

CLICKERS IN THE CLASSROOM:  
CAN THE USE OF ELECTRONIC RESPONSE SYSTEMS IMPROVE STUDENT  
LEARNING?

by

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In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

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## ABSTRACT

Lectures can be an efficient means to introduce new material, however they do not allow for all students to actively participate. Some students are engaged in answering questions and asking them during lecture, but many are not. They passively sit and observe. Without their participation it is difficult for the instructor to gauge their understanding. The purpose of this study was to see if the use of student electronic response systems could help students increase their understanding and retention of the biology curriculum. An electronic student response system involving clickers was used over the course of a semester. Exam scores, student interviews, and surveys were used to evaluate their effectiveness. A comparison of exam scores did not show a statistically significant difference. Student and teacher opinions were very positive as a large majority of student respondents said that clickers help to engage them in the learning process.

## INTRODUCTION AND BACKGROUND

### Project Background

#### Teaching and Classroom Environment

For the past ten years I have been teaching Tenth Grade Biology at Kingswood Regional High School in Wolfeboro, New Hampshire. My classroom is well equipped with a laboratory area that can support 12 lab groups and a lecture area that can seat a maximum of 24 students. Most classes range from 15 to 24 students. The science department has a budget that has allowed us to incorporate a variety of new technologies in the classroom from gel electrophoresis machines to LCD projectors and Smart Boards.

Most students are highly motivated and take their education seriously. Their maturity allows me to develop a classroom climate that is interesting, entertaining, and educational. A variety of activities are used in the classroom including lectures and discussions, labs, demos, skits, projects and formative and summative assessments.

Wolfeboro is situated on Lake Winnepesaukee and the main source of income is tourism. The school has roughly 1200 students attending and is currently overcrowded in a building designed to hold 800. Over the course of the next three years the Kingswood complex will be renovated and expanded including new science labs. Although there is not a great deal of racial diversity, there is a large amount of economic diversity. Six towns send their students to Kingswood. Due to the number and size of the towns we are the largest land-area school district in the state of New Hampshire. The difference in family incomes amongst the towns is immense and this diversity is noticeable in the classroom.

The students in my Honors class are college-bound students who take their education very seriously. They are involved in school sports and many are members of Student Council or one of our community volunteer groups such as Key Club. The A block Honors Biology class takes place Monday through Friday, 7:30 AM – 9:15 AM. The D block class runs from 1:00 PM to 2:30 PM. Both classes will run from the last week of August to the middle of January. The class syllabus is shown in Appendix A. The Advanced Placement Course runs forty-five minutes a day from the end of August to the end of May. The class syllabus is found in Appendix B.

### Focus Question

Concerns over the breadth of student participation during lecture led me to examine the use of electronic response systems, specifically (clickers). Most of the questions I ask during class are answered by a handful of students in the class. I hoped to increase student participation, including all students in the answering of questions during lectures. My primary focus question was: Can the use of clickers improve student interest and attention during lecture? I believe students will pay more attention during lectures and that the clicker systems will provide me with immediate formative assessment data from which to guide instruction.

### CONCEPTUAL FRAMEWORK

Although not the most exciting teaching method, lecture notes are an efficient means to introduce new vocabulary and concepts in a short period of time. In order to increase the breadth of student participation and allow teachers to get constant formative

assessment data, many universities and a few high schools now use electronic student response systems during lecture. The electronic response system works by including questions on the subject matter in the PowerPoint lecture presentations. During lecture students were asked to respond to these questions using clickers. The student responses were then presented graphically. There are many positive benefits from using such a system, such as keeping all students engaged during lecture and allowing the teacher to keep track of student understanding during each lesson and over the course of a unit.

