% (21)**
  - d) I don't know what podcasts are. **2% (2)**
  - e) I didn't know how to find/use podcasts. **13% (14)**
  - f) My regular study methods already work fine. **35% (39)**

## CHAPTER V

### CONCLUSION

I set out to examine how students use podcasts in a naturalistic setting and to determine if their use would result in measurable differences in student performance on exams. An additional aspect of this project was the opportunity to relate podcast use and exam scores with survey responses across the student population. Based on current cognitive theories, I predicted that students using podcasts would have higher percent gain scores than students who did not use podcasts. Additionally, I predicted that students using certain podcast strategies would produce higher percent gain scores than students using other strategies. Based on findings from this study, it appears that neither podcast use nor podcast type has a significant effect on student scores when studied in a naturalistic, inquiry-based science lecture setting. Perhaps the results would be different in a non-inquiry course where lectures are detailed and in-class student collaboration for problem solving is not encouraged. That this study returned no significant differences between exam scores and podcast use seems contrary to students' reported enthusiasm for podcasts and the fact that universities across the country are investing millions of dollars towards the support of mobile learning (m-learning) strategies, like podcasting (Deal 2007).

Pilot studies for this project indicated that students had a very favorable attitude towards podcasts, indicating that nearly 80% of those sampled would use podcasts if they were provided. However, in practice, this number was much lower. The lecture instructor or graduate teaching assistants informed students of the availability of podcasts throughout the semester. Additionally, a web link for podcast subscription was clearly displayed on the course home page. Roughly 30% of the students chose to subscribe to podcasts in either semester, and out of those who subscribed, half reported infrequently using the available podcasts. Podcast subscription and use rates similar to what was reported in this study have been documented elsewhere in the literature. A previous survey of a large university course reported that while almost all of the students were aware podcasts were available, only 36% chose to utilize this resource (Nataatmadja and Dyson 2008). Similarly, a survey conducted at the University of Washington found that of the students who subscribe to podcasts, half use fewer than 50% of the podcasts provided (Lane 2006). It should be noted that in all of these studies, the podcasts were recordings of course lectures offered to students after they had an opportunity to attend said lecture. The relatively low subscription and use rate could be because that students, having already attended lecture once, do not feel a need to access a podcast covering the same information.

Although the course has a common curriculum and exams, a different faculty member teaches each lecture section. The lecture podcasts were recordings made of only one of the faculty. This could have confused students from other sections and led to disuse of podcasts. However, students did not seem to be bothered by viewing a lecture delivered by a different professor. Some students commented, “Hearing the information



presented by [a different professor] was helpful.” Similarly, another student stated he didn’t use podcasts because he assumed that they would be recordings of his lecture professor. Based on other student comments, factors affecting low podcast use could include a perceived disconnect between the information provided in podcasts and the material covered on exams, that users are more likely to study just before exams, inexperience with podcasts, or that the types of podcasts offered to students were not appropriate for an inquiry science lecture.

The lower than expected use of podcasts among students and a lack of increased scores among podcast users may cast doubt upon the learning theories that support their utility. However, many current studies on podcasting neglect to provide podcast users with any theory-based instruction on how best to utilize this new tool. Without guidance from instructors on the best practices of podcast use, students end up using podcasts as a “high-tech tape deck” for last minute note revision instead of as a tool for reflective learning and concept scaffolding. French (2003) found that students who studied from video recordings of lessons were unhappy with their performance on assessments, and less likely to learn the information than students who had received instruction on proper use of the study videos.

### **Lectures anywhere?**

Although podcasting has been touted as way for students to take their information anywhere and multitask as they learn, this simply was not the case here when podcasting was put into practice, since the majority of students accessed podcasts on their personal computers instead of a portable media player. This study was developed to evaluate m-

learning by allowing students to choose a podcast format (i.e. video or audio) that would be appropriate for use on their portable device, thereby encouraging its use. Results from this study and several others indicate that students rarely install or access podcasts on their portable media players, making educators concerns regarding appropriate podcast format for portable media players unfounded. (Copley 2007; Fose and Mehl 2007; Kurtz, Fenwick et al. 2007; Nataatmadja and Dyson 2008). Even when iPods were provided to students specifically for the purpose of viewing podcasts, students eschewed them in favor of their PCs (Kurtz, Fenwick et al. 2007).

Portable media players like the iPod are marketed to students as instruments of entertainment, which could explain why so few students use their portable media player in an educational context. Fosse and Mehl (2007) reported that students felt that the “entertainment functionality” of their portable media player would be jeopardized if it also contained course podcasts. That many students indicated they felt they were studying when using podcasts, along with the very small numbers who actually used podcasts on their portable devices, may indicate that students consider course podcasts as lacking in entertainment value. Postman (2005) found that when serious information was presented via a medium normally reserved for entertainment (i.e. television, or in this case, portable media players) the recipients were less likely to remember the information or take it seriously. That is, students may be listening to podcasts with a different mindset or focus than they would use to listen to music or watch a TV show. This should be interpreted as a positive result, because it indicates that students may consider that multi-tasking with a podcast at the gym or while driving is not an appropriate study method for class (Evans 2008). The most likely reason that students in this study did not

multitask when listening to or viewing podcasts, is that students were using podcasts as a tool for note revision. 50% of podcast users in this study reported regularly reviewing or updating notes while using podcasts.

### **Student podcast use and study habits**

While it was encouraging to find that many students may recognize podcasting as having scholastic value, many students reported they only used podcasts for last minute studying and note revision the day before an exam. This is particularly interesting because the trait that sets podcasting apart from other methods of downloadable media is that podcasting is in a “push” format via an RSS subscription, i.e. students do not have to seek out the podcasts because they are automatically sent, or “pushed”, onto their computers soon after each lecture. Proponents of podcasting suggest that students would be more likely to use podcasts regularly because the students wouldn’t have to expend the effort to seek them out (Deal 2007). This advantage of the subscription format seems to be largely ignored by students; in cases of both push and pull formats, students wait until the last minute before an exam to access the podcasts (Copley 2007; White 2009). This may have more to do with the content offered in the podcast than it does with the method by which the media is made available to students.

Early podcasting studies reported on instructor’s reluctance to make podcasts available to students prior to class, fearing that students would not attend (Duke Center for Instructional Technology 2005). Similar to previous studies, this study released podcasts of lecture to students after each class had ended. Perhaps this combination of podcast content and the timing of their availability had the unintended consequence of

removing the incentive for students to use podcasts except as a tool for last-minute note revision. Although faculty may encourage students to review course notes and readings on a daily basis, students may not feel it is necessary to immediately access podcasts of a lecture they have just attended. Similarly, since studies show that podcasts do not adversely affect class attendance (Deal, 2007; Lane, 2006), accessing every podcast may not seem useful to students since they would have experienced most of the lecture material when it was originally presented. It seems likely that students may be using all the podcasts they need, but they simply don't need to use all the podcasts.

### **Does podcasting enhance the learning experience?**

Although this study found that podcasting did not significantly affect student percent gain scores, the benefit of podcasting on student attitude appears to be an effect. Students consistently have a very positive attitude towards podcasting and courses that offer it. Evans (2008) found that students felt podcasts were a better study tool than their text or even their own notes. In this study 68% of students reported that podcasts were a valuable resource, while 80% of students liked having podcasts available. If podcasts did not provide some degree of benefit, one would expect the percentage of satisfied students to be lower than what was reported. However, if podcasts were as valuable as students insist, why did many of these same students use less than half the available podcasts while 38% report discontinuing their use at some point during the semester? Perhaps the podcasts provide a "life jacket" effect in student's minds. You may never use a life jacket while on a cruise, but it's nice to know one is available for you if the ship were to sink.

With many students reporting that they used podcasts the day before an exam, they are circumventing the beneficial traits of podcasting; those of the spacing effect and reflective learning. In other studies, students who were encouraged to repeatedly review course podcasts and revise notes before a quiz scored higher than students who only revised their notes (McKinney, Dyck et al. 2009). It should be noted that those students received the podcasts in lieu of classroom instruction and were asked to keep a log of the frequency and duration of podcast use which may have artificially increased podcast use (McKinney, Dyck et al. 2009). While podcasts may increase scores under such conditions, under the naturalistic conditions of this study the effects were not measurable. Students in this study who used podcasts reported studying less frequently and were more likely to study at the last minute for exams than their non-podcast using peers, yet they received similar exam scores as non-podcast users who reported studying more often. It may be possible that podcast users studying with podcasts the day before an exam experienced a small, yet beneficial spacing effect.

### **Podcasting and the inquiry science lecture**

When students attend Biology 1114 lecture, they are introduced to new concepts through scenarios as they work with their classmates to solve problems that require an understanding of the concepts being taught. Students may earn points for participating in group problem-solving discussions and brain-storming sessions. This instructional format increases group cohesiveness and accountability for learning the information. Russell and French (2002) found students in an inquiry setting had greater engagement and participation in the learning process when compared to being instructed in a

traditional method. Additionally, students are given multiple opportunities to discuss and question new information, which would increase their engagement in lecture and self-efficacy regarding course content. Students with a higher self-efficacy may not feel a need to rely on podcasts for note revision, thus decreasing their desire to listen to podcasts containing content about which they already feel knowledgeable (Ketelhut, 2007).

Students who did not use podcasts reported that podcasts were mainly to be used if they had poor class attendance, but that if they attended class, watching an additional video of the lecture wouldn't necessarily help, as supported by student comments, "I go to class and take good notes so I don't need to use podcasts. I guess if I got sick and had to miss [class] they would be useful to get me caught up." Students in this study who did not use podcasts reported studying more often than students who relied on podcasts, which may contribute to a high self-efficacy of non-users with respect to knowledge of biology. Although these non-users may have had an increased comfort with material covered in class, they did not earn a significantly higher score on exams.

While students were required to know and apply correct terminology when solving problems for course exams, knowing the correct terms is a means to an end, not the end itself. Students were told in lecture that scenarios used in class will not be the same scenarios that appear on exams. Students must transfer existing knowledge developed in lecture to correctly answer questions from new situations described on exams. Knowing this, students may be less inclined to subscribe to podcasts of lecture if they do not perceive a direct link between what is discussed in lecture and what will be asked on an exam, some students commented "I would use podcasts if they had study tips and

[material] for the exam.” Students used the online practice exams most often when studying, instead of podcasts. This may explain the lower than expected subscription rate and the 64% of podcast subscribers who reported using less than half of the available podcasts. Other podcasting studies, which used task-transfer assessments reported a low use rate among students similar to what was found in this study (Lane 2006; Nataatmadja and Dyson 2008).

### **What strategies are appropriate for inquiry?**

The success of podcasting in the inquiry classroom requires that the instructor do less, and that the learner do more. Simply podcasting verbatim recordings of a lecture that has already been delivered may not increase student learning in the inquiry classroom, as this type of instruction relies on opportunities for collaborative learning. Successful development of podcasts should adhere to the same three design principles as other quality instruction: learner-centered design, learner-centered delivery skills, and learner participation (Ostendorf 1997). Conversational podcasts that model collaborative learning may be able to fill this role, especially if they contain learner-generated content (Lee, McLoughlin et al. 2008). The lectures currently being podcast across the nation’s campuses were developed for, and recorded with, an audience addressed by a single speaker. However a student viewing the podcast is typically alone and outside the scholastic setting of a classroom (McKinney, Dyck et al. 2009). Therefore we should not expect that student to have the same level of learning and engagement as a student who is attending class.

Students have long realized that podcasting is not a substitute for lecture. Several

studies, including this one, have documented that students do not feel that using podcasts would make them more likely to miss class (Duke Center for Instructional Technology 2005; Deal 2007; Evans 2008; Nataatmadja and Dyson 2008; White 2009). The flow of information on a podcast is in one direction, whereas in the Biology 1114 lecture where the instructor used inquiry methods to keep students engaged in learning, there is a bidirectional flow of information. While students did have limited interaction with the podcast by controlling the pace at which information is presented, the interactions that occurred in an inquiry lecture cannot be adequately conveyed in a standard podcast. In a traditional lecture setting, with unidirectional flow of information, podcasting may be more appropriately matched to the curriculum.

I developed the conversational podcast to increase the interactivity and engagement between the podcast and the user similar to what might be experienced in an inquiry classroom. The podcast had a lively conversational tone where the four participants asked each other questions and discussed concepts in detail, giving the feel of sitting in on a study session with friends. During each podcast episode questions were posed directly to the listener followed by 15 seconds of music and a pause in the dialogue intended to cue the listener to pause the podcast and reflect on information to answer the question. In some cases, the listener was provided with page numbers from the text to read over and reflect upon before continuing with the podcast. This method provided an opportunity and direction for reflective learning and should have encouraged its use among students (Lowe, Rappolt et al. 2007).

Although it was possible for the student to simply fast-forward to the answer, students who used conversational podcasts were significantly less likely to skip around to



different parts of the podcast than users of other podcast formats based on self-reported data. In light of this, it seems reasonable that students may have felt greater levels of engagement than with standard lecture podcasts since most users reported that they learned more by listening to the conversational format.

### **Future directions in podcast research**

The future success of podcasting will rely on our ability as instructors to ensure that the podcasts contain content appropriate for the m-learning environment. Hour-long recordings of lecture appear a poor choice for courses utilizing inquiry-teaching strategies as evidenced by the low use rate of podcasts in this study. Is there a particular style of science course where podcasts would enhance the learning experience? Future studies need to examine the use and efficacy of podcasts in traditionally taught (non-inquiry) science courses with detail-oriented lectures, as well as upper division science courses with an academically mature student population.

Several studies reported an increase in student podcast use when shorter 6-10 minute podcasts of lecture were made available. Is there an ideal length, format, or content to make podcasts better suited for students engaged in m-learning outside the classroom? Although segment podcasts are shorter, they are still pieces of a longer lecture that were written for a stationary, passive audience. Shorter (< 3 min.) “micro-lectures”, fact-dense podcasts that are specifically developed with a mobile audience in mind, may show a positive effect when used in conjunction with inquiry or non-inquiry strategies (Shieh 2009). Micro-lectures could be a very useful note revision tool for students who have already been to lecture and are seeking specific information.

Similarly, they could be used to briefly introduce concepts or assess student prior knowledge before they attend lecture.

Additionally, more investigations are needed into how students actually use podcasts. That podcast-using students seemed to study less frequently, but earned similar percent gain scores to non-podcast users who studied more often, is intriguing. Did the podcast users in this instance spend more time engaged while in lecture than students who did not use podcasts? Are they more likely to be auditory learners? Did they take detailed notes when in class, thus making reviewing their notes with podcasts more efficient, or did they combine podcast use with other study tools, like practice exams?

In the future, podcasts must be designed to incorporate a two-way exchange of ideas and information. A study I hope to perform in the near future involves creating shorter versions of conversational podcasts, which would require students to answer questions and create hypotheses before attending an inquiry lecture over the content. When podcasts are made available before lecture, and students are encouraged to use them, more time in lecture can be devoted to student inquiry and discussion (Kurtz, Fenwick et al. 2007). Podcast creators are still operating under the assumption that students are accessing podcasts via their portable medial player, which lacks the functionality to incorporate a two-way exchange of information into the podcast. This study found that most students use podcasts via their PC so responding to questions posed in a podcast would be possible, while the increasing popularity of smartphones will only make it easier for students to view and respond to podcasts, allowing true m-learning.

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## APPENDICES

## Appendix A

### In-class exams used for assessment of podcasting strategies.

**Table 1.** Exam 1 from Spring and Fall semesters, 2008

BIOL 1114

Exam #1 (Star form)

February 9, 2009

Use a #2 pencil to fill in the information on your NCS answer sheet. Put your **O-Key Account Username** in the boxes indicated for **LAST NAME** and darken the appropriate circles. **Write your Name (Last, First)** and “**Star**” in the space above the boxes containing your **O-Key Account Username**. Darken the (S) in the last column of the name circles. Enter the number **911** and **darken the corresponding circles** in the **first 3 columns** of the “**Student ID.**” Failure to perform this correctly will incur a **-10pt handling fee**. Read all questions and answers *carefully* before choosing the **single BEST response** for each question. Feel free to ask the instructor for clarification.