Caldwell (2007) concluded that most reviews support the uses of clickers. They help increase student achievement on exams, comprehension, and student participation. However, Caldwell was quick to point out the following:

It is possible that the alteration of teaching methods is responsible, rather than the use of clickers themselves. It is also possible that a 'Hawthorne Effect' is responsible: the treatment of our student 'test subjects' is different when we use clickers and this special treatment causes the improvement rather than the use of clickers. (p. 9)

Crossgrove and Curran (2008) looked at the use of clickers in non-major and major biology courses and how it affected student opinion, learning, and long-term retention of material. Crossgrove and Curran compared the final exam questions of classes that were taught with the use of clickers to those classes that did not get the clicker treatment. They compared the data using a Wilcoxon Signed Ranks Test. Each multiple choice test question was also classified according to Bloom's taxonomy, "as to whether the question assessed knowledge, comprehension, application, or analysis". Non-major biology exam scores showed no significant difference between classes that used

the clickers and classes that did not. However, in Crossgrove's genetics class for students majoring in biology, there was significant improvement in exam scores (7.2%) when clickers were used (Wilcoxon  $z = -3.826$ ,  $p < 0.001$ ).

Crossgrove and Curran (2008) also studied the retention rates after the completion of the course. They gave volunteer students a total of 20 questions, 10 of which were on material covered in a lecture using clickers and 10 that were not. Again, the data was analyzed using a Wilcoxon test. Crossgrove and Curran found that student performance did improve: "in the non-major biology course, students better retain knowledge from clicker-based exam questions compared with non-clicker based exam questions" (p. 152). In students that majored in biology, retention was unchanged by the use of clickers.

Crossgrove and Curran (2008) also looked at student opinions on clickers. Both groups of students had positive feelings, with the non-major students giving greater positive feedback. They hypothesized that these positive feelings arise because it helps students become engaged in the class and provides practice in answering questions.

Hoekstra (2008) examined student opinions of clickers. Her qualitative research was gathered data through participant observation, survey questions, and interviews. Hoekstra (2008) stated (p. 333):

Professors encouraged peer discussion through instructions such as, 'Feel free to work with your neighbor' and 'Remember, two heads are better than one' and students turn to their neighbors to discuss the questions, challenging one another to explain the reasoning behind their answers. Students are given just one attempt at discussion; after 2-3 minutes of peer interaction, they are notified they have a small amount of time left to click

in. When the time expires a histogram of student response frequency is displayed.

Hoekstra concluded that students felt positively about the use of clickers and through student interviews she was able to gain an insight as to why this is true. One of the main reasons cited by Hoekstra is the anonymous manner through which answers are submitted. Students feel less anxious and are more willing to participate. With the use of clickers all students have to pay attention and can give an answer without the stress of potentially looking foolish in front of their friends.

At the end of the article Hoekstra identified some questions for future research. Does gender play a role in how clickers are viewed? Does the discipline matter? What is the possibility that they will become 'Edutainment' as opposed to academic education?

Cotner, Fall, Wick, Walker, and Baepler (2008) examined a variety of rapid feedback assessment methods and their usefulness in improving student engagement and preparation for exams. Cotner et al. looked at the use of clickers, and also a scratch-off immediate feedback assessment technique (IF-AT), which are both produced by Epstein Education. As Cotner et al. describe (p. 2):

Students select their answer by scratching off the film, exposing either a star for a correct answer or a blank space. Students may then continue scratching item choices until they get a star; however they are unable to 'erase' prior attempts.

The group used these scratch-off test preparation forms in two biology classes. A third biology class alternated between IF-AT and clickers each week. One of the main goals of this group's work was to increase student awareness of the level of subject

mastery that is expected, and to encourage them to continually prepare for exams (Cotner et al, 2008). Cotner's study (2008) also looked at student performance of IF-ATs over the course of a semester. They sought to determine if performance decreased. Cotner stated (p. 8-9):

We interpret these data to show that most students did not tire of the IF-AT activities, even with daily exposure . . . We interpret these data to support that most students remain engaged in the IF-AT questions throughout the course and made serious attempts to answer them, and were not simply scratching-off haphazardly to find the correct answer.

In comparing IF-ATs to clicker use, Cotner et al. (2008) found that students preferred clickers to scratch off sheets. They felt this was most likely due to the fact that clickers are anonymous and that students can see how they did compared to the rest of the class.

Knight and Woods (2005) compared the use of clickers by evaluating the learning gains between two different classes. They gave each group the same pre- and post-test and looked at the percent gain as a means to compare learning gains and conceptual knowledge.

As described by Knight and Woods (2005), their procedure was very simple yet effective. The procedure is described as follows (p. 300): "for both classes we administered a multiple-choice pretest during the first week and then re-administered the same test as embedded questions in the final exam, to provide a rough measure of student learning gains". The only difference between the two classes was the use of clickers as a

tool for formative assessment. Students were given five points per class for correct answers during lecture and 2.5 points for incorrect answers.

Comparing normalized learning gains showed a 33% increase in improvement in the class taught with clickers (Knight & Wood, 2005). As Knight and Wood explain on p. 301, “learning gains of greater than 60% were achieved by substantially more students in the interactive class (43/70) than in the traditional class (19/72)”. Knight and Wood tried the same treatment on a second set of students and found similar results.

It should be noted that there were some technical problems identified by a few authors. Draper and Brown (2004) report that several instructors had difficulty setting up and taking down the equipment and that this used up valuable class time. This was one factor that led to many students feeling that, “the equipment was being used for its own sake, because of the enthusiasm of the teacher, rather than being of direct benefit to the class,”(Draper and Brown, 2004; p 87).

Current research points to clickers improving student participation and attentiveness in lecture. Students enjoy their use and have very favorable opinions on them. Research into the effectiveness on student learning is mixed. Most quantitative analysis shows a slight improvement in content retention.

Beatty (2004) identifies the proper way in which classroom communication systems (CCS, or clickers) could be used to optimize student learning. Beatty states on p. 4:

A successful approach is to expose students to new subject material before class, perhaps through readings and Web-based multimedia. In-class time can then be devoted to CCS-mediated activities and discussions aimed at refining and extending students’ understanding of the material. Following

class, homework can solidify this understanding and develop related procedural skills such as quantitative problem solving.

Beatty (2004) provided the reader with a question cycle for organizing CCS-based teaching during lecture. The teacher sends out a question to the students. A short discussion occurs in small groups. Answers from each group are submitted. A histogram is then displayed and the teacher asks each group why they chose the answer they did and facilitates a discussion. The instructor then lectures to clear up any misconceptions. Beatty discussed one of the most difficult aspects of using a student response system when he stated on p. 6:

One of the most daunting aspects for many instructors may be the necessity of giving up control of the class. A lecture is predictable and controlled. With attention safely focused on the instructor. CCS-based teaching, on the other hand, necessarily turns the classroom over to the students while they debate in small groups and while they discuss their reasoning after the histogram displays.

Beatty also discussed the types of questions that should be posed using CCS. Beatty identified general goals of questions and indicated they should include the following (p. 6):

- Drawing out students' background knowledge and beliefs on a topic
- Making students aware of their own and others' perceptions of a situation
- Discovering points of confusion or misconception
- Distinguishing two related concepts
- Realizing parallels or connections between different ideas

- Elaborating the understating of a concept
- Exploring the implications of an idea in a new or extended context

Barber and Njus (2007) reviewed actual individual clicker systems. In this article the authors compared six different clicker systems and identified the strengths and weaknesses of each. They recommended looking at several factors including the following: keypad design, cost, compatibility with presentation software, data reporting, and registration and reconciliation of class rosters. Barber and Njus recommended iClicker from Turning Point Technology, citing “it runs alongside PowerPoint, having a toolbar floating above the PowerPoint presentation” (p. 2). Furthermore, they summarized the system to be a small, cost-efficient clicker with full integration into PowerPoint.

Another article regarding the implementation of the electronic response systems was *Clicker Resource Guide: An Instructor’s Guide to the Effective Use of Personal Response Systems in Teaching* (2009). This has been prepared by the staff of the Colorado University Science Education Initiative and the UBC Carl Wieman SEI. It is a “how-to” for teachers getting started with clickers and it provides many useful hints on how to successfully use clickers. In this guide, the authors stated (p. 10):

Ideally you would like a question that the students will interpret properly and will see as interesting and challenging, will stimulate students to want to hear and analyze the ideas of their classmates, will shape student thinking in desired ways, will reveal unanticipated student difficulties or interpretations and will accurately reveal whether or not students are mastering the material.

The authors further noted a common problem in use of clickers is making questions that are too easy. The authors also discussed the topic of grading clicker questions. As stated, “there is no consensus view recommended by research or convention, but our anecdotal observations lead us to lean toward this later grading policy of always giving credit for participation and occasionally giving additional reward for correct answers” (Clicker Resource Guide, 2009, p. 20).