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**Use the following information to answer the next 4 questions:**

Antimycin is a natural chemical produced by a type of bacteria. It is toxic to a variety of organisms because it inhibits the electron transport chain. Antimycin is toxic to fungi and protozoa, organisms that often either eat bacteria or compete with bacteria for resources. The bacteria that make antimycin have a salt content of 1% within their cells.

1. In a protozoa that has been poisoned by antimycin, which of the following would you predict would stop first?
  - a) No ATP would be produced.
  - b) Oxygen production would stop.
  - c) Carbon dioxide production would stop.
  - d) Glucose use would stop.
  - e) Oxygen use would stop.
2. Producing antimycin requires a great deal of energy. What is the immediate source of energy for the biochemical reactions that produce antimycin?
  - a) Glucose
  - b) ATP
  - c) NAD<sup>+</sup>
  - d) CO<sub>2</sub>
  - e) O<sub>2</sub>
3. If a bacterial cell that produces antimycin is placed in a jar containing water with a salt content of 5%, you would predict which of the following?
  - a) Nothing would occur.
  - b) The bacterial cell would enlarge and possibly burst as water moves in.
  - c) The bacterial cell will shrink as water moves out.
  - d) The bacterial cell will dissolve as membranes dissolve in water.
  - e) The electron transport chain will increase in activity producing more O<sub>2</sub>.
4. Based on natural selection, which of the following is a hypothesis that describes the production of antimycin by bacteria?



- a) Antimycin is produced by bacteria because most bacteria have plenty of energy to make extra chemicals.
- b) Toxic chemicals kill bacterial predators.
- c) Antimycin is produced by bacteria because the few original bacteria that were capable of making it were able to survive and reproduce more than the bacteria that didn't produce antimycin.
- d) Protozoa eat bacteria.
- e) Antimycin is produced by bacteria because the ability to make it is needed in order for them to survive attacks by predators.

5. A frog (an ectotherm) with an internal temperature of 81°F is sitting on a rock that has a temperature of 86 °F. You would predict that the temperature of the frog will \_\_\_\_\_ by \_\_\_\_\_ from the rock.

- a) increase, convection
- b) increase, conduction
- c) decrease, convection
- d) decrease, conduction
- e) increase, evaporation

6. A sudden flood sweeps the frog into cold water (70°F). You would predict that the temperature of the frog would be reduced by \_\_\_\_\_ and its rate of metabolism will...

- a) conduction, stay the same since this is within the frog's thermal neutral zone.
- b) convection, decrease
- c) evaporation, increase
- d) convection, increase
- e) conduction, decrease

7. A second frog, which had the same body temperature and shape as the first frog but was three times bigger, was also swept into the flood water. Which of the following would you predict and why?

- a) Both frogs will cool down at the same rate because they have the same surface area to volume ratio.
- b) The larger frog will cool down faster because it has a higher surface area to volume ratio.
- c) The smaller frog will cool down faster because it has a higher surface area to volume ratio.
- d) The larger frog will cool down faster because it has a lower surface area to volume ratio.
- e) The smaller frog will cool down faster because it has a lower surface area to volume ratio.

8. A snake, feeling fortunate to find an easy meal, eats one of these frogs. Unfortunately for the snake, the frog had a chemical in its skin that makes the inner mitochondrial membrane leaky to protons (H<sup>+</sup>). Although the poison wasn't strong enough to kill the snake, you would predict that the snake would...

- a) produce less CO<sub>2</sub>.
- b) produce less H<sub>2</sub>O
- c) produce less ATP.
- d) produce less NADH.
- e) have problems staying within its thermal neutral zone.



<http://www.ipm.ucdavis.edu/PMG/A/I-SM-ARET-AD.015.html>

**Use the following information to answer the next 5 questions:**

A gardener is having problems with slugs (a shell-less snail that lives on land) in her garden. She read on the internet that they cannot tolerate salt and wants to know if that is true. She also read that they have very high water content and are surrounded by semipermeable membranes that can allow water and air to pass through. She formulated the following hypothesis: salt will remove snails from her garden because salt kills snails. Then, she designed an experiment to test if salt will kill slugs. She captured 30 snails and placed each in a small jar. She sprinkled 10 with 1000 mg of table salt, 10 with 300 mg of table salt, and the final 10 did not receive salt. After 2 hours, she checked them to see if they were dead. In both treatments with salt, all of the snails died. However, all snails that were not treated with salt lived.

9. This is an example of what type of experiment?

- a) suggestive (theoretical)
- b) documented
- c) controlled
- d) correlational (observational)
- e) biased

10. In order to graph the data obtained from this experiment, you would plot the \_\_\_\_\_ on the x-axis because it is the \_\_\_\_\_ variable.

- a) number dead, independent
- b) number dead, dependent
- c) amount of salt applied, independent
- d) amount of salt applied, dependent
- e) hours, dependent

11. The highest amount of salt used was enough to cover the slug. Upon checking her experiments, you would predict that the slugs in this treatment would be...

- a) shriveled due to osmosis.
- b) the same size as before the experiment.
- c) swollen due to osmosis.

12. Based on the results of her experiment, the gardener should conclude that...

- a) her theory was confirmed.
- b) her hypothesis was proven.
- c) her hypothesis was supported.
- d) natural selection will not favor slugs.
- e) her hypothesis was false.

13. Following the test, the gardener sealed a jar and left it in the sunlight for a few minutes. The slug heated rapidly due to...

- a) convection
- b) conduction
- c) evaporation
- d) radiation
- e) natural selection

14. In the nephron loop, water moves from the inside to the surrounding area where it can be retained by the body. The movement of water is due to \_\_\_\_\_ and can only occur because the salt concentration is \_\_\_\_\_ surrounding the nephron loop as compared to inside the nephron loop.

- a) convection, higher
- b) diffusion, lower
- c) osmosis, lower
- d) diffusion, equal
- e) osmosis, higher

15. A scientist investigating cellular respiration in a solution containing isolated mitochondria, notices the production of H<sub>2</sub>O, ATP, NADH, and CO<sub>2</sub> but detects no FADH<sub>2</sub>. What portion of cellular respiration should the scientist hypothesize is failing?

- a) Glycolysis
- b) Acetyl-CoA formation
- c) Krebs cycle
- d) Electron Transport Chain
- e) ATP synthase

16. A species of flower is commonly pollinated by a species of hummingbird. After many generations, the nectar for the species of flower changes to contain all the nutrients that the bird needs and the flower is very attractive to the bird. At the same time, the hummingbird tends to visit this species of flower much more regularly, helping to insure that the flower's pollen reaches another flower of the same species. This relationship is an example of coevolution of ...

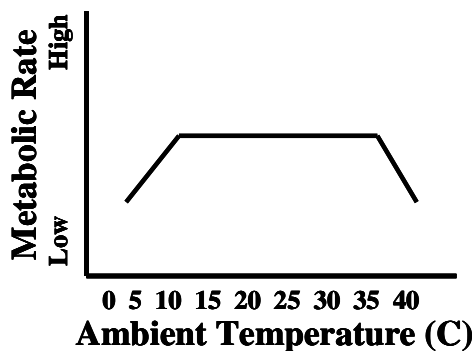
- a) the hummingbird.
- b) the flower.
- c) both the hummingbird and the flower.
- d) neither the hummingbird nor the flower.

17. Some dolphins often swim in very cold water. In these dolphins, counter-current exchange exists between the blood vessel that carries blood from their heart to their tail and the blood vessel that carries blood from their tail back to their heart. You would correctly predict that...

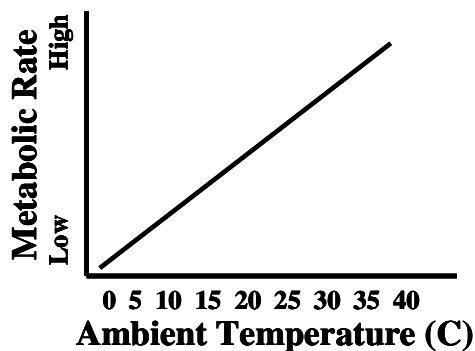
- a) the temperature of the blood is greater in their tail than in their heart to keep their tail warm.
- b) counter-current exchange prevents heat exchange between the two blood vessels in order to prevent heat loss from the organism.
- c) counter-current exchange insures that all of the blood in the animal is always the same temperature.
- d) convection to the colder water keeps their whole body warm.
- e) the temperature of the blood returning from the tail increases as it goes through the counter-current exchange mechanism.

18. A new species of animal was found in a remote rainforest. Although the animal looks like a mammal, the scientists who discovered it hypothesized that it is a poikilotherm. Which of the following results would support this hypothesis?

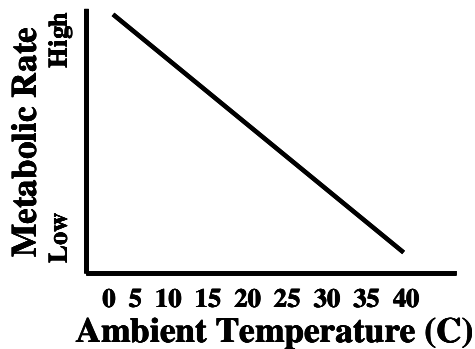
a)



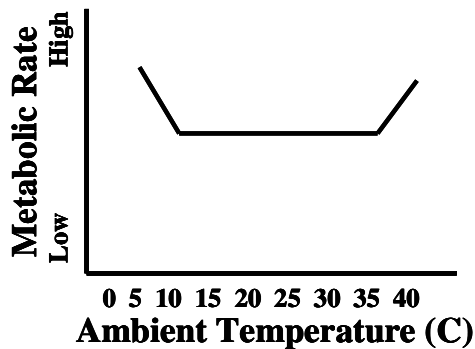
b)



c)

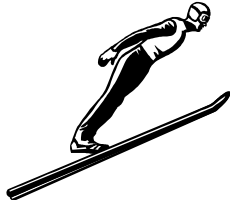


d)



Use the following information to answer the next 7 questions:

The Olympic Games, whether in summer or winter, are the favorite sporting events for millions of people.



19. "Some athletes use ATP at different rates because they have significantly different surface area to volume ratios." This was stated by a team of sports medicine experts in 1980. After several measurements of marathon runners' ATP levels during the 1984, 1988, 1992 and 1996 summer Olympiads, this stated \_\_\_\_\_ was supported by many experiments and became known as a scientific...

- a) theory; fact.
- b) hypothesis; fact.
- c) theory; hypothesis.
- d) hypothesis; theory.
- e) observation; hypothesis.

20. "Utilization of ATP" would normally be plotted on the \_\_\_ axis since it is considered to be the...

- a) x; dependent variable.
- b) x; independent variable.
- c) y; dependent variable.
- d) y; independent variable.
- e) y; controlled variable.

21. The type of experiment described above would be considered a(n)...

- a) controlled experiment.
- b) correlational (observational) experiment
- c) irreproducible experiment.
- d) thought experiment.
- e) reversible process.

22. The marathon runners' arms and legs are bare, which would increase the effects of \_\_\_ on heat loss.

- a) evaporation.
- b) vasodilation.
- c) insulation
- d) both a and b
- e) All of the above are correct.

23. On the other hand, bare arms on the skiers (at  $-20^{\circ}\text{C}$ ) would lead to the greatest loss of body heat from...

- a) vasoconstriction.
- b) convection
- c) conduction.
- d) evaporation.
- e) counter-current exchange.

24. At the top of the slope, one of the skiers begins to shiver because of involuntary muscle contractions of up to 20 per second. You would hypothesize that this skier is ...
- within his thermal neutral zone.
  - to the right of his thermal neutral zone.
  - below his critical low temperature.
  - failing to employ countercurrent exchange.
  - in respiratory failure.
25. During the race, the runners will need to synthesize more ATP, the majority of which will be derived directly from...
- glycolysis.
  - the Krebs Cycle.
  - fermentation.
  - chemiosmosis (electron transport chain)
  - both a and b
26. During aerobic cellular respiration glucose and  $O_2$  is converted to  $CO_2$ ,  $H_2O$  and energy. At what steps in this pathway is  $CO_2$  generated?
- glycolysis and chemiosmotic phosphorylation (electron transport chain)
  - formation of acetyl CoA and glycolysis
  - the Krebs cycle and chemiosmotic phosphorylation (electron transport chain)
  - formation of acetyl CoA and the Krebs cycle
27. Murder mysteries sometimes involving a poisoning: Use of cyanide, which inhibits a key enzyme in the electron transport chain, is a frequently employed method. After cyanide poisoning, you would hypothesize that the victim would have...
- a shortage of NADH.
  - a shortage of oxygen ( $O_2$ ).
  - a shortage of ATP.
  - an excess of  $CO_2$ .
  - an excess of  $NAD^+$ .
28. Kangaroo rats derive 90% of their water metabolically. What is absolutely essential for the synthesis of this "metabolic water"?
- nephron loops
  - $CO_2$
  - oxygen ( $O_2$ ).
  - sodium ions ( $Na^+$ )
  - ATP synthase
29. Compared to other species of rodents, kangaroo rats have relatively long nephron loops because...
- their ancestors had relatively long nephron loops.
  - more of them and their ancestors survived longer in desert climates due to longer nephron loops.
  - their ancestors grew long nephron loops in the desert in order to survive.
  - both a and b
  - All of the above are correct.
30. After a section of an asphalt (black pavement) road was closed to traffic, a scientist counted 2 snakes per day resting on the road and 26 snakes per night resting on the road. Which is the best hypothesis?
- Snakes are chased onto the road by predators during the day.
  - The snakes use conduction from the road to warm themselves at night.

- c) The snakes use evaporation from the road to warm themselves at night.
- d) During the daytime, the black asphalt absorbs too much heat and would cool the snakes, excessively.

**Use the following information to answer the next 4 questions:**

Amphibians (frogs, toads, and salamanders) are currently going through worldwide declines. One current hypothesis explains that parasites increase amphibian deformities and therefore parasites are responsible for amphibian declines. To investigate this hypothesis, scientists randomly selected 40 wetlands in Minnesota and collected 20 randomly selected leopard frogs from each site in July of 1999. In the laboratory, they examined each frog for the number of parasites and recorded the number of deformities in each frog. [http://www.foxnews.com/images/309684/0\\_61\\_frog\\_mutant.jpg](http://www.foxnews.com/images/309684/0_61_frog_mutant.jpg)



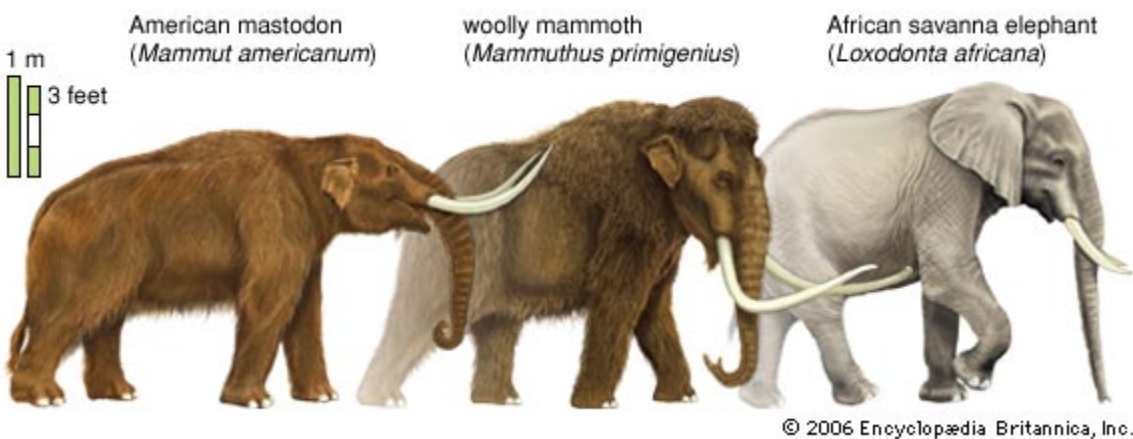
31. This is an example of what type of experiment?
- a) controlled
  - b) observational (correlational)
  - c) both a & b
  - d) This is not an experiment.
32. To investigate whether the presents of parasites increases amphibian deformities, which one or more of the following would be best?
- a) Use parasites as the independent variable.
  - b) Plot parasites on the x-axis.
  - c) Both a & b are correct.
  - d) Use parasites as the dependent variable.
  - e) Both b & d
33. After collecting all the data, scientists discovered that there was no relationship (no correlation) in the number of parasites and the number of deformities in each frog. Based on these results, you would correctly state the following about the original hypothesis.
- a) The hypothesis was supported.
  - b) The hypothesis was true.
  - c) The hypothesis was not supported.
  - d) The hypothesis was false.