The literature reviewed was extremely helpful in providing me with ideas about different methodologies I could use in my action research project and several different types of data I could collect during my action research project including a quantitative comparison of exam scores, student survey data, and student and faculty interviews. It has also given me example questions to use in student interviews to assess efficacy of the treatment.

Several articles have provided reviews of actual clicker systems, which proved invaluable in purchasing a quality system. *The Instructors Guide to the Effective Use of Personal Response Systems in Teaching* (2009) provided step-by-step directions on how to successfully start using clickers in the classroom.

Although studies on academic improvement show only slight to moderate gains (Caldwell, 2007; Cotner et al., 2008; Crossgrove & Curran, 2008; Draper & Brown, 2004; Knight & Wood, 2005), current research into student perceptions of the technology show that students have a very favorable opinion of clickers and enjoy using them, indicating a sentiment that they improve their education (Hoekstra, 2008).

There are a variety of ways in which clickers can be used in the classroom to facilitate student participation. Based on current research it is the way in which the

students use the clickers (pedagogical method) that will have the greatest impact on their success. I adopted the approach suggested by Beatty (2004) in his paper, that students must have time for reflection and communication in small groups before submitting an answer (think/pair/share) and a class discussion should take place before students submit their answers. Beatty's article along with the others I have read have proven to be invaluable in the adoption and effective use of an electronic student response system in my classroom.

## METHODOLOGY

In order to see if clickers can increase student retention of material, their use was evaluated over a five-month period from September 14, 2009 – January 15, 2010. The study involved 40 honors biology students and 19 Advanced Placement Biology students. Over the course of the study 4-6 questions were included in presentations for the lectures covering the topics of biochemistry, cell structure and transport and cellular respiration. The questions consisted of mainly two types: True/False or Multiple Choice. The questions were a mix of prior knowledge and a review of recently introduced material. Students were given time to read the question and then submitted their answers using the clickers. The results were then displayed in graph form, showing the percent of students choosing a specific answer. A short discussion then ensued. I would generally ask for volunteers to explain their reasoning behind choosing a specific answer. The correct answer was then identified by the instructor followed by a short explanation. The majority of clicker questions were answered by individual students in the class. Approximately 25% of the questions involved small group discussion at their desks

before the submission of an answer. Students were told that they should try to convince their neighbor of the right answer before submitting an answer. Students then talked back and forth for a few minutes before I announced that answers should be submitted.

### Data Collection Methods

Several different pieces of data were examined in order to achieve triangulation. Because chapter exams, labs and student make-up are different each year, midterm and final exam questions from last year's honors biology classes (2008-2009) were compared with this year's honors biology classes (2009-2010). Midterms and finals are not released to the students so this allowed for comparison of identical questions.

Sixty eight questions from the midterm exam were selected for comparison. Questions were identified by chapter. Questions coming from biochemistry, cell structure and transport, and respiration were deemed "clicker" units because clicker questions were embedded in the PowerPoint presentations given on that material. Questions coming from the chapters on the study of life, basic chemistry (including water, acids and bases), and photosynthesis were non-clicker units. The percentage of correct answers on 34 questions on material not covered with clicker questions from the 2008-2009 honors biology classes to the 2009-2010 classes was calculated. This provided a baseline upon which improvement was measured. The other 34 questions were regarding material covered with clicker questions on the 2009-2010 exams. The data were analyzed to see if significant differences existed between the two groups.

Student interviews and student surveys were also conducted to gain an understanding of student perspectives on the usefulness of this technology (Appendix C). All students were required to complete a survey at the end of the course. Answers were

based on a five-point Likert scale. A smaller number of individuals (six) participated in longer, more in-depth interviews (See Appendix D). These students were selected from each of the Honors Biology Classes. Each student had their name written on a piece of paper and three names were drawn from a hat. The interviews were recorded by audio recorder and a transcript was written.

Interviews of two other science teachers that piloted this technology were also conducted to gain their perspective on the effectiveness of clickers (See Appendix E). Trends in the responses were identified. It was my hope that they could shed more light on the question of whether students have more interest and attentiveness during lecture when clickers are used.

The triangulation matrix in Table 1 identifies the three focus questions for this action research project and the data to be collected for each.

Table 1  
*Data Triangulation Matrix*

Focus Questions	Data Source 1	Data Source 2	Data Source 3
Primary Question: 1. Do clickers increase student retention of material?	A comparison of clicker and non-clicker questions on the Honors Biology midterm and final exam	Student attitude surveys and interviews	
Secondary Questions:			
2. Does the practice of answering multiple choice questions daily using clickers increase Advanced Placement biology test scores?	A comparison of Advanced Placement Biology exam averages	Student interviews	
3. Does the use of clickers improve student interest and	Instructor observations and interviews	Student attitude surveys	Student interviews

attention during lecture?			
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The variety of data collected, both quantitative and qualitative, allowed for a clear analysis of effectiveness of electronic response systems in improving student learning.

## DATA AND ANALYSIS

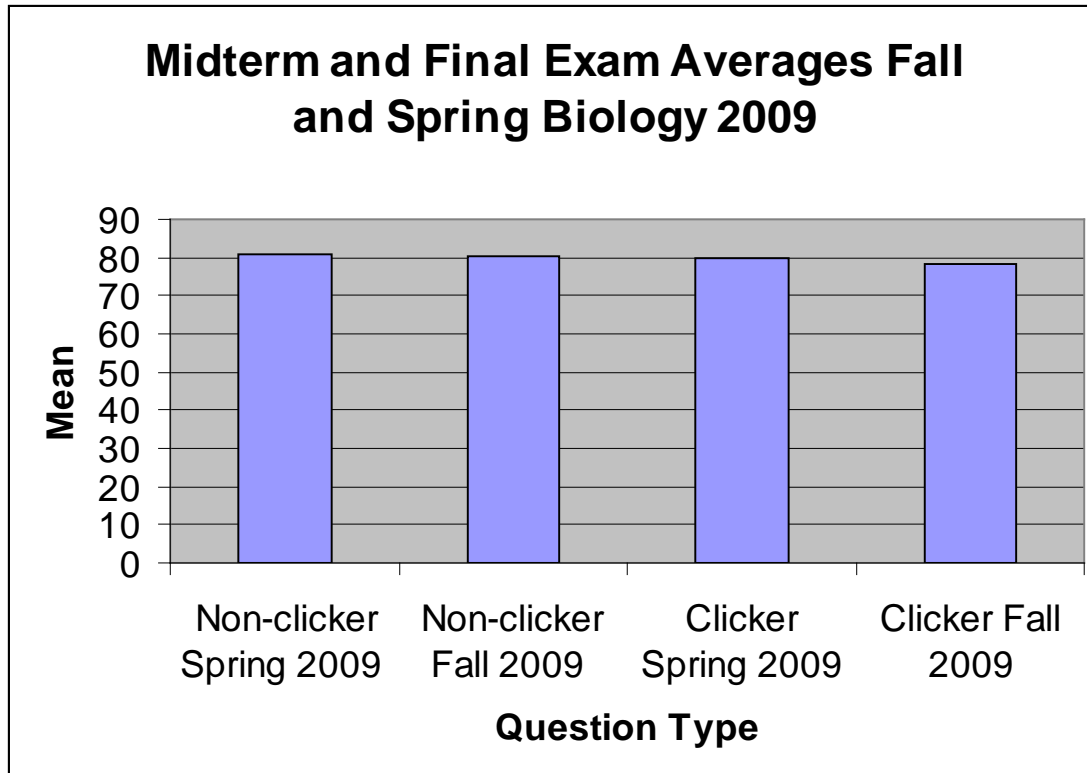
In order to observe the effects of clickers on student retention of course material several instruments were used. These instruments included a comparison of exam scores, student surveys and student and teacher interviews. The data was collected over several months during the fall of 2009 and the early part of 2010.

The use of clickers did not appear to increase or decrease the student's retention rate of material. One of the first pieces of data that was collected early in the project was midterm and final exam scores from the previous year's (Spring 2009) Honors Biology course ( $N=24$ ). The percentage of students answering each of the 80 true/false and multiple choice questions was calculated and this was compared to the averages of this year's (Fall 2009) two Honors Biology classes ( $N=40$ ) where clickers were implemented. Refer to Appendix F for the midterm exam, Appendix I for the final exam, and Appendices G and H to review a synopsis of the data.