34. Because of their permeable skin, most amphibian species can only live in fresh water (0.5% salt content), and quickly dehydrate in brackish water (1.5% salt content). However, the Crab Eating Frog, which also has permeable skin, lives in brackish water by increasing the salt concentration in its cells. Based on these observations you would correctly predict that when cells of the crab eating frog are placed in fresh water

- a) water would move into the cells
- b) salt would move into the cells
- c) there would be no net movement of water
- d) water would move out of the cells

**Use the following information to answer the next 6 questions:**

You and your friend visit the Sam Noble Oklahoma Museum of Natural History. As you enter the museum you notice Archie the mammoth, and decide to look at the exhibition on extinct and modern elephants. The display indicates that mammoths and mastodons lived during the ice age in North America and went extinct approximately 10,000 years ago. You observe that compared to the modern African elephant, which live in grass land and forest, mastodons and mammoths had thick hair, short tails, a short trunk, and very small ears.



<http://www.exotichide.com/G/mastodon.jpg>

35. Your friend wonders why these extinct elephants had such short extremities. Knowing that mammoths and mastodons lived in a cold climate, you would correctly hypothesize that mammoths and mastodons had short extremities which...

- a) reduce the surface area to volume ratio and conserve heat.
- b) increase the surface area to volume ratio and conserve heat.
- c) reduce the surface area to volume ratio and radiate heat.
- d) reduce the surface area to volume ratio and absorb heat.



36. Two days after your visit to the Sam Noble Oklahoma Museum of Natural History, scientists announce that they just discovered a new species of extinct mastodon in North America. The new species description is based on a single tooth found in the Sonoran Desert, and data support that this animal lived in a very hot and dry environment. Based on your knowledge of adaptations of desert animals you would correctly predict that these extinct mastodons would...

- a) have very high water content in their urine.
- b) have large bodies and lots of hair.
- c) have longer nephron loops (Loop of Henle) than modern day elephants.
- d) have shorter nephron loops (Loop of Henle) than modern day elephants.

37. A few years later, scientists isolate DNA from the tooth of the newly described North American Sonoran Desert mastodon, inject that DNA into an elephant egg, and a live mastodon is born. Once the baby mastodon is born, scientists want to determine whether it is a homeotherm or a poikilotherm. The best prediction that scientists would make would be a...

- a) poikilotherm because it would eat more as the temperature decreased.
- b) homeotherm because its body temperature would increase as the ambient temperature increased.
- c) poikilotherm because its metabolism would increase as its body temperature remained constant.
- d) homeotherm because its body temperature would remain constant as the ambient temperature increased.

38. On a very cold day in the tundra, shortly after his birth, Archie snuggled up to his mom to stay warm. Adorable baby Archie is only 1/5<sup>th</sup> the size of his mom. Based on Archie's size, if Archie was left alone for an entire day you would correctly predict that by the end of that cold day...

- a) Archie's metabolic rate is higher than his mom's metabolic rate.
- b) Archie lost heat more quickly than his mom.
- c) Archie's metabolic rate is the same as his mom's metabolic rate.
- d) a & b
- e) b & c

39. Knowing that Archie, the woolly mammoth, lived in the tundra of North America you would correctly predict that the body temperature at the tip of his trunk would be \_\_\_\_\_ than his core body temperature because of...

- a) colder, vasoconstriction.
- b) warmer, vasodilation.
- c) warmer, counter current circulation.
- d) colder, vasodilation.

40. To maintain his body temperature you would correctly predict that on a very cold day, Archie would...

- a) raise his body hair.
- b) role up into a fetal position.
- c) eat more.
- d) shiver.
- e) all of the above

**BIOL1114**

**Exam #1 (Star form)**

**15 September 2008**

Use a #2 pencil to fill in the information on your NCS answer sheet. Put your **O-Key Account Username** in the boxes indicated for **LAST NAME** and darken the appropriate circles. **Write your Name (Last,First)** and “**Star**” in the space above the boxes containing your **O-Key Account Username**. Darken the **(S)** in the **last column of the name circles** depending on your test form. Enter the number **831** and **darken the corresponding circles** in the **first 3 columns** of the “**Student ID.**” Failure to perform this correctly will incur a **-10pt handling fee**. Read all questions and answers *carefully* before choosing the **single BEST response** for each question. Feel free to ask the instructor for clarification.

---

1. Given that humans have a body temperature of approximately 98.6°F, wearing a wind breaker (light jacket) on a windy day **interferes** with convection under which one or more of the following conditions?

- a) an outside temperature of 75°F
- b) an outside temperature of 102°F
- c) an outside temperature of 98.6°F
- d) both a & b
- e) both b & c

2. If you were to lean against the south face (facing the sun) of the OSU library wall on a cool and sunny fall day, which one or more of the following would you predict to transfer heat to your body?

- a) radiation
- b) conduction
- c) evaporation
- d) both a & b
- e) both b & c

3. Recently, some individuals claimed to have found the remains of a “Big Foot” (a large, furry human-like creature) in Georgia, a warm southeastern US state. Based on surface area to volume ratio, you would correctly predict that a Big Foot found in Idaho, a cold northwestern state, would be ...

- a) smaller than the Georgia Big Foot and have a larger surface area to volume ratio.
- b) larger than the Georgia Big Foot and have a larger surface area to volume ratio.
- c) larger than the Georgia Big Foot and have a smaller surface area to volume ratio.
- d) smaller than the Georgia Big Foot and have a smaller surface area to volume ratio.

4. While taking a stroll through the north Georgia mountains, a Big Foot is chased by a pack of coon hounds. After several miles of running, Big Foot is able to lose the hounds and stops to rest and cool down. If the outside temperature has not changed during the chase, what is the primary source of the heat in the Big Foot's body?

- a) Convection
- b) Evaporation
- c) Metabolism
- d) Radiation
- e) Conduction

5. If Big Foot were a homeotherm, which of the following would you predict regarding its cellular respiration?

- a) ATP synthase produces ATP using the energy provided by an  $H^+$  gradient.
- b) The end product of glycolysis is 2 molecules of Acetyl-CoA.
- c) Pyruvate directly donates its excess electrons to  $O_2$  to make water.
- d) NADH is converted into ATP in the Krebs cycle.

6. While Big Foot was running from the hounds his body used up large amounts of glucose. The initial breakdown of glucose is called \_\_\_\_\_ and occurs in the \_\_\_\_\_ of cells.

- a) gluconeogenesis; cytoplasm
- b) glycolysis; mitochondria
- c) the Krebs cycle; mitochondria
- d) glycolysis; cytoplasm
- e) the Krebs cycle; cytoplasm

7. NADH and  $FADH_2$  are coenzymes capable of transferring protons ( $H^+$ ) from \_\_\_\_\_ to the \_\_\_\_\_.

- a) the glycolysis pathway; Krebs cycle
- b) the Krebs cycle; electron transport chain
- c) the electron transport chain; glycolysis pathway
- d) Acetyl CoA; Pyruvate molecule
- e) the Krebs cycle; glycolysis pathway

8. The final electron acceptor in the Electron Transport Chain in the mitochondria is...

- a) oxygen ( $O_2$ ), which becomes water ( $H_2O$ ).
- b) oxygen ( $O_2$ ), which becomes carbon dioxide ( $CO_2$ ).
- c) carbon (C), which becomes carbon dioxide ( $CO_2$ ).
- d) water ( $H_2O$ ), which becomes hydrogen peroxide ( $H_2O_2$ )

9. The night after being chased by the hounds, Big Foot (a homeotherm) decided to sleep outside instead of in his cave. During the night, the temperature dropped to 25°F (a rare occurrence). If Big Foot's Thermal Neutral Zone is 45°F-75°F, which of the following would you correctly predict will occur to his metabolic rate after the temperature drop?

- a) It will remain the same to maintain internal body temperature.
- b) It will decrease to conserve energy in the cold.
- c) It will increase to conserve energy in the cold.
- d) It will increase to maintain internal body temperature.
- e) It will decrease to maintain internal body temperature.

10. One afternoon, Big Foot unwittingly ate some berries containing a toxin which blocks the H<sup>+</sup> channel of ATP synthase. Which of the following will be the first result of this toxin's action?

- a) an increase in the rate of glycolysis.
- b) a decrease in the rate of water production in the mitochondria.
- c) an increase in the proton (H<sup>+</sup>) gradient across the mitochondria inner membrane.
- d) an increase in the output of NADH by the Krebs cycle.
- e) a decrease in the output of FADH<sub>2</sub> by the Krebs cycle.

11. The salt concentration of Big Foot's cells is 2%. If a cheek cell from his mouth falls into a freshwater creek (0.5% salt content) while he is getting a drink of water, which one or more of the following would you predict will occur most rapidly?

- a) Salt will move out of the cell and into the creek.
- b) Water will move out of the cell and into the creek.
- c) Water will move from the creek and into the cell.
- d) both a & b
- e) both b & c

12. If a subpopulation of Big Foot also evolved in the desert southwest of the United States, a very hot and dry environment, you would correctly predict that these creatures would ...

- a) have very high water content in their urine.
- b) have longer nephron loops than their Georgia cousins.
- c) have large bodies and dark colored hair.
- d) have shorter nephron loops than their Georgia cousins.
- e) spend a lot of time outside during the day.

13. During cellular respiration, one molecule of glucose is "used" to produce many molecules. Which of the following represents the number of molecules from greatest to fewest involved in cellular respiration?

- a) ATP>NADH>CO<sub>2</sub>>pyruvate>glucose
- b) pyruvate>NADH>CO<sub>2</sub>>ATP>glucose

- c) ATP>pyruvate>CO<sub>2</sub>>NADH>glucose
- d) ATP>NADH>pyruvate>CO<sub>2</sub>>glucose

**Use the following information to answer the next 8 questions:**

Zebra mussels are a small clam-like creature that originated in Russia and were accidentally introduced to the Great Lakes in the 1980s. This species reproduces very quickly (females can produce more than 30,000 eggs per year) and has spread rapidly causing a variety of environmental problems. In the last few years, zebra mussels have been reported in several locations in Oklahoma. They can become densely populated and completely cover the bottom of a stream or lake, often smothering native freshwater mussels. They can grow in thick bunches within pipes, causing blockages and problems in water intakes of municipal water supplies and electric companies. Scientists are interested in the maximum temperatures that zebra mussels can withstand as this will help them predict how far they will spread into the southern US and the types of industrial pipes in which they can live in. To test the mussel's temperature tolerance, scientists placed them in aquariums at their optimal temperature for growth (19°C) and two higher temperatures of 25°, and 31°C. For each temperature, 20 mussels were tested. After four days, scientist counted the number of mussels that had died in each pipe. Following the experiment, the scientist noted that no mussels died at 19° and 25°C. At 31°C, all mussels died.

14. To correctly analyze this data, which of the following would be best?
  - a. Use temperature as the dependent variable.
  - b. Use temperature as the independent variable.
  - c. Plot temperature on the y-axis.
  - d. Ignore temperature.
  - e. Both a & c are correct.
  
15. This is an example of what type of experiment?
  - a. controlled
  - b. correlational (observational)
  - c. both a & b
  - d. irrational
  
16. After a few days in the 25°C aquarium, you would correctly predict that the mussels (ectotherms) body temperature would measure...
  - a) near their optimal temperature of 19°C.
  - b) near the maximum reproductive temperature of 20°C.
  - c) much higher than 25°C due to thermogenesis.
  - d) much lower than 25°C due to heat exchange mechanisms.
  - e) near the water temperature of 25°C.

17. The cells of zebra mussels have a higher concentration of salt than the surrounding fresh water. In order to create this gradient...

- a) salt must freely pass through the cell membrane.
- b) salt must easily diffuse into the cell through the membrane.
- c) salt is actively transported through the cell membrane, into the cell, requiring energy.
- d) salt is actively transported through the cell membrane, into the cell, producing ATP.
- e) water is actively transported into the cell requiring energy.

18. You would correctly predict that for mussels ...

- a) enzyme activity would be higher at 19°C than 9°C.
- b) enzyme activity would be higher at 9°C than 19°C.
- c) enzyme activity is not temperature dependent in poikilotherms.
- d) metabolic activities do not need enzymes.
- e) both c & d

19. In another experiment, scientists monitored the metabolic rate of mussels by measuring the amount of  $O_2$  consumed. Which step in cellular respiration uses  $O_2$ ?

- a) glycolysis
- b) Krebs cycle
- c) electron transport chain
- d) both a & b
- e) both b & c

20. Assume that workers at an electric plant tried to poison the mussels with a chemical that makes the inner membrane of their mitochondria leaky to protons, but did not use enough to kill them. Which of the following would you correctly predict?

- a)  $O_2$  consumption will decrease.
- b)  $O_2$  consumption will remain constant or increase.
- c) ATP production will decrease.
- d) both a & b
- e) both b & c

21. Zebra mussels can survive outside of water for longer than other mussel species. If this trait was shaped by natural selection, you would correctly predict that zebra mussels have this ability because their ancestors...

- a) decided to move to new streams that did not have mussels.
- b) also had the ability, which allowed them to survive during dry periods and produce more offspring when wet conditions returned.
- c) were able to swim upstream.
- d) rarely reproduced.
- e) did not have the ability and were able to use all their resources towards producing more offspring.

**Use the following information to answer the next 3 questions:**

Chili (hot) peppers are one of the earliest crops to be domesticated in South America. It is suggested that the early domestication of chili pepper is related to their ability to prevent food infection by microbes such as bacteria and fungi. Before humans used refrigeration to preserve their food, food poisoning was more common in hot regions as compared to cold regions.

22. Food spoilage and poisoning by microbes was more common in hotter regions because ...

- a) people in cold regions were smarter than people in hot area and they knew how to protect themselves.
- b) at higher temperatures the microbes have higher metabolic rates and multiply faster.
- c) at higher temperatures enzyme activity in microbes is faster and they multiply faster.
- d) at higher temperatures some microbes produce more toxic material.
- e) b, c & d are correct

Scientists suggest that the production of capsaicin is a defense mechanism developed in some peppers to protect them from the fungus *Fusarium* that enters the fruit through punctures made in the fruit skin by insects. The fungus destroys the seeds in the fruit before they can be eaten and dispersed by birds.

23. To test the hypothesis that capsaicin protects the seeds, scientist collected fruits from wild plants and measured both the level of capsaicin and the viability (ability to germinate) of the seeds. This type of experiment is best labeled as a(n) \_\_\_\_\_ experiment.

- a) conclusive
- b) affirmative
- c) correlational or observational
- d) controlled
- e) subcontrol

In order to test the role of natural selection in the production of capsaicin scientists collected wild chili peppers from seven different populations of the same species spread over 1,000 square miles in Bolivia. They selected peppers randomly and measured levels of capsaicin and scars caused by insect bites on the fruit surface.

24. Which one or more of the following is likely if natural selection has been playing a role in the development of the defense mechanism against the fungus using capsaicin?

- a) Some plants may not produce capsaicin.
- b) In the same population, different plants produce different levels of capsaicin

- c) Higher levels of capsaicin are found in plants in areas with larger populations of insects that feed upon the plant fruits.
- d) The plants with the highest levels of capsaicin are found in areas where fungal diseases are very common.
- e) All of the above are correct.

**Use the following information to answer the next 2 questions:**

An experimental site was selected at Yuma Agricultural Research Center in Arizona, to evaluate the effect of a new synthetic fertilizer on melon plant yields (the number of melons produced). Groups of ten plants were tested. One group received fertilizer treatments, while another group served as the control. Results indicated the group of melons receiving fertilizer had an increased yield.

25. One observes that melon yields differ depending on the type of fertilizer usage (natural vs synthetic). Which statement best represents a hypothesis?

- a) Synthetic fertilizers increase melon yields by providing nutrients.
- b) Is the water content in the desert soil important for melon yield?
- c) As fertilizer increases, flavor of the melons increases.
- d) All plants receive the same amount of water during irrigation.
- e) The number of melons represented the yield or dependent variable.

26. To set up an experiment based on a hypothesis, which one or more of the following is necessary?

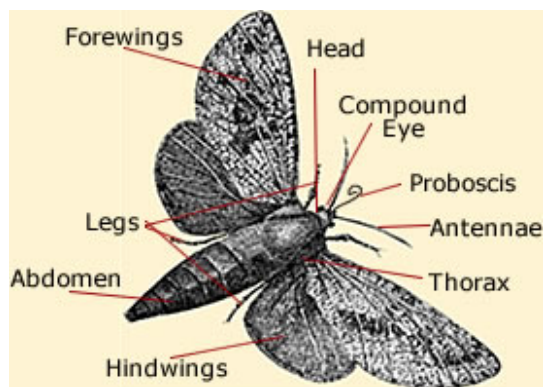
- a) independent variable
- b) standardizing or controlling variables for all groups
- c) dependent variable
- d) adequate sample size
- e) all of the above

27. Theory and hypothesis are linked but they also have different meanings. Which one or more of the following statements describes the differences?

- a) A theory is tentative and specific, and a hypothesis is broadly accepted.
- b) A hypothesis is a tentative explanation based on previous knowledge, and a theory reflects broader agreement.
- c) Theories describe what has happened while hypotheses correctly predict what will happen.
- d) both b & c
- e) both a & c



Use the following information to answer the next 11 questions: When the Sphinx moth, *Manduca sexta*, flies, heat is produced by its flight muscles. When it flies at low ambient temperatures, its thorax (midsection), which is surrounded by a thick coat of scales, may be 23° C warmer than the surrounding air. At high ambient temperatures, the moth's abdomen (hind section) can become nearly as warm as the thorax and acts as a thermal radiator (releases heat).



(<http://entomology.unl.edu/ent801/temp.html>) (<http://www.animalcorner.co.uk/insects/moths/graphics/mothanat.jpg>)

Dr. Elle Gent-Papillion decides to test whether the scales help regulate the moths' body temperatures by serving as an insulator. To test this, she takes a set of moths and glues their dorsal surfaces (backs) to sticks so that their legs and wings can still move. This allows her to suspend the moths in tiny air chambers where the wind flowing past them stimulates them to flap their wings as if they are flying. She also inserts very tiny thermal probes into the insects to measure their internal temperatures. Then she goes about planning and conducting her experiment, which involves removing scales from half the individuals. [http://www.fs.fed.us/wildflowers/pollinators/pollinator-of-the-month/images/hawkmoths/agrius\\_cingulata\\_lg.jpg](http://www.fs.fed.us/wildflowers/pollinators/pollinator-of-the-month/images/hawkmoths/agrius_cingulata_lg.jpg)

28. Which of the following quotes from the passage above would most correctly be labeled a hypothesis?

- a) "suspend the moths in tiny air chambers"
- b) "scales helps to regulate the moths' body temperatures by serving as an insulator"
- c) "flap their wings as if they are flying"
- d) "thermal probes into the insects to measure their internal temperatures"
- e) "thoracic temperatures may be 23° C warmer than the temperature of the surrounding air"

29. Which of the following would serve as the independent (manipulated) variable in Dr. Gent-Papillion's experiment?

- a) the number of moths used
- b) the air temperature
- c) the moths' internal temperature
- d) the presence (or absence) of scales
- e) attaching the moth's to the sticks

30. If Dr. Gent-Papillion increased the insulation around the moths using synthetic scales, she should be able to \_\_\_\_\_ that the moths would radiate heat more slowly.

- a) hypothesize

- b) predict
- c) theorize
- d) prove

31. Dr. Gent-Papillion places several moths in 18°C air (low temperature), and makes them fly for 5 minutes. She then increases the air temperature to 30°C (high temperature), and continues to make the moths fly. Based on the description provided above, you would correctly predict that as the moths begin to fly at high temperatures the temperature gradient between the moths' thoraxes and abdomens would \_\_\_\_\_.

- a) increase
- b) decrease
- c) remain unchanged

32. You would correctly predict that the chemical reaction/process that directly powers the moth's flight muscles is (are) ...

- a)  $ADP + P \rightarrow ATP + \text{Energy}$
- b)  $NADH + H \rightarrow NADH_2 + \text{Energy}$
- c)  $\text{Glucose} \rightarrow 2 \text{ pyruvate} + \text{Energy}$
- d)  $ATP \rightarrow ADP + P + \text{Energy}$
- e)  $NAD + FADH_2 + \text{Energy} \rightarrow NADH_2 + FAD + P$

33. How would you predict the Krebs Cycle would be involved in the process of flight?

- a) It would not.
- b) It would provide the pyruvate needed for the muscles to work.
- c) It would provide  $H^+$  ions to the electron transport system using energy rich molecules to carry them over.
- d) It would use the  $H^+$  ions to produce ATP and Acetyl-CoA.
- e) It would use oxygen to turn energy into glucose molecules that would power flight directly.

34. Potassium cyanide (KCN) is a common poison used by entomologists like Dr. Gent-Papillion to kill insects for collections. One observes that  $O_2$  use stops immediately when insects are exposed to KCN. Which would be the best hypothesis for this?

- a) KCN blocks the conversion of Pyruvate to Acetyl-CoA.
- b) KCN absorbs  $O_2$  preventing its binding to ADP to make ATP.
- c) KCN disrupts the Krebs Cycle.
- d) KCN blocks an electron carrier in the electron transport chain.
- e) KCN blocks ATP synthase.

35. As moths begin to fly faster, the overall movement of  $H^+$  ions into the inter-membrane compartments of their mitochondria would \_\_\_\_\_.

- a) increase

- b) decrease
- c) remain the same

36. Moths do not have counter-current exchange mechanisms in their legs, but Big Foot most likely would and this would prevent heat loss by...

- a) preventing the buildup of a temperature gradient between arteries.
- b) maintaining a temperature gradient between blood vessels that flow in the opposite direction.
- c) reducing the temperature gradient between blood vessels that flow in the same direction.
- d) transporting blood in opposite directions without any temperature gradients between the vessels involved.
- e) using  $O_2$ .

37. Sphinx moths are, of course, ectotherms. If prevented from flapping their wings, and placed in cool temperatures, their  $O_2$  consumption would \_\_\_\_\_ when they are at warm temperatures.

- a) increase compared to
- b) decrease compared to
- c) be the same as

38. However, if allowed to flap their wings, sphinx moths are somewhat like endotherms, and therefore you would correctly predict that below some lower critical temperature they would...

- a) raise their metabolic rate by flapping their wings and keep warm.
- b) switch to glycolysis to generate large amounts of ATP.
- c) lower their metabolism.
- d) vasodilate their blood vessels to release heat.
- e) increase their surface-area-to-volume-ratios to prevent heat loss.

39. Near a gold mining operation, where KCN is used to extract gold from ore, a population of bacteria has become tolerant KCN in the soil. One would correctly hypothesize that such resistance results from ...

- a) the need for the bacteria to survive.
- b) coevolution.
- c) individual bacteria changed themselves so that they had a new ability to resist KCN poisoning.
- d) natural selection by which only those who were resistant reproduced.
- e) the build up of toxins which allowed the bacteria to change.

40. According to Dr. Hoefnagels, the author of our textbook, a hypothesis is...

- a) any educated guess about future events.

- b) a prediction about what will happen.
- c) a tentative explanation based on prior knowledge.
- d) a well supported fact that scientists widely support.
- e) a set of observations that taken together always occur.

**Table 2.** Exam 4 from Spring and Fall semesters, 2008

BIOL 1114

Exam #4 (Star form)

May 6, 2009

Use a #2 pencil to fill in the information on your NCS answer sheet. Put your **O-Key Account Username** in the boxes indicated for **LAST NAME** and darken the appropriate circles. **Write your Name (Last, First)** and **“Star” in the space above the boxes containing your O-Key Account Username**. Darken the (S) in the **last column of the name circles**. Enter the number **914** and **darken the corresponding circles in the first 3 columns** of the **“Student ID.”** Failure to perform this correctly will incur a **-10pt handling fee**. Read all questions and answers *carefully* before choosing the **single BEST response** for each question. Feel free to ask the instructor for clarification.

*Use the following formulas and chart as needed.*

$r = \text{birth rate}(b) - \text{death rate}(d)$

$G = rN$

$G = rN \frac{(K - N)}{K}$

mRNA-Codon-to-Amino-Acid Decoder Chart									
1 <sup>st</sup> Letter	U	2 <sup>nd</sup> Letter						3 <sup>rd</sup> Letter	
		C	A	G					
U	UUU	Phenylalanine	UCU	Serine	UAU	Tyrosine	UGU	Cysteine	U
	UUC		UCC		UAC		UGC		C
	UUA	Leucine	UCA		UAA	STOP	UGA	STOP	A
	UUG		UCG		UAG		UGG	Tryptophan	G
C	CUU	Leucine	CCU	Proline	CAU	Histidine	CGU	Arginine	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	Glutamine	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	Isoleucine	ACU	Threonine	AAU	Asparagine	AGU	Serine	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	Lysine	AGA	Arginine	A
	AUG	Methionine; START	ACG		AAG		AGG		G
G	GUU	Valine	GCU	Alanine	GAU	Aspartate	GGU	Glycine	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	Glutamate	GGA		A
	GUG		GCG		GAG		GGG		G

1. A biologist friend informs you that the population of goldfish within your aquarium has reached its carrying capacity (K): Your best prediction would be that...
  - a) many goldfish are starving to death.
  - b) a density-dependent disease epidemic is occurring.
  - c) the goldfish birth rate is equal to the goldfish death rate.

- d) the goldfish growth rate is positive and exponential.
- e) the goldfish growth increment is negative.

2. The concentration of dissolved substances (salt) inside the cells of goldfish is higher than that in the aquarium water. Thus your biologist friend would predict that the goldfish would ...

- a) gain water by active transport
- b) lose water by diffusion.
- c) gain water by osmosis
- d) lose charged and uncharged molecules and ions by osmosis
- e) use facilitated diffusion to further concentrate ions within their cells.

3. If carp and goldfish are truly different species, you would predict that goldfish and carp could NOT...

- a) consume the same diet.
- b) live in the same habitat.
- c) fertilize each other's eggs.
- d) breed with each other and produce fertile offspring.
- e) swim upstream with the same pattern of fin motions.

4. You place an ordinary mirror near your aquarium so as to reflect sunlight into the bowl. A goldfish sees its mate as orange in color partly because the sunlight's blue wavelengths were...

- a) absorbed by the mirror and then reflected by the goldfish's mate.
- b) reflected by the mirror and then absorbed by the goldfish's mate.
- c) reflected by the mirror and then reflected by the goldfish's mate.
- d) absorbed in equal portions by both the mirror and the goldfish's mate.
- e) reflected completely by the glass in the aquarium.

5. The goldfish can see its mate as orange because its \_\_\_\_\_ were stimulated, resulting in \_\_\_\_\_ being transmitted by the fish's optic nerve to its brain.

- a) cones; proton ( $H^+$ ) gradients
- b) cones; action potentials
- c) rods; action potentials
- d) rods; ATP
- e) cones; ATP

**Use the following information to answer the next 7 questions:**

Microbiologists have observed that many spirochetes (undulating whip-shaped bacteria) often cluster on the surface of a larger cell where they beat in unison and propel the larger cell forward. Biologist Lynn Margulis has hypothesized that ancient spirochetes integrated into (eukaryotic) protozoan cells where they received nutrients from their host's cytoplasm. In turn, the spirochetes gave their host protozoa greater motility. The Margulis Hypothesis postulates that many present-day motile protozoa possess whip-shaped cilia and flagella because of that ancient integration of spirochetes into protozoa.

6. The Margulis Hypothesis is similar to the process of \_\_\_\_\_ postulated for the origin of mitochondria and chloroplasts, involving \_\_\_\_\_ for both species.

- a) endosymbiosis; the founder effect.
- b) endosymbiosis; coevolution.
- c) endosymbiosis; exocytosis.
- d) coevolution; parasitism.
- e) coevolution; the Good Genes Hypothesis.

7. A highly publicized spirochete is *Borrelia burgdorferi*, the agent of Lyme disease. Microbiologists can distinguish the cytoplasm of *Borrelia* from that of the macrophages engulfing them because all macrophages possess...

- a) DNA.
- b) cell membranes.
- c) cell walls.
- d) ribosomes.
- e) mitochondria.

8. Unlike people, termites are capable of using cellulose (from wood) for food. This occurs because flagellated protozoa, known as *Trichonympha*, reside in the termite gut. *Trichonympha* are capable of digesting cellulose into glucose. *Trichonympha* are safe from predators and have access to nutrients that travel through the termite's gut. You would hypothesize that this relationship between these two species is a result of...

- a) coevolution.
- b) eutrophication.
- c) adaptive radiation.
- d) the founder effect.
- e) biomagnifications.

9. Cellulose in the termite gut originally came from tree cells in which carbon dioxide (CO<sub>2</sub>) had been fixed into glucose that gained its energy directly from...

- a) ATP.
- b) NADPH.
- c) oxygen (O<sub>2</sub>).
- d) both a and b
- e) all of the above.

10. When *Trichonympha* reside in parts of the termite gut that are anaerobic (without oxygen), you would hypothesize that digested cellulose can be used to synthesize ATP only by means of \_\_\_\_

- a) photosystem II.
- b) chemiosmosis.
- c) glycolysis.
- d) the Krebs Cycle.
- e) the Calvin Cycle.

11. To undulate rapidly, the whip-like flagella on *Trichonympha* require a large amount of energy, for which \_\_\_\_ is the immediate source.

- a) ATP
- b) ADP
- c) CO<sub>2</sub>
- d) glucose
- e) sunlight

12. Just as macrophages engulf bacteria by phagocytosis, *Trichonympha* ingest cellulose by engulfing wood fibers into their cytoplasm: Both processes are classified as types of...

- a) exocytosis.

- b) endocytosis.
- c) secretion.
- d) osmosis.
- e) facilitated diffusion.

13. Which of the following processes will increase the amount of CO<sub>2</sub> in the atmosphere?

- a) the light-dependent reactions of photosynthesis
- b) the Calvin cycle in photosynthesis
- c) the Krebs cycle in cellular respiration
- d) the electron transport chain in cellular respiration
- e) glycolysis

14. What is the source of phosphorus found in the DNA of a deer (an herbivore)?

- a) grass in the diet
- b) meat of tertiary consumers in the diet
- c) atmospheric phosphorus obtained by breathing
- d) phosphorus produced at the end of the electron transport chain in the mitochondria
- e) water breakdown in the mitochondria

15. Which of the following statements regarding the nitrogen cycle is incorrect?

- a) All organisms have nitrogen in their nucleic acids (e.g. DNA and RNA).
- b) All organisms have nitrogen in their proteins.
- c) The nitrogen found in plant proteins is absorbed directly from the atmosphere.
- d) The nitrogen found in tertiary consumers comes directly from eating secondary consumers.
- e) Organic material in the soil is decomposed by bacteria into usable nitrogen that can be used by plants.

16. Which of the following diets would feed the fewest people if the same amount of land was used for production for each diet?

- a) beans and grain
- b) grain, eggs and milk
- c) all red meat from grain-fed animals
- d) grasshoppers

17. Under which of the following conditions will the most fish die in a lake that underwent eutrophication (algal bloom)?

- a) a very hot night
- b) a very cold night
- c) a very hot sunny day
- d) a very hot cloudy day
- e) a very cold sunny day

18. \_\_\_\_\_ produced by the algae in photosynthesis is used by fish to produce \_\_\_\_\_ in cellular respiration.

- a) proteins, fats
- b) RNA, DNA
- c) ATP, NADPH
- d) oxygen, ADP
- e) glucose, ATP

19. Which of the following takes place in photosynthetic algae but not in fish?



- a) ATP formation by chemiosmosis
- b) Cell division by mitosis
- c) Glycolysis
- d) Oxygen consumption
- e) NADP acts as the final electron acceptor for an electron transport chain

20. The lake was also contaminated with cyanide which interferes with one of the electron acceptors in the electron transport chain in the mitochondria. Which of the following will occur in the mitochondria of the fish?

- a) More production of ATP
- b) Less production of ATP
- c) Increased leakiness of the inner membrane
- d) More consumption of oxygen
- e) More consumption of CO<sub>2</sub>

**Use the following information for the next 9 questions**

Azaleas are green flowering plants, some of which produce a poison, called grayanotoxin, which is found in the nectar and the plant tissues. This species has very few natural predators. If bees gather nectar from the plant and produce honey, grayanotoxin is carried to the honey resulting in what is called “mad honey”. Grayanotoxin is known to bind to the sodium channel of the axon holding it open. As little as 3 ml nectar/kg body weight may be toxic or lethal.