Out of the 80 midterm exam questions three were removed because they were not shared between the spring and fall courses. From the remaining 77 items, 34 were identified as questions coming from one of three chapters where clickers were not used (Study of Life, Basic Chemistry, and Photosynthesis) during the Fall 2009 course. From the final exam 20 questions were determined to have come from two chapters where

clickers were not used (Genetic Engineering and Classification). Using a paired  $t$  test with a 95% confidence interval, there was not a significant difference in the scores from the Fall of 2009 (M=80.35, SD 16.37) and Spring 2009 (M=80.80, SD 17.25) conditions  $t(2) = 0.3090$ ,  $p = 0.05$  where clickers were not used.

The remaining forty-three questions on the midterm exam were identified as questions that came directly from units where clickers were used during lecture (Biochemistry, Cell Structure and Transport, and Respiration). To keep the number of questions compared identical, nine questions were removed by drawing numbers randomly. Using a paired  $t$  test with a 95% confidence interval, there was no significant difference in the scores from the Fall of 2009 (experimental group where clickers were used) (M=78.17, SD 16.11) and the Spring 2009 (control group) (M=79.96, SD 14.47) conditions  $t(2) = 1.3632$   $p = .05$



*Figure 1. A Comparison of Non-Clicker and Clicker Questions Between the Spring 2009 Honors Biology Course (N=24) and the Fall 2009 Honors Biology Course, (N=40). The bars represent the class mean for those question types, (N=40).*

Clickers did appear to improve student interest and attention in lecture. Student Surveys were used to gain an understanding of student opinions on clickers. Refer to Appendix D for the survey. Both Honors and Advanced Placement Biology students were surveyed ( $N = 55$ ). A Likert scale (1-5) was used to identify student opinions on instructional methods and their feelings related to the use of clickers. A score of one meant the students did not find the clickers helpful at all, three meant the clickers were somewhat helpful, and score of five meant the students found the clickers very helpful. The first question asked was how helpful are clickers in testing student understanding of the material. The average for this answer was 4.13, meaning students found clickers helpful. In fact, students noted they found clickers helpful to very helpful in the following areas: helping them identify prior knowledge, getting the discussion started in class, and

testing to see how well (students) know the material. Refer to Table 2 for additional results.

One of the strongest positive responses came from the question: *How helpful is it when the teacher tells you to work with your neighbor to answer the clicker questions?*

The Advanced Placement students gave clickers a rating of 4.4. After collection of the surveys several students voiced the opinion that they like the ability to discuss an answer before submitting it because it forces them to explain their thinking.

Table 2  
*Means of Student Responses to Survey Questions on the Effectiveness of Clickers*

Question	Average Response	Combined Answer categories
Asking questions to test how well you understand the material	4.13	Helpful
Asking questions to identify prior knowledge	4.1	Helpful
Asking questions to get the discussion started in class	4.1	Helpful
When the teacher tells you to work with your neighbor to answer the clicker questions	4	Helpful
Receiving feedback about how well you understand the material	4.4	Helpful/Very Helpful

A second set of survey questions asked the students to identify if clickers had increased or decreased their performance in a number of areas. See Table 3 for results. Again the answers came in the form of a five-point Likert scale, where one meant the students performance slightly decreased, three it remained the same, or five it greatly increased. Results were very favorable. The students expressed that they felt clickers increased their comprehension of the course material and that clickers also increased their participation and achievement in the course. The area that showed the strongest response

was attentiveness/engagement in lecture. It scored a 4.4 which meant students found clickers increased/greatly increased their attentiveness in lecture.

Table 3

*Means of Student Responses to Survey Questions on the Effectiveness of Clickers*

Question	Average Response	Combined Answer categories
Comprehension of course material	3.8	Has remained the same / Increased
Attentiveness/engagement in lecture	4.4	Increased / Greatly increased
Participation in lecture	4.2	Increased
Achievement in the course	3.6	Has remained the same / Increased

Interestingly when students were asked if clickers helped to motivate them to study more, only ten out of the 55 respondents (18%) replied yes. Fifty-four out of the 55 respondents (98%) said that they would like to see clickers used in other classes.

Three open response questions were asked at the end of the survey. The first question asked students to identify any problems they may have had with clickers. Thirty-three out of 55 students, or 60% did not identify a problem. Thirty-one percent of the students replied that logging into the system was a problem, and 9% of respondents indicated the inability to change an answer to a question. Two days after the completion of the survey we found out that a student could change an answer, as the system records the last button pressed.

I asked students to identify any advantages to using a student response system in class. The responses indicated 51% of the class expressed it helped them pay better attention and 27% of students replied it helped them know what they need to study. Several students replied that it was fun and the clickers created competition. One student

wrote: “It feels like a game show, so I have more fun in class. But if it was a game show I would have been eliminated by now.”

The final question asked students to identify any disadvantages of using student response systems in class. There were several disadvantages listed, but it was difficult to draw a common theme between the answers. Eleven percent of respondents said it made them feel like a “loser” or “dumb” if they are the only person to answer the question incorrectly. Others reported the hassle of logging in every time. Some said it slowed the class down and one student even put that it made them pay attention as a disadvantage. Overall, 49% of the class reported no problems.

### Student Interviews

I was able to sit down with six randomly chosen students, four females and two males to talk about their experience with clickers (See Appendix D). Their responses echoed what I had found in the student surveys. The first question I asked each student was, “Has the use of clickers in class increased your comprehension of material?” All responded that it had increased their comprehension. One student responded, “I really enjoyed the times that I was able to talk over the question with my partner before I had to submit an answer.”

The second question posed to the students asked them if it had increased their engagement/attention to lecture. All six students responded that it had. They also stated that it increased their participation in lecture although two said that they “usually participate in class anyway”.

I really wanted to find out what type of clicker question the students found most useful. I had been alternating between true/false, multiple choice, and opinion questions throughout the semester. Five out of six responded that they enjoyed the multiple choice

the most. When probed as to why they felt this was the best question type, two students responded that they felt it best prepared them for the exam. One of the two continued, “I like multiple choice because if you get it wrong you can see why when we discuss the question after.”

As with the survey questions, none of the students reported having any problem with the clickers and they all wanted their use to continue and would like to see them implemented in other classes. One student responded that she would like to see them used in math class. She usually doesn’t volunteer to answer questions, but this way she could participate.

#### Faculty Interview

I also had a chance to sit down and speak to two other faculty members that began using clickers during the Fall 2009 semester. Please see Appendix E for the faculty interview questions. Overall both of the interviewed teachers reported very positive feelings toward the use of clickers. When asked what advantages they noticed from using clickers, one teacher replied, “Students were excited and focused,” and the other said, “It garners more interest from the students.” Both teachers thought that it helped the students understand the material. The first teacher interviewed answered, “Whenever a score was low I explained the concept again.” When asked if they would continue to use a student electronic system both replied that they would.

Two areas of weakness were also identified during the interview. One teacher thought that one of the disadvantages was that some students appeared to lose interest over time and that a few lower level students were intimidated by the process. This was the same concern that several students identified during their student surveys. The second

teacher felt that clickers didn't help the students retain the information over the long-term (ex. Midterm and Final Exams).

## INTERPRETATION AND CONCLUSION

As in previous studies (Crossgrove et al., 2008) students have very positive feelings towards the use of clickers in the classroom. They believe that it helps them increase their comprehension of course material. It helps students pay more attention in lecture and allows all students to participate. Student opinion was not affected by what level of biology in which they were enrolled (Honors/Advanced Placement).

Interestingly the use of clickers did not motivate students to study more. I believed that if individual students struggled to answer questions correctly during lecture they would realize the need to study. For the majority of students this tends not to be the case. I'm really not sure why this feedback to them would not cause them to study more.

The fact that 54 of 55 respondents want clickers to be used in their other classes also surprised me. I expected a majority of students to answer yes, but the popularity of clickers is astounding. I have also come to note this popularity throughout the semester as students routinely complain during lecture that did not have clicker questions embedded in the PowerPoint presentation.