21. If a person collected and ate “mad honey” you predict that...

- a) more action potentials would occur leading to seizures.
- b) fewer action potentials would occur leading to paralysis
- c) excess acetylcholine would be released.
- d) ATP synthesis would stop in his mitochondria leading towards paralysis.

22. Grayanotoxin is made in the cytoplasm of the plant cells. The immediate source of most of the energy to make this chemical comes from...

- a) ATP produced in the chloroplast.
- b) NADPH produced during photosynthesis.
- c) ADP produced during glycolysis.
- d) ATP produced in the mitochondria.

23. The red flower of an azalea appears red because...

- a) azaleas need to attract pollinators and so they mutate to do so.
- b) azaleas need to absorb more adaptive radiation.
- c) they must do so to survive and natural selection makes sure they do so.
- d) it improves counter-current exchange,
- e) red azaleas produce at least as many surviving offspring as others.

24. The green leaves of the azalea...

- a) capture the energy for photosynthesis primarily through absorbing green light.
- b) produce CO<sub>2</sub> through aerobic respiration only at night (when light is absent).
- c) produce O<sub>2</sub> through photosynthesis only during the day (when light is present).
- d) produce sugar only at night (when light is absent).
- e) both b and d.

25. A large bee and a small bee are both pollinating azalea flowers during a pleasant 23° C day. A

sudden blast of cold air ( $1^{\circ}\text{C}$ ) drastically cools the bees. The cooling was due to\_\_\_\_\_.

- a) convection
- b) conduction
- c) radiation
- d) thermogenesis

26. Both bees, described in the previous question, cannot fly when their body temperatures reach  $7^{\circ}\text{C}$ . Assuming that neither bee is an endotherm, predict which bee will be able to fly longer.

- a) the larger bee
- b) the smaller bee
- c) both bees will fall from the sky at the same time
- d) neither bee will cool off since they are homeotherms

27. The carbon that makes up the leaves and the stems of the azalea plant came primarily from...

- a) the soil.
- b) water.
- c) the air.
- d) the bee.
- e) the azalea seed.

28. A scientist hypothesizes that some azalea plants have more flowers because the plant is growing in soil that has high nitrogen content (an essential plant nutrient). To test the prediction, the scientist randomly selects 100 azalea plants and measures the nitrogen in the soil near their roots and counts the number of flowers on the plant. This is an example of what type of experiment?

- a) suggestive (theoretical)
- b) documented
- c) controlled
- d) correlational (observational)
- e) biased

29. To graph the data described in the previous question, you would plot \_\_\_\_\_ on the y-axis because it is the \_\_\_\_\_ variable.

- a) number of flowers, independent
- b) number of flowers, dependent
- c) nitrogen concentration, independent
- d) nitrogen concentration, dependent

**Use the following information for the next 3 questions.**

Assume that the color of the flower in a certain type of azalea is controlled by a single gene and two alleles for that gene exist. Individuals that are homozygous for the first allele have yellow flowers and individuals that are homozygous for the second allele have red flowers. The two alleles are codominant and the resulting flower is orange.

30. How many genotypes and phenotypes are possible?

- a) two genotypes and four phenotypes
- b) three genotypes and two phenotypes
- c) three genotypes and three phenotypes
- d) four genotypes and three phenotypes
- e) two genotypes and three phenotypes

31. What would be the result of cross-pollinating (breeding) a plant with yellow flowers with a plant with

orange flowers?

- a) 25% red, 50% orange, 25% yellow
- b) all yellow
- c) all orange
- d) 50% orange, 50% yellow
- e) 25% red, 25% orange, 50% yellow

32. Which of the following would you hypothesize is the mechanism resulting in the orange color?

- a) DNA from the red and yellow alleles combine to make a new gene prior to transcription.
- b) The RNA produced from the red and yellow allele combine to make a new longer protein.
- c) Both alleles are expressed resulting in proteins, each of which results in a pigment. The combination of the pigments provides the new color.
- d) The DNA from the red allele interferes with the signal that results in the transcriptional translation of the yellow allele resulting in no RNA production. The resulting protein would then always be orange.

**Use the following information to answer the next 4 questions:**

A population of spiders (50 individuals), which inhabits a 1,000 square meter meadow, is monitored for many years. The first year the population experienced 500 births and 100 deaths. Later, it was determined that the carrying capacity of the meadow is 2000 spiders.

33. If this population is undergoing exponential growth, what is  $r$  (the growth rate) for this population for the first year it is monitored?

- a) 0.8 individuals per individual per year
- b) 1.0 individuals
- c) 8 individuals per individual per year
- d) 100 individuals
- e) 400 individuals per individual per year

34. If this population is undergoing exponential growth, what is  $G$  (the population growth increment) for the first year?

- a) 10 individuals
- b) 100 individuals
- c) 400 individuals
- d) 1,000 individuals
- e) 2,000 individuals

35. As the population of spiders increased, the population of a lizard that feeds on the spider also increased. This is an example of...

- a) a density-independent control factor
- b) a density-dependent control factor
- c) an emerging disease
- d) an epidemic

36. After several years and in the presence of the lizards, the population of spiders is 2004, you would predict that in the following year...

- a) the growth increment ( $G$ ) will be near 0.
- b) the growth increment ( $G$ ) will be the same as the first year.
- c) the growth increment will be larger than the first year since the population is now larger.
- d) the carrying capacity will continue to increase as the size of the population increases.

37. These spiders produce a venom that contains the neurotoxin JSTX. The neurotoxin blocks the postsynaptic receptor for glutamate, a neurotransmitter in insects. You would predict that the toxin results

in...

- a) too many action potentials leading towards seizures.
- b) too few action potentials leading towards paralysis.
- c) too little ATP available in the synapse.
- d) creation of metabolic water.

**Use the following information to answer the next 4 questions:**

These four siblings have the following blood types:

Leonardo—Type O      Katherine—Type B

Isaac—Type A      Holly—Type AB

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38. Could all four siblings have the same biological parents? Yes, if...

- a) Father is homozygous type A; Mother is heterozygous type B.
- b) Father is heterozygous type A; Mother is heterozygous type B.
- c) Father is type AB; Mother is heterozygous type B
- d) Father is type O; Mother is type AB
- e) No, the same 2 people could not have produced all four children!

39. Which of the siblings can successfully donate blood to the other three without the recipient rejecting the donation by developing antibodies against the donor cells?

- a) Leonardo
- b) Katherine
- c) Isaac
- d) Holly
- e) None of the siblings could be such a donor.

40. If Holly someday marries a man with her blood type, what is the chance that their first child will also have that blood type?

- a) 0 %
- b) 25 %
- c) 50 %
- d) 75 %
- e) 100 %

**Use the following information for the next 2 questions.**

Insulin is produced in the pancreas and is released into the bloodstream to move throughout the body. It has several metabolic and vascular (related to the blood stream) effects on the body. One way that insulin regulates blood glucose levels is by causing fat and liver cells to take in glucose when the glucose concentration in the blood is too high. Imbalances in this system are known as diabetes. In one form of diabetes, type II, the insulin levels are in the normal range, but the blood sugar levels are still higher than normal.

41. Based on the description of insulin's movement and effects on the body, insulin is best described as a

- ...
- a) neurotransmitter.
  - b) glucotransmitter.
  - c) active transport protein.
  - d) hormone.

42. Which of the following would you predict could cause type II diabetes?

- a) The pancreas is producing too much insulin.
- b) The pancreas is not producing enough insulin.
- c) Insulin receptors on the cells are not responding to insulin.
- d) No antibodies to insulin are being produced.

43. Because leptin is a protein hormone of 167 amino acids, you would correctly predict that the messenger RNA transcript that coded for it consisted of \_\_\_\_ bases.

- a) 56
- b) 167
- c) 501
- d) 1503
- e)  $167^3$

**Use the following information for the next 4 questions.**

DNA sequence → C C C A C C G A C T T C C A T  
 nucleotide base # → 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

44. The sequence above represents a small central portion of a single DNA strand from the leptin gene. What is the correct amino acid sequence for which this portion of the gene codes?

- a) valine-lysine-leucine-tryptophan-glycine
- b) glycine-tryptophan-leucine-lysine-valine
- c) glycine-tryosine-isoleucine-lysine-valine
- d) proline-threonine-aspartate-phenylalanine-glutamate
- e) proline-aspartate-threonine-phenylalanine-asparagine

45. Within fat cells, the translation to the amino acid sequence you selected above occurs at the \_\_\_\_ after an RNA message has been transcribed within the \_\_\_\_.

- a) nucleus; smooth ER
- b) nucleus; ribosomes
- c) ribosomes; mitochondria
- d) ribosomes; nucleus
- e) ribosomes; rough ER

46. Molecular biologists use a method known as deamination to mutate the cytosine (C) bases on a DNA strand to uracil (U) bases. This DNA is then transcribed normally. One type of “site-directed mutagenesis” deamination protocol can mutate every third base (#3,#6, #9, etc) to uracil if cytosine is originally located there. If you used this method, you would predict that a mutation to what nucleotide base within the DNA sequence above would result in the translation of an ineffective or incomplete leptin protein?

- a) # 3
- b) # 6
- c) # 9
- d) # 12
- e) # 15

47. The molecular biologists isolated the normal (non-mutated) leptin genes and determined that 32% of their nucleotide bases were guanine (G). They could then correctly calculate that \_\_\_\_ of the bases in the

genes consisted of adenine (A).

- a) 68%
- b) 64%
- c) 36%
- d) 32%
- e) 18%

**Use the following information to answer the next 10 questions:**

The journal *Nature* reported recently that a team of paleontologists had discovered fossilized skeletal remains of snakes that lived in northern South America about 60 million years ago (the Paleocene Epoch). These enormous snakes, known by their genus *Titanoboa*, grew to an adult size of about 43 feet from nose to tail tip and weighed more than 2,500 pounds. In its time *Titanoboa* was the largest vertebrate on the post-dinosaur Earth. These non-venomous ectotherms were well adapted to aquatic habitats and were predominantly found in tropical ecosystems. They are thought to have fed predominantly on the giant sea turtles and crocodiles of that era, dispatching their prey by constriction—enwrapping and suffocating them—like modern boa constrictors and anacondas.

48. An adult *Titanoboa* emerges from its cool swamp on a sunny Paleocene day and promptly slithers onto a warm flattened boulder that increases its body temperature by means of...

- a) countercurrent exchange.
- b) adaptive radiation
- c) vasoconstriction.
- d) conduction
- e) convection

49. What metabolic change(s) probably had occurred to the *Titanoboa* between the time it was in the swamp until it had basked for 2 hours on the boulder, reaching ambient temperature?

- a) Its rate of ATP production increased.
- b) Its rate of metabolic water formation increased in mitochondria.
- c) Its rate of mitochondrial electron transport decreased.
- d) Both (a) & (b) are correct.
- e) No substantial metabolic changes had occurred.

50. If the adult *Titanoboa* was a female that was accompanied onto the boulder by an adolescent offspring (about ½ the adult's size), what would you predict was a reasonable time for the adolescent snake to warm itself to ambient temperature?

- a) 30 minutes
- b) 2 hours
- c) 4 hours
- d) 10 hours

51. Paleontologists who study the Paleocene Epoch have noted that, over that 11 million year time period, both *Titanoboa* skeletons and crocodile skeletons were becoming progressively larger and larger in size. Which of the following provides the best hypothesis for this?

- a) adaptive radiation.
- b) biomagnification.
- c) coevolution.
- d) the founder effect.
- e) gluttony.

52. Some species of *Titanoboa* may have ventured on "hunting trips" into the cooler waters of the higher

latitudes. These migratory snakes appear to have had primarily mammalian diets. You would hypothesize that this most likely occurred because...

- a) *Titanoboa* was adapted to feed only after a long migration.
- b) *Titanoboa* would digest endothermic prey more rapidly than ectothermic prey.
- c) mammals are generally better prey because they are slower than most reptilian prey.
- d) mammalian prey were better adapted to the cooler latitudes than smaller reptilian prey.
- e) *Titanoboa* that wanted to put on more weight selectively consumed mammalian prey.

53. Paleontologists supported the above hypothesis because of the discoveries of a higher proportion of mammalian skeletons associated with *Titanoboa* in cooler latitudes as compared to the proportion of similar skeletons in warmer latitudes. You would correctly conclude that the paleontologists' conclusions were due to the results of \_\_\_\_\_ experiments.

- a) observational
- b) irreproducible
- c) controlled
- d) thought
- e) both a and b

54. Adult *Titanoboas* would have survived longer than smaller species of snakes who ventured into the cooler waters of the high latitudes because, relative to smaller snakes, *Titanoboa*'s...

- a) greater surface area to volume ratio would permit them to cool off faster.
- b) greater surface area to volume ratio would permit them to cool off more slowly.
- c) smaller surface area to volume ratio would permit them to cool off faster.
- d) smaller surface area to volume ratio would permit them to cool off more slowly.

**Use the following information to answer the next 7 questions:**

An earthquake causes a nearby cliff to collapse, spilling large quantities of soluble phosphates and organic mercury compounds into the swamp inhabited by *Titanoboa*. A bloom of a formerly sparse species of algae (photosynthetic and often unicellular eukaryotes) rapidly appears. Many animals within the *Titanoboa* food chain become ill, and a massive fish kill occurs in the swamp.

55. The fish kill occurs after a long warm night. The most plausible hypothesis for fish mortality would be \_\_\_\_\_ following a night of algal \_\_\_\_\_.

- a) anoxia; photosynthesis
- b) starvation; respiration
- c) anoxia; respiration
- d) starvation; photosynthesis
- e) anoxia; meiosis

56. The appearance of the algal bloom would likely have been a consequence of \_\_\_\_\_ that resulted in the \_\_\_\_\_ biodiversity of species within the swamp.

- a) eutrophication; increased
- b) eutrophication; decreased
- c) adaptive radiation; increased
- d) adaptive radiation; decreased
- e) biomagnification; decreased

57. Crocodiles dwelling in the swamp normally fed on algae-eating jawless fish. If the adult *Titanoboa* feasted on a crocodile for lunch, this would mean that the *Titanoboa* acted as a \_\_\_\_\_ by eating a ...

- a) primary consumer; primary producer
- b) secondary consumer; primary consumer
- c) secondary consumer; tertiary consumer
- d) tertiary consumer; secondary consumer
- e) tertiary consumer; primary consumer

58. If 100 grams of algae consumed by the fish (see above question) had 500,000 calories (500 kcal) of energy, then you would predict that \_\_\_\_ of those calories would end up in the biomass of the *Titanoboa* population.

- a) 50
- b) 100
- c) 500
- d) 5,000
- e) 50,000

59. A mercury compound (first absorbed by the algae) appears within the *Titanoboa* (at the top of the fish's food chain) at twenty times its concentration within the fish. You would hypothesize that this difference was a consequence of ...

- a) biomagnification
- b) eutrophication
- c) endosymbiosis
- d) active transport
- e) a poor diet

**Use the following information for the next 2 questions.**

Although it can cause cancer and is extremely toxic, dinitrophenol has been used as a weight loss drug. This chemical makes the inner mitochondrial membrane “leaky” to protons (H<sup>+</sup>). In order to study the effects of the drug, a scientist over-feeds normal mice to make them obese. He then supplements their food with dinitrophenol. The scientist also studies cellular respiration in brown fat, which is responsible for non-shivering thermogenesis.

60. As the mice gained weight (fat), you would predict that leptin levels would \_\_\_\_\_ resulting in a (an) \_\_\_\_\_ in metabolism.

- a) increase; increase
- b) decrease; increase
- c) decrease; decrease
- d) increase; decrease

61. You would predict that as the dinitrophenol is affecting the mice the amount of ATP produced for each molecule of glucose used would \_\_\_\_\_.

- a) increase
- b) decrease
- c) stay the same

62. Following the experiment, the scientist catches the “rodent flu” from his work in the lab. While he is quarantined, he ponders why he caught this strain of flu just a few weeks after getting his flu shot. Which of the following is his best prediction?

- a) The antibodies given to him in the flu shot failed to make his macrophages produce more antibodies.
- b) The antigens given to him in the flu shot failed to make his macrophages produce antibodies.
- c) The antibodies given to him in the flu shot do not match the antibodies needed for the rodent flu.



- d) The antigens given to him in the flu shot do not match the antigens present in the rodent flu.
- e) Vaccines for the flu would only work to protect rodents from the rodent flu and humans from the human flu.

**Use the following information for the next 4 questions.**

Slatey-grey snakes are non-venomous snakes in a different family than the boa constrictors. Male slatey-grey snakes, *Stegonotus cucullatus* are much larger than females. After fertilization, which takes place internally, a female creates a nest, lays her batch of eggs in them, and leaves. When Drs. Sylvain Dubeya, Gregory P. Brown, Thomas Madsen, and Richard Shine studied these snakes they found that on average 2.3 males fertilized each batch of eggs.

63. You would interpret these data as supporting the conclusion that the mating system was closest to \_\_\_\_\_.

- a) Monogamous
- b) Polygamous

64. If male size was a result of sexual selection, you would predict that in any one batch of eggs, larger males fertilize \_\_\_\_\_ of the eggs in any one clutch.

- a) more
- b) fewer
- c) all
- d) none

65. One hypothesis for the presence of eggs fertilized by alternate males is that some fertilizations were performed by sneaky males. If you were testing this hypothesis, you would predict that sneaky males would be those that ...

- a) spend the most time guarding females.
- b) are the largest and strongest.
- c) fertilize the most eggs in a single clutch.
- d) perform mating dances most noticeably and attract the most females at once.
- e) are smaller males and less capable of fighting off others.

66. If the Handicap Hypothesis was the best explanation for body size in Slatey-grey snakes then you would correctly predict....

- a) the most successful males would be smallest.
- b) the most successful males would have the fewest offspring.
- c) the largest males would be the least likely to reproduce.
- d) some characteristic would place males with the greatest fitness at higher risk of death.
- e) the males with the highest fitness would reproduce least.

**Use the following information for the next 4 questions.**

Dr. Roe Dentia discovers a new overweight mutant mouse while researching the gene for the leptin receptor that results in severe obesity in Pima Indians. She names the phenotype squishy because of its large fat deposits. She also discovers that at position 326 in the gene a point mutation in codon 109 results in a lysine to arginine amino acid substitution.

67. If leptin levels in the squishy mutant were high, Dr. Dentia should hypothesize that...

- a) something blocked transcription of the leptin gene.
- b) something blocked translation of the leptin RNA.

- c) something blocked transcription of the leptin receptor gene.
- d) NPY no longer serves as an appetite suppressant.
- e) something increased the level of thyroxin.

68. Which of the mutations in the template DNA could result in the change in amino acids identified?

- a) TTC → TTT
- b) TTT → TTC
- c) TTC → TCC
- d) TTT → TTG
- e) TTC → TTG

69. How many amino acids would you predict Dr. Dentia would find in the polypeptide chain (protein) in front of the codon with the mutation?

- a) 108
- b) 167
- c) 326
- d) 978

70. Which of the following would you predict Dr. Dentia would find in the mitochondria of squishy mice?

- a) inner-mitochondrial membranes that are highly permeable to  $H^+$
- b) relatively high  $CO_2$  production
- c) relatively high  $O_2$  use
- d) slow rotation of ATP synthase molecules
- e) build up of  $FADH_2$

Use a #2 pencil to fill in the information on your NCS answer sheet. Put your **O-Key Account Username** in the boxes indicated for **LAST NAME** and darken the appropriate circles. **Write your Name (Last, First)** and **“Star”** in the space above the boxes containing your **O-Key Account Username**. Darken the (S) in the **last column of the name circles**. Enter the number **834** and **darken the corresponding circles in the first 3 columns of the “Student ID.”** Failure to perform this correctly will incur a **-10pt handling fee**. Read all questions and answers *carefully* before choosing the **single BEST response** for each question. Feel free to ask the instructor for clarification.

Use the following formulas and chart as needed.

$$r = \text{birth rate}(b) - \text{death rate}(d)$$

$$r = \frac{\text{births} - \text{deaths}}{N}$$

$$G = rN$$

$$G = rN \left( \frac{K - N}{K} \right)$$

mRNA-Codon-to-Amino-Acid Decoder Chart									
1 <sup>st</sup> Letter	2 <sup>nd</sup> Letter								3 <sup>rd</sup> Letter
	U		C		A		G		
U	UUU	Phenylalanine	UCU	Serine	UAU	Tyrosine	UGU	Cysteine	U
	UUC		UCC		UAC		UGC		C
	UUA	Leucine	UCA		UAA	STOP	UGA	STOP	A
	UUG		UCG		UAG		UGG	Tryptophan	G
C	CUU	Leucine	CCU	Proline	CAU	Histidine	CGU	Arginine	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	Glutamine	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	Isoleucine	ACU	Threonine	AAU	Asparagine	AGU	Serine	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	Lysine	AGA	Arginine	A
	AUG	Methionine; START	ACG		AAG		AGG		G
G	GUU	Valine	GCU	Alanine	GAU	Aspartate	GGU	Glycine	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	Glutamate	GGA		A
	GUG		GCG		GAG		GGG		G

**Use the following information to answer the next 9 questions.**

Rough skinned newts, an amphibian that lives in the western US, has few predators due to the potent toxin, tetrodotoxin or TTX, they produce in their skins. The toxin from one newt is potent enough to kill 12 humans. One of the few organisms that can eat the newt is the common garter snake. Although these snakes often eat the newt with no effect, sometimes the snake is poisoned. In one recent study, scientists compared the concentration of toxin in newts from 28 different areas to the level of resistance to TTX found in snakes from the same areas. In most cases, the snakes' level of resistance very closely matched the concentration of TTX in the newts. When resistance matches toxin concentrations, the toxin temporarily slows the snake down but isn't enough to kill it.

1. It appears that as the snakes evolve to become more resistant to TTX, the newts in the same region evolve to make more of the toxin. This is an example of...

- a) adaptive radiation.
- b) coevolution.
- c) the founder effect.
- d) thermogenesis.
- e) x-linked inheritance.

2. TTX causes its toxic effect by blocking the  $\text{Na}^+$  channel in the axon of the nerve. You would predict that neurons in a human poisoned by TTX would...

- a) have more action potentials leading to paralysis.
- b) have more action potentials leading to seizures.
- c) have fewer action potentials leading to paralysis.
- d) have fewer action potentials leading to seizures.

3. In another study, the garter snakes from a specific region were found to be completely resistant to TTX. These snakes have a single mutation in the gene that codes for the  $\text{Na}^+$  channel protein. The mutation results in a new form of the  $\text{Na}^+$  channel protein that has a serine in the position that was phenylalanine. TTX does not bind to this new form of the protein. Which of the following changes in DNA would result in that change in amino acid?

- a) UUC to UCC
- b) AAG to GAG
- c) UUC to UUA
- d) UUC to AGG
- e) AAG to AGG

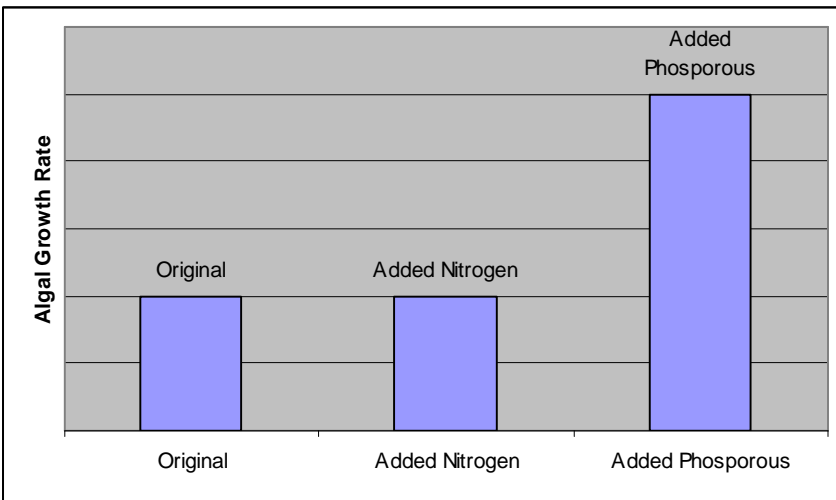
4. Which of the following best describes how the  $\text{Na}^+$  channel protein would be produced?

- a) translation in the nucleus, transcription in the mitochondria
- b) transcription in the nucleus, translation in the rough ER
- c) translation in the nucleus, transcription in the rough ER
- d) exocytosis into the synapse

5. When a scientist looks at the garter snake, the yellow stripe appears yellow because...
- a) yellow light is absorbed by the snake's skin and then all other colors are absorbed by the rods in the scientist's eyes.
  - b) yellow light is reflected by the snake's skin and is absorbed by the rods in the scientist's eyes.
  - c) yellow light is reflected by the snake's skin and is absorbed by the cones in the scientist's eyes.
  - d) yellow light is absorbed by the snake's skin and then all other colors are absorbed by the cones in the scientist's eyes.
6. As temperatures grow colder, the metabolism of snakes (ectotherms) will...
- a) increase since the snake is outside of its thermal-neutral zone.
  - b) increase due to thermogenesis.
  - c) decrease due to thermogenesis.
  - d) decrease due to lower enzyme activity.
7. The scientists are also interested in the food web involving the snakes and newts. Assuming the newts primarily eat earthworms and the snakes primarily eat the newts, which of the following rankings (starting with the most biomass and decreasing to the least biomass) would you predict for this simplified food web?
- a) earthworms – snakes – newts
  - b) snakes – newts – earthworms
  - c) newts – snakes – earthworms
  - d) snakes – earthworms - newts
  - e) earthworms – newts – snakes
8. On a hot afternoon, a newt climbs under a rock to avoid direct sunlight heating its body through \_\_\_\_\_. The body of the newt is also cooled by contact with the cool soil through \_\_\_\_\_.
- a) evaporation; conduction
  - b) conduction; convection
  - c) radiation; convection
  - d) radiation; conduction
  - e) convection; radiation
9. The neurons (nerve cells) of the newt have 24 chromosomes. How many chromosomes would be in an unfertilized newt egg?
- a) 6
  - b) 12
  - c) 24
  - d) 48

Use the following information to answer the next 7 questions.

A student is trying to develop a new research project studying algae and their use of photosynthesis. In order to perform his experiments, he must learn to grow the algae in a laboratory. In his first attempt, he follows a recipe published by another researcher to make a growth solution containing water and nutrients, but the algae grew very slowly. Next, he conducted an experiment to test his hypothesis that the original growth solution does not have rapid algae growth because not enough of either nitrogen or phosphorous was in the solution. In his experiment, he measured algae growth in the original growth solution, the original growth solution plus nitrogen, and the original growth solution plus phosphorous. Algae in the original growth solution grew slowly as did the treatment with nitrogen added. However, in the treatment that phosphorous had been added, the algae grew very rapidly.



10. The experimental design the student used is an example of...

- a) pseudoscience experiment.
- b) a controlled experiment.
- c) a correlational experiment.
- d) logistical experiment.
- e) an observational experiment.

11. Based on these experiments, you could predict that...

- a) phosphorous was limiting in his initial growth solution.
- b) nitrogen was limiting in his initial growth solution.
- c) algae doesn't need nitrogen to grow.
- d) algae doesn't need phosphorous to grow.

12. Once the student had a growth solution that provided everything the algae needed to grow, he decided to put a very small number of algae in a large container so that all resources are available for many generations of growth. During the first few generations, you expect the growth curve to appear...

- a) j-shaped (exponential).
- b) s-shaped (logistic).
- c) l-shaped (probabilistic).
- d) flat - no growth will occur since the container is too large.

13. The student has his light system on a timer so that the lights turn on at 8:00 am in the morning and turn off at 10:00 pm at night. Following many days of growth, there is a great deal of algae in the jar. Each morning (8:00 am) and evening (7:00 pm) he measured the oxygen dissolved in the growth solution. You would predict that...

- a) the oxygen concentration is lower in the morning and higher in the evening.
- b) the oxygen concentration is higher in the morning and lower in the evening.
- c) oxygen levels do not change.

14. If the algae were in a pond and part of a natural food web, it would be considered a \_\_\_\_\_ and would occupy a \_\_\_\_\_ trophic level.

- a) secondary consumer; high
- b) primary consumer; low
- c) primary producer; high
- d) primary producer; low
- e) primary consumer; high

15. Algae are primarily made of organic molecules (carbon based). What is the environmental source of this carbon \_\_\_\_\_. (hint: environmental means originating outside of the organism)

- a) glucose
- b) amino acids
- c) oxygen
- d) carbon dioxide
- e) carbon tetrachloride

16. One hour after the light was turned off and the algae were in the dark, you would correctly predict that...

- a) ATP synthase in the mitochondria would no longer be active.
- b) protons would no longer be pumped into the thylakoid space of the chloroplast.
- c) O<sub>2</sub> would continue to be produced in the chloroplast.
- d) sugar will still be created through the Calvin cycle.
- e) CO<sub>2</sub> production in the mitochondria will stop.

17. If the thylakoid membranes in a chloroplast become leaky and allow protons to easily pass, you would correctly predict which of the following would occur?

- a) Production of ATP will increase.
- b) Production of ATP will decrease.
- c) Sugar production will remain stable
- d) NADPH production will stop.
- e) both a and c

**Bigfoot – The Final Adventures (Next 5 questions)**

18. For the Big Foot population that lives in Georgia, hair on their upper lip (mustache area) is a dominant autosomal trait, while a bare upper lip is a recessive autosomal trait. A hairy-lipped male and a hairy-lipped female have 8 offspring. Three of the offspring have bare lips and 5 have hairy lips. What is the genotype of the parents?

- a) Both are homozygous recessive.
- b) Both are homozygous dominant.
- c) Both are heterozygous.
- d) One was homozygous dominant and the other heterozygous.
- e) Hairy-lipped parents cannot have bare-lipped offspring.

19. Bigfoot hunters observed a different Big Foot family. In this case, both the male and the female had bare upper lips. They also noted that the female had a baby with a hairy upper-lip. Which of the following statements is likely correct?

- a) The species is strictly monogamous and the observed adults are parents to all the children.
- b) The observed baby is genetically haploid.
- c) The observed male cannot be the father of the baby.
- d) The offspring are different phenotypes due to the “good gene” hypothesis.
- e) Both a and d are correct.

20. A viral disease similar to chicken pox is common in juvenile Big Foot. Each individual usually only has symptoms of this disease once in their lifetime. Which of the following would you predict?

- a) This disease causes mutations that cause macrophages to evolve into a more potent form.
- b) After the first infection, macrophages immediately recognize the virus that causes the infection during the second infection.
- c) After the first infection, memory B-cells are present that can engulf the virus.
- d) After the first infection, memory B-cells are present that can recognize antibodies on the virus resulting in a quick response to the infection.
- e) After the first infection, memory B-cells are present that can recognize antigens on the virus resulting in a quick response to the infection.

21. As Big Foot walks through the woods, you would correctly predict that the chemical reaction/process that **directly** powers the leg muscles is (are) ...

- a)  $ADP + P \rightarrow ATP + \text{Energy}$
- b)  $ATP \rightarrow ADP + P + \text{Energy}$
- c)  $\text{pyruvate} \rightarrow \text{Glucose} + \text{Energy}$
- d)  $NADPH \rightarrow NADP + H + \text{Energy}$
- e)  $NAD + FADH_2 + \text{Energy} \rightarrow NADH_2 + FAD + P$



22. Unwittingly, a Big Foot ate some berries that contain a toxin that prevents the electron transport chain in the mitochondria from accepting electrons from NADH and FADH<sub>2</sub>. After the poisoning, which of the following would you correctly predict?

- a) After several minutes, ATP production will decrease then stop.
- b) CO<sub>2</sub> and H<sub>2</sub>O will continue to be released.
- c) The Calvin cycle will stop.
- d) O<sub>2</sub> will continue to be consumed.
- e) H<sub>2</sub>O will continue to be consumed.

**Use the following information to answer the next 2 questions.**

In the cichlid fish, *Cichlasoma citrinellum*, males and females both tend the young, which stay with the parents for 4-6 weeks. The young fish feed on the mucous secreted from the skin of their parents. Another cichlid fish, *Pseudocrenilabrus nicholsi*, is a mouthbrooder, which means that the females carry the young around for several weeks in their mouths and are solely responsible for their care.

23. Which would you correctly predict is monogamous?

- a) *Cichlasoma citrinellum*
- b) *Pseudocrenilabrus nicholsi*
- c) both
- d) neither

24. Under the circumstances described above, you would correctly predict that in *Cichlasoma citrinellum*

- a) the males would have greater fitness than the females because they produce more gametes.
- b) the females would have greater fitness because they produce the eggs and those are what are fertilized.
- c) the males fitness is substantially lower than the females because they are prevented from fertilizing the eggs of other females.
- d) the males and females have equal fitness because they are each raising the same number of offspring.

25. The MHC genes encode proteins that are very important in the immune response.

Individuals that have a greater diversity in the alleles for the MHC genes can respond to a greater number of pathogens. In sticklebacks, a fish, when females choose a mate, they select males with the most diverse set of MHC alleles. This would be predicted by the \_\_\_\_\_ hypothesis.

- a) good genes
- b) handicap
- c) both
- d) neither

26. A section of double-stranded DNA has 90 nucleotides. For how many amino acids will you predict that the **template strand** of this DNA codes?

- a) 10
- b) 15
- c) 30
- d) 90

27. In the axon of a neuron at resting potential, a higher concentration of \_\_\_\_\_ is present on the outside of the cell membrane, which requires \_\_\_\_\_.

- a)  $K^+$ ; passive transport
- b)  $K^+$ ; active transport
- c)  $Na^+$ ; passive transport
- d)  $Na^+$ ; active transport
- e)  $Na^+$ ; diffusion

**Use the following information to answer the next 4 questions.**

A scientist, who was interested in cold tolerance of the arctic fox, placed a fox in a room held at  $-60^{\circ}C$ . Although the fox easily survived and was uninjured, its metabolism was measured to be twice as high during the exposure to the cold compared to during warmer temperatures.

28. You would correctly predict that...

- a)  $-60^{\circ}C$  was below the foxes thermal neutral zone.
- b)  $-60^{\circ}C$  was within the foxes thermal neutral zone.
- c) The foxes enzymes quit working and resulted in an elevated metabolic rate.
- d) The foxes blood vessels dilated allowing full flow of blood to the extremities.

29. During the test, the fox curled up into a ball. This body position...

- a) effectively increased his surface to volume ratio thus reducing the rate of heat loss.
- b) effectively decreased his surface to volume ratio thus reducing the rate of heat loss.
- c) effectively increased his surface to volume ratio thus increasing the rate of heat loss.
- d) effectively decreased his surface to volume ratio thus increasing the rate of heat loss.

30. A population of arctic foxes was discovered on an island. The foxes in the island population are smaller and males and females are dimorphic. Which of the following would best demonstrate that although population differences are present, they are still the same species as the mainland arctic foxes?

- a) They eat the same food.
- b) They have the same mating rituals.
- c) After cross-breeding, their offspring are fertile.
- d) They are both cold-tolerant.
- e) They have the same thermal neutral zone.

31. Both male and female arctic foxes have short snouts, compact bodies, thick fur coats, and counter current blood vessel mechanisms. You predict that these adaptations...

- a) are the result of natural selection and provide greater fitness in a cold environment.
- b) are the result of sexual selection and provide greater fitness in a cold environment
- c) are the result of sexual selection and expands the thermal neutral zone of the fox.
- d) allow the fox to have a lower critical temperature of their thermal neutral zone as compared to foxes that do not have these adaptations and live in warmer environments.
- e) both a and d

32. In a park in Chicago there are squirrels and their fur color is affected by a single gene. The allele for brown fur is dominant over the allele for grey fur. When you started your study you observed that the numbers of brown squirrels and grey squirrels are equal. You calculated their birth (b) and death (d) rates and discover that for grey squirrels  $b = 1.1$  squirrels/squirrel/year and  $d = 0.3$  squirrels/squirrel/year. For brown squirrels  $b = 1.1$  squirrels/squirrel/year and  $d = 0.1$  squirrels/squirrel/year. You correctly predict that ....

- a) natural selection will cause future populations to have more brown squirrels.
- b) natural selection will cause future populations to have more grey squirrels.
- c) there are now two species of squirrels.
- d) the squirrel population is not growing.

33. As an action potential moves through an axon, first the \_\_\_\_\_ resulting in the outside of the neuron becoming less positive, then the \_\_\_\_\_ allowing the membrane to become positive on the outside again.

- a)  $\text{Na}^+$  gate closes;  $\text{K}^+$  gate closes
- b)  $\text{Na}^+$  gate opens;  $\text{K}^+$  gate closes and  $\text{Na}^+$  gate opens
- c)  $\text{Na}^+$  gate opens;  $\text{Na}^+$  gate closes and  $\text{K}^+$  gate opens
- d)  $\text{K}^+$  gate opens;  $\text{Na}^+$  gate opens
- e)  $\text{K}^+$  gate opens,  $\text{Na}^+$  gate closes

34. The **final** products of cellular aerobic respiration are ...

- a)  $\text{O}_2$  and ATP.
- b)  $\text{CO}_2$ , ATP, and  $\text{H}_2\text{O}$ .
- c)  $\text{CO}_2$  and ATP.
- d)  $\text{CO}_2$ , NADPH, and  $\text{H}_2\text{O}$ .
- e)  $\text{O}_2$ , ATP and  $\text{H}_2\text{O}$ .

35. A double-stranded segment of DNA has 200 nucleotides and 40 of them are Thiamine. How many are Guanine?

- a) 40
- b) 60
- c) 80
- d) 120
- e) 160

36. In a local park there is a population of chipmunks and a population of squirrels. For the chipmunks the birth rate (b) is 1.0 chipmunks/chipmunk/year and the death rate (d) is 0.9 chipmunks/chipmunk/year. For the squirrels b is 0.6 squirrels/squirrel/year and d is 0.2 squirrels/squirrel/year. You correctly predict that ...

- a) the population growth rate (r) is higher for squirrels than for chipmunks.
- b) the population growth rate (r) is lower for squirrels than for chipmunks.
- c) the population growth rate (r) is equal for squirrels and chipmunks.
- d) you don't have enough information to compare population growth rates.

37. You have tickets to see the OSU Cowboys play in the Ice Bowl in Fargo, North Dakota. Before the game there is an outdoors tailgate party. You were smart and wore a thick coat that keeps you warm by preventing \_\_\_\_\_ caused by the cold wind.

- a) conduction.
- b) convection.
- c) a gradient.
- d) evaporation.
- e) countercurrent exchange

38. Alcohol causes our blood vessels to dilate (vasodilation). If you drink alcohol while outside at this cold tailgate party, **initially...**

- a) your core temperature will get higher.
- b) the temperature of your fingers will get colder
- c) the temperature of your fingers will get warmer
- d) a & b
- e) a & c

39. Santa Claus with his large belly has a \_\_\_\_\_ surface area to volume ratio than a skinnier person and this causes him to more \_\_\_\_\_ lose heat to the cold outside temperatures at the North Pole.

- a) smaller; quickly
- b) larger; quickly
- c) smaller; slowly
- d) larger; slowly

40. Plants can benefit by having multiple types of pigments because they ...

- a) are harder for insects to find.
- b) absorb more wavelengths of light.
- c) taste bad for herbivores.
- d) have increased rates of respiration.
- e) reflect more wavelengths of light.

41. When you get a flu shot you are injected with \_\_\_\_\_ which protects you against future infections by causing the production of \_\_\_\_\_.

- a) antigens; B memory cells
- b) antibodies; B memory cells
- c) macrophage; B memory cells
- d) antigens; macrophages
- e) antibodies; neurotransmitters

42. Energy in trophic systems ...

- a) cycles from producers to consumers and back to producers.
- b) is perfectly converted when one animal consumes another.
- c) all originally comes from the Sun.
- d) comes from weathered rocks.
- e) comes from N and P.

43. Which of the following cycles does not have an atmospheric phase?

- a) H<sub>2</sub>O
- b) N
- c) P
- d) C

44. Photosystem II, and its associated electron transport chain in the thylakoid, pumps \_\_\_\_\_ into the thylakoid space.

- a) protons (H<sup>+</sup>)
- b) P
- c) ADP
- d) electrons
- e) H<sub>2</sub>O

45. A gradient is ...

- a) a density of protons.
- b) a difference in concentrations.
- c) an amount of protons.
- d) an equal concentration of solutes.
- e) a lack of potential energy.

46. Your blood type is A and your sister's is B. What two genotypes can your parents be?

- a) AA and AB
- b) BB and Ao
- c) AA and Bo
- d) Ao and Bo
- e) AB and BB

47. If your blood type is A you can not receive a transfusion of blood type B because ...

- a) the B blood cells will produce the wrong antibodies.
- b) the B blood cells will not produce the memory cells that you need.
- c) that blood will contain macrophages that will attack your body.
- d) your immune system will attack blood cells with the B antigen.
- e) your immune system will attack blood cells with the A antigen.

48. Male pattern baldness is an X-linked recessive trait. Your dad and sister both have the trait (they are bald), but your mom does not. What is the probability you will have the trait?

- a) 0%
- b) 25%
- c) 50%
- d) 75%
- e) 100%

49. There is a population of prairie chickens that for many years was at their carrying capacity (K) of 200 individuals. A series of tornadoes struck the population and reduced the number of individuals (N) to 80 prairie chickens. If their birth rate (b) is 1.2 chickens/chicken/year and their death rate (d) is 0.2 chickens/chicken/year, then how large will the population be one year after the tornadoes struck?

- a) 90 chickens
- b) 128 chickens
- c) 138 chickens
- d) 160 chickens
- e) 200 chickens

50. Many years later the population has once again reached its carrying capacity of 200. Based on the logistic model, you correctly conclude that this means that...

- a) the birth rate (b) is 0.
- b) the death rate (d) is 0.
- c) the growth increment (G) is 0.
- d) the population is decreasing.
- e) the population is growing exponentially.

**Use the following information to answer the next 8 questions.**

A farmer starts a field of corn from seeds. The seeds will germinate and develop into plants that will produce kernels to feed cows that in turn are eaten by humans. In order to increase the yield of the crop the farmer adds fertilizer to the soil (the fertilizer contains nitrogen and phosphorus) and sprays the plants with a bioaccumulating pesticide that kills insects that eat the corn kernels.

51. As corn plants and cows grow larger the new cells in the corn plant are produced by \_\_\_\_\_ and new cells in cows are produced by \_\_\_\_\_.

- a) meiosis, mitosis
- b) meiosis, meiosis
- c) mitosis, meiosis
- d) mitosis, mitosis

52. In the trophic food pyramid described above, corn plants are \_\_\_\_\_, corn-eating insects are \_\_\_\_\_ and cows are \_\_\_\_\_.

- a) producers, secondary consumers, secondary consumers
- b) producers, secondary producers, tertiary producers
- c) producers, primary consumers, primary consumers
- d) primary consumers, secondary consumers, tertiary consumers
- e) primary consumers, primary consumers, secondary consumers

53. In which organism's tissues will you find the lowest levels of the pesticide?

- a) humans
- b) insects
- c) cows
- d) corn
- e) All organisms will have about the same level of the pesticide.

54. \_\_\_\_\_ produced by corn plants in photosynthesis is used by cows to produce \_\_\_\_\_ in cellular respiration.

- a) oxygen, glucose
- b) RNA, DNA
- c) ATP, NADPH
- d) proteins, fats
- e) glucose, ATP

55. Which of the following statements is **incorrect**?

- a) Cows conduct cellular respiration in the dark and in the light.
- b) Corn plants conduct cellular respiration in the dark and in the light.
- c) Corn plants conduct photosynthesis in the light and cellular respiration in the light and dark.
- d) Corn plants conduct cellular respiration only in the dark and photosynthesis only in the light.
- e) Insects conduct cellular respiration in the dark and in the light.

56. The phosphorus and nitrogen in the fertilizer used in the field may run off into a lake. This may result in \_\_\_\_\_.

- a) lower oxygen levels during the day than at night
- b) an initial reduction of algal growth
- c) eutrophication
- d) an increase in species diversity
- e) a, b and c

57. When insects eat corn, they use the carbon containing molecules in the kernels to fuel their own metabolism by respiration. Their respiration releases \_\_\_\_\_.

- a) glucose
- b) CO<sub>2</sub>
- c) nitrogen
- d) phosphorus
- e) CO<sub>2</sub> in the day and nitrogen in the night

58. Which of the following human diets would require the most amount of energy to produce?

- a) Diet of only corn
- b) Diet of only cow meat
- c) Diet of cow meat and corn
- d) None of the above. Human diets do not require energy input.
- e) All diets have the same ecological impacts if they have the same level of calories.

59. What is the effect of plants on the global water cycle?

- a) They evaporate water during the night and absorb water vapor during the day
- b) They absorb water vapor from the atmosphere
- c) They evaporate water into the atmosphere
- d) Plants do not participate in the water cycle

**Use the following information to answer the next 8 questions.**

An elderly woman fell in her home and was not discovered for several days. Despite carefully watching her diet, the woman had gained much weight over the years, which may have cushioned the fall and prevented her from breaking any bones. However, it also prevented her from getting up, which resulted in her developing a severe sore on her side. When she was hospitalized she was suffering from dehydration, pneumonia, and systemic sepsis (i.e. a bacterial infection throughout her body) caused by *Staphylococcus aureus*. She was treated with a broad range of antibiotics for 4-6 weeks. Following the treatments and not eating for a few days, the woman began to have intestinal spasms (seizures), which the doctors treated with Clonidine. Another possible cause of her intestinal problem was “C Diff”, a bacterium (*Clostridium difficile*), which is a normal inhabitant of human intestines, but could have taken over in her intestines causing diarrhea. C Diff is only a problem following long-term treatment with antibiotics. The woman’s son was very concerned about her, as one might expect, and had many long conversations with the physicians caring for her, relying on his knowledge of basic biology to understand the ailments and treatments.

60) Which of the following hypotheses could account for her weight gain before her accident?

- a) She produced too much leptin.
- b) She produced too little leptin.
- c) She has leptin receptors that no longer work.
- d) She has uncoupler proteins that are too effective.
- e) Both b and c.

61) Which of the following could test if the problem was that she was homozygous recessive for the leptin producing gene (i.e. more likely to be obese)?

- a) Check to see if any of her children were obese.
- b) Check to see if all of her children were obese.
- c) Inject leptin and see if she loses weight.
- d) Measure the flow of electrons in her mitochondria.



62) Which of the following hypotheses is most likely the way in which the Clonidine prevents the intestinal spasms (seizures)?

- a) By reducing the release of the neurotransmitter
- b) By increasing the release of the neurotransmitter
- c) By blocking the breakdown of the neurotransmitter
- d) By mimicking the neurotransmitter
- e) By blocking the reuptake of the neurotransmitter

63) Which of the following hypotheses best explains why *Clostridium difficile* do not adversely affect the people that they normally inhabit?

- a) There is no reason for it to reproduce and pass along its genes.
- b) Anaerobic bacteria are incapable of reproducing.
- c) We are born with immunity to it.
- d) There is normally high bacterial species diversity in human intestines, and when species diversity is high the populations of each individual species are small.
- e) Because of bioaccumulation the bacteria are able to absorb large amounts of antibiotics and become immune to them by producing antibodies using their rough endoplasmic reticulum.

64) Once antibiotics eliminated the other species of bacteria, you would correctly predict that the *Clostridium difficile* population would increase \_\_\_\_\_ in this almost ideal environment.

- a) exponentially
- b) logistically
- c) logarithmically
- d) linearly
- e) liturgically

65) Which of the following hypotheses best explains why *Clostridium difficile* grew uncontrollably in this woman?

- a) She already has memory cells that are specific to it.
- b) She cannot make proteins.
- c) The elderly have reduced immune responses.
- d) Her macrophages can not release antigens.
- e) Her intestinal cells lack mitochondria.

66) For the sore on her hip to heal, through production of new healthy cells, which of the following processes was **NOT** necessary?

- a) mitosis
- b) meiosis
- c) DNA replication
- d) protein synthesis
- e) transcription

67) The woman received her medicines intravenously and they were mixed in a 1.0% saline solution that prevents osmosis. You would correctly predict that if the solution was instead 0.5%, the cells surrounded by that solution would...

- a) gain water and swell.
- b) lose water and swell.
- c) gain water and shrink.
- d) lose water and shrink.
- e) remain unaffected because the cell membranes are impermeable to water.

68. You were recently hired by an agribusiness firm to investigate how to increase the yields (number of tomatoes) of tomato plants. Your boss has some ideas and shows you the results of an experiment he did. In a greenhouse, he manipulated conditions and found that plants grown at 70° F with nitrogen added to the soil yielded an average of 40.2 tomatoes while plants grown at 80° without nitrogen added to the soil yielded an average of 31.1 tomatoes. You conclude that your boss...

- a) should use a correlational experiment for these variables.
- b) has incorrectly designed a controlled experiment.
- c) needs a larger sample size.
- d) has not identified a dependent variable.
- e) needs to vary more independent variables.

69. While observing the tomato plants in the greenhouse, you notice that plants with larger leaves have produced more tomatoes. You do not have a way to change the leaf size, therefore to test whether leaf size and yield are related, you should conduct (a/an) ...

- a) controlled experiment.
- b) manipulative experiment.
- c) repeated measures experiment.
- d) observational (correlational) experiment.
- e) no experiment (it is impossible).

70. To correctly analyze these data, you would use \_\_\_\_\_ as the independent variable and plot it on the \_\_\_\_\_ axis, and \_\_\_\_\_ as the dependent variable and plot it on the \_\_\_\_\_ axis.

- a) number of tomatoes, x; leaf size, y
- b) number of tomatoes, y; leaf size, x
- c) leaf size, x; number of tomatoes, y
- d) leaf size, y; number of tomatoes, x

# Appendix B

## Student survey questions

**Table 1:** Complete Video and Audio podcast using students who elected to complete the end of semester survey responded to the following items.

Hi there biology student! Thank you for taking this survey on podcast use. Your responses will allow us to help future Biology 1114 students. Although you logged in to access this survey, no information regarding your name will be attached to this survey. The log in procedure was simply to determine if you had previously subscribed to podcasts. I want to stress that this survey is anonymous, so please answer the following questions honestly and accurately.

1. My gender is
  - a) Male
  - b) Female
  - c) Prefer not to say
  
2. My major is
  - a) Science oriented
  - b) Non-science
  - c) Undecided
  
3. Which of the following **best describes** when you study for Biology lecture?
  - a) Studying after or before every lecture
  - b) Studying once a week
  - c) Studying only when the instructor tells me what to study
  - d) Studying mostly the day before the exam
  
4. What resource do you rely on most when you study for Biology?
  - a) Text readings
  - b) My notes from class
  - c) Podcasts
  - d) On-line practice exams
  - e) Classmates or review sessions
  
5. Which of the following **best describes** how often you used podcasts?
  - a) Used all new episodes as they became available
  - b) Used the podcasts about once a week
  - c) Used podcasts every time I studied
  - d) Used multiple podcasts the day before each exam
  
6. About what percentage of the available Bio podcasts do you think you've listened to so far this semester?
  - a) 0-25%
  - b) 25%-50%

- c) 50%-75%
- d) 75%-100%
- e) I'm not sure

**Read each following statement and indicate if you:**

- a) Strongly Agree with the statement
  - b) Agree with the statement
  - c) Neither agree or disagree
  - d) Disagree with the statement
  - e) Strongly Disagree with the statement
7. I found the podcasts to be a valuable resource for this course.
8. I had trouble finding the information I needed in the podcast.
9. I listened to/watched podcasts on my portable mp3 player instead of my computer.
10. I liked having podcasts available for my use.
11. I did better in this class because I used podcasts.
12. I only listened to the podcasts that had titles describing the information I needed.
13. When I downloaded a new lecture podcast, I listened to/watched the entire lecture.
14. Instead of listening to/watching the entire lecture, I skipped around to find the information I needed.
15. I take notes, or follow along in my notebook when I use podcasts
16. The podcasts didn't fit with my regular study habits so I quit using them.
17. I feel like I am studying when I use podcasts.

**Table 2:** Segmented Audio podcast using students who elected to complete the end of semester survey responded to the following items.

Hi there biology student! Thank you for taking this survey on podcast use. Your responses will allow us to help future Biology 1114 students. Although you logged in to access this survey, no information regarding your name will be attached to this survey. The log in procedure was simply to determine if you had previously subscribed to podcasts. I want to stress that this survey is anonymous, so please answer the following questions honestly and accurately.

1. My gender is
  - a) Male
  - b) Female
  - c) Prefer not to say
  
2. My major is
  - a) Science oriented
  - b) Non-science
  - c) Undecided
  
3. Which of the following **best describes** when you study for Biology lecture?
  - a) Studying after or before every lecture
  - b) Studying once a week
  - c) Studying only when the instructor tells me what to study
  - d) Studying mostly the day before the exam
  
4. What resource do you rely on most when you study for Biology?
  - a) Text readings
  - b) My notes from class
  - c) Podcasts
  - d) On-line practice exams
  - e) Classmates or review sessions
  
5. Which of the following **best describes** how often you used podcasts?
  - a) Used all new episodes as they became available
  - b) Used the podcasts about once a week
  - c) Used podcasts every time I studied
  - d) Used multiple podcasts the day before each exam
  
6. About what percentage of the available Bio podcasts do you think you've listened to so far this semester?
  - a) 0-25%
  - b) 25%-50%
  - c) 50%-75%
  - d) 75%-100%
  - e) I'm not sure

**Read each following statement and indicate if you:**

- a) Strongly Agree with the statement
- b) Agree with the statement
- c) Neither agree or disagree
- d) Disagree with the statement
- e) Strongly Disagree with the statement

7. I found the podcasts to be a valuable resource for this course.

8. I had trouble finding the information I needed in the podcast.

9. I listened to podcasts on my portable mp3 player instead of my computer.

10. I liked having podcasts available for my use.

11. I did better in this class because I used podcasts.

12. I only listened to the podcasts that had titles describing the information I needed.

13. I would have rather listened to an hour long podcast of lecture instead of the shorter lecture segments.

14. Instead of listening to the entire segment, I skipped around to find the information I needed.

15. I take notes, or follow along in my notebook when I use podcasts.

16. The podcasts didn't fit with my regular study habits so I quit using them.

17. I feel like I am studying when I use podcasts.

Please feel free to make any comments regarding podcasts in the box below:

**Table 3:** Conversational podcast using students who elected to complete the end of semester survey responded to the following items.

Hi there biology student! Thank you for taking this survey on podcast use. Your responses will allow us to help future Biology 1114 students. Although you logged in to access this survey, no information regarding your name will be attached to this survey. The log in procedure was simply to determine if you had previously subscribed to podcasts. I want to stress that this survey is anonymous, so please answer the following questions honestly and accurately.

1. My gender is
  - a) Male
  - b) Female
  - c) Prefer not to say
  
2. My major is
  - a) Science oriented
  - b) Non-science
  - c) Undecided
  
3. Which of the following **best describes** when you study for Biology lecture?
  - a) Studying after or before every lecture
  - b) Studying once a week
  - c) Studying only when the instructor tells me what to study
  - d) Studying mostly the day before the exam
  
4. What resource do you rely on most when you study for Biology?
  - a) Text readings
  - b) My notes from class
  - c) Podcasts
  - d) On-line practice exams
  - e) Classmates or review sessions
  
5. Which of the following **best describes** how often you used podcasts?
  - a) Used all new episodes as they became available
  - b) Used the podcasts about once a week
  - c) Used podcasts every time I studied
  - d) Used multiple podcasts the day before each exam
  
6. About what percentage of the available Bio podcasts do you think you've listened to so far this semester?
  - a) 0-25%
  - b) 25%-50%
  - c) 50%-75%
  - d) 75%-100%
  - e) I'm not sure

**Read each following statement and indicate if you:**

- a) Strongly Agree with the statement
- b) Agree with this statement
- c) Neither agree or disagree
- d) Disagree with the statement
- e) Strongly Disagree with the statement

7. I found the podcasts to be a valuable resource for this course.
8. I had trouble finding the information I needed in the podcast.
9. I listened to podcasts on my portable mp3 player instead of my computer.
10. I liked having podcasts available for my use.
11. I did better in this class because I used podcasts.
12. I take additional notes, or follow along in my notebook when I use podcasts.
13. I think I learned more listening to students conversing about biology than if I had listened to a lecture.
14. Instead of listening to the entire podcast, I skipped around to find the information I needed.
15. The podcasts didn't fit with my regular study habits so I quit using them.
16. I only listened to the podcasts that had titles describing the information I needed.
17. I feel like I am studying when I use podcasts.

Please feel free to make any comments regarding podcasts in the box below:



**Table 4:** Non-podcast using students who elected to complete the end of semester survey responded to the following items.

Hi there biology student! Thank you for taking this survey on podcast use. Your responses will allow us to help future Biology 1114 students. Although you logged in to access this survey, no information regarding your name will be attached to this survey. The log in procedure was simply to determine if you had previously subscribed to podcasts. I want to stress that this survey is anonymous, so please answer the following questions honestly and accurately.

1. My gender is
  - a) Male
  - b) Female
  - c) Prefer not to say
  
2. My major is
  - a) Science oriented
  - b) Non-science
  - c) Undecided
  
3. Which of the following **best describes** when you study for Biology lecture?
  - a) Studying after or before every lecture
  - b) Studying once a week
  - c) Studying only when the instructor tells me what to study
  - d) Studying mostly the day before the exam
  
4. What resource do you rely on most when you study for Biology?
  - a) Text readings
  - b) My notes from class
  - c) On-line practice exams
  - d) Classmates or review sessions
  
5. Were you aware that podcasts of this course were available for you to use?
  - a) yes
  - b)no
  
6. Which one of the following **best describes** the reason why you decided not to use podcasts?
  - a) I don't have an mp3 player/iTunes
  - b) Listening to podcasts seemed too time consuming
  - c) I didn't think they would help me
  - d) I don't know what podcasts are
  - e) I didn't know how to find/use podcasts.
  - f) My regular study methods already work just fine

In the box below please tell us why you didn't use podcasts or what might make you want to use podcasts in the future:

# Appendix C

## Results from Hypothesis Testing

**Table 1:** Key to PCTYPE

PCTYPE	Podcast Treatment
1	Control (No treatment)
2	Video Podcast
3	Complete Audio Podcast
4	Segmented Audio Podcast
5	Conversational Audio Podcast

**Table 2:** Confidence intervals returned by a Dunnett's test comparing treatments against a control.  
No significant results were returned.

### Dunnett's t Tests for SCORE

NOTE: This test controls the Type I experimentwise error for comparisons of all treatments against a control.

Alpha	0.05
Error Degrees of Freedom	4
Error Mean Square	491.0766
Critical Value of Dunnett's t	3.99708

Comparisons significant at the 0.05 level are indicated by \*\*\*.

PCTYPE Comparison	Difference Between Means	Simultaneous 95% Confidence Limits
5 - 1	4.077	-8.587 16.741
2 - 1	0.251	-5.891 6.392
4 - 1	-3.350	-16.633 9.933
3 - 1	-4.658	-18.999 9.682

**Table 3:** Confidence intervals returned by a Tukey's test comparing treatments against each other.  
No significant results were returned.

Tukey's Studentized Range (HSD) Test for SCORE

NOTE: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	4
Error Mean Square	491.0766
Critical Value of Studentized Range	6.28702

Comparisons significant at the 0.05 level are indicated by \*\*\*.

PCTYPE Comparison	Difference Between Means	Simultaneous 95% Confidence Limits
5 - 2	3.827	-11.058 18.711
5 - 1	4.077	-10.008 18.163
5 - 4	7.427	-12.400 27.255
5 - 3	8.736	-11.983 29.455
2 - 5	-3.827	-18.711 11.058
2 - 1	0.251	-6.580 7.081
2 - 4	3.600	-11.937 19.138
2 - 3	4.909	-11.751 21.569
1 - 5	-4.077	-18.163 10.008
1 - 2	-0.251	-7.081 6.580
1 - 4	3.350	-11.423 18.123
1 - 3	4.658	-11.291 20.608
4 - 5	-7.427	-27.255 12.400
4 - 2	-3.600	-19.138 11.937
4 - 1	-3.350	-18.123 11.423
4 - 3	1.308	-19.884 22.501
3 - 5	-8.736	-29.455 11.983
3 - 2	-4.909	-21.569 11.751
3 - 1	-4.658	-20.608 11.291
3 - 4	-1.308	-22.501 19.884

# Appendix D

IRB documentation that this research does not qualify as human subject research as defined in 45 CFR 46.102(d) and (f) and is not subject to oversight by the OSU IRB.

Oklahoma State University Institutional Review Board  
**Request for Determination of Non-Human Subject or Non-Research**

- E. Are the data/specimen(s) coded such that a link exists that could allow the data/specimen(s) to be re-identified?  
 No  Yes  
If "Yes," is there a written agreement that prohibits the PI and his/her staff access to the link?  
 No  Yes

6. Signatures

Signature of PI Tamm Shan Date 1-26-07  
Signature of Faculty Advisor Donald P. Karl Date 26 Jan 2007  
(If PI is a student)

- Based on the information provided, the OSU-Stillwater IRB has determined that this research **does not** qualify a human subject research as defined in 45 CFR 46.102(d) and (f) and **is not subject to oversight by the OSU IRB.**
- Based on the information provided, the OSU-Stillwater IRB has determined that this research **does** qualify as human subject research and **submission of an application for review by the IRB is required.**

Sue C Jacobs  
Dr. Sue C. Jacobs, IRB Chair

1-26-07  
Date

## VITA

Tarren John Shaw

Candidate for the Degree of

Doctor of Philosophy

Dissertation: THE EFFECTS OF DIFFERENT PODCASTING STRATEGIES ON STUDENT ACHIEVEMENT IN A LARGE, COLLEGE LEVEL INQUIRY BIOLOGY COURSE

Major Field: Zoology

Biographical:

Personal Data: Born in Stillwater, Oklahoma on 2 July 1976, to Terry and Thelia Shaw.

Education: Received a Bachelors of Science degree in Entomology from Oklahoma State University in December, 1998. Received a Masters of Science in Curriculum Development and Instruction from Oklahoma State University in May, 2002. Completed the requirements for the Doctor of Philosophy in Zoology at Oklahoma State University, Stillwater, Oklahoma in December, 2009.

Experience: Entomology lab technician from 1995-1998. Biology teacher at R.L. Turner High School from 2002-2003. Teaching Assistant for Biology 1114 and Zoology 3204 from 1999-2001 and 2003-2009. Consultant for FOSS, University of California, Berkeley, 1999 and 2005.

Professional Memberships: National Association of Biology Teachers, National Science Teachers Association, Society of College Science Teachers

Name: Tarren John Shaw

Date of Degree: December, 2009

Institution: Oklahoma State University

Location: Stillwater, Oklahoma

Title of Study: THE EFFECTS OF DIFFERENT PODCASTING STRATEGIES ON  
STUDENT ACHIEVEMENT IN A LARGE, COLLEGE LEVEL  
INQUIRY BIOLOGY COURSE.

Pages in Study: 118

Candidate for the Degree of Doctor of Philosophy

Major Field: Zoology

Scope and Method of Study: The search for instructional tools that help engage students with the concepts taught in introductory biology courses has led to the untested adoption of many technological solutions. Podcasting can be used as an instructional technology that allows students access to course information at a time and place of the students' choosing. Because students choose when to use podcasts, students should be more receptive to the information. While several cognitive theories support the proposed benefits of podcasting as an instructional tool, to date no studies have examined the effect of podcast use on student performance in a naturalistic, semester-long, class setting. This study examined whether students who used course-related podcasts had a greater understanding of biological concepts as measured by higher percent gain scores on exams, compared to percent gain scores from students who had not used podcasts. Current research in cognitive theory was used when developing the four podcast types for this study: complete audio, complete video, segmented audio, and conversational audio. Students enrolled in a mixed-majors biology course were tracked with a computer program that recorded student podcast subscription, exam responses, and information regarding student study habits and attitudes toward podcasting.

Findings and Conclusions: Although different podcasting strategies were used, none were found to have had a significant effect on student percent gain scores when compared to a control group. However, student attitude toward podcasting remained very positive and significant findings regarding the study habits of podcast users were reported. Future research in the area of podcast use was recommended.

ADVISER'S APPROVAL: Dr. Donald French

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