Improvement in test scores was not shown. The experimental group of students receiving the clicker questions did not have statistically significant differences in exam scores when compared with the control group.

## VALUE

The implementation of an electronic student response in my classroom has been an enjoyable and positive experience for both my students and me. I have enjoyed learning a new piece of software and the creative aspect of designing interesting and challenging clicker questions.

The use of clickers in my classroom has had many positive impacts. Their use has increased my students' engagement and attention during lecture. I have been able to immediately identify areas of weakness by using it as a formative assessment tool. This has allowed me to go over topics that the students did not fully understand the first time they were introduced.

Over the next year I would like to incorporate clicker questions in all of my units and further help other teachers become comfortable with their use and implementing them in their classrooms. I need to continue to work on developing challenging questions that can spark discussion among students. These are the most successful types of clicker questions because it gets students to discuss the topic before submitting an answer.

In the future I would like to track student interest over a period of time to see if it fades as the "newness" wears off. I would also like to see how standard students respond to using these devices and if they find them as helpful as the honors and Advanced Placement biology students. I would also like to increase the use of clickers in identify misconceptions that each student brings into class, prior to covering the material. My students firmly believe clickers are an effective educational tool. I hope to continue to use clickers for many years to come.

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APPENDICES

APPENDIX A

HONORS BIOLOGY COURSE SYLLABUS

APPENDIX A

## HONORS BIOLOGY COURSE SYLLABUS

**Kingswood Regional High School**

**Course Outline:** Honors Biology

**Instructor:** Mr. Fuller

**Length of course:** One Semester

**General outline:** Honors Biology is a preparatory course for the student who plans to seek higher education in the sciences or for honor track students in non-science fields. The course is centered around central biological themes such as structure and function, nature of life, the diversity of life, taxonomy, genetics, microbiology, evolution, human biology, ecology, and science and society. The course is fast paced and focuses on content mastery, laboratory skills, and report writing. Extensions assignments will explore selected topics in greater depth than the college tech-prep level course. Independent work on projects and greater depth in laboratory analysis is an expectation.

**Instructional outcomes:** The student will

1. Apply the scientific method.
2. Apply analytical skills in drawing and communicating conclusions through a scientific approach.
3. Demonstrate observation, data collection, measuring, organizing, classifying, hypothesizing, analyzing and inferring skills through lab work.
4. Use lab equipment safely and appropriately.
5. Demonstrate basic dissection procedure. (not required, encouraged)
6. Make independent decisions showing a linkage to material previously covered.
7. Relate basic chemistry to biological processes such as photosynthesis and respiration.
8. Identify cell structures and state their functions.
9. Explain in their own words basic biological processes such as osmosis, diffusion, and protein synthesis.
10. Explain two types of cell division, their function and structure of their genetic material.
11. Differentiate the basic theories of evolution, state evidence supporting basic evolutionary theory and the formation of species.
12. Understand the key characteristics, methods of reproduction, and importance to man and the biosphere of viruses, bacteria, protozoa, algae, and fungi.
13. Discuss the importance of plants, their basic structures and how they function.
14. Understand the key characteristics, method of reproduction, importance to man and the biosphere of sponges, mollusks, flatworms, arthropods, insects, etc.
15. Demonstrate a basic knowledge of vertebrates such as fishes, amphibians, reptiles, birds, and mammals.
16. Demonstrate a basic knowledge of human organ systems: skeletal, muscular, circulatory, respiratory, digestive, nervous, and reproductive.

**Content outline:**

1. Biological principles
2. Chemistry
3. Biochemistry
4. Cell Structure
5. Photosynthesis / Respiration
6. DNA, RNA, Protein Synthesis
7. Cell Cycle
8. Genetics
9. Biotechnology
10. Evolution
11. Microbiology
12. Invertebrate Zoology
13. Vertebrate Zoology

**Text:** Modern Biology; Holt, Rinehart, and Winston. 2006

**Course activities:**

1. Teaching methods will include: discussion, laboratory work, lectures, audio – visual, demonstrations, skits, projects, written and oral reports.
2. Homework typically includes chapter reading, vocabulary, chapter review questions, lab report writing, test and quiz preparation. Usually 4-5 nights a week.
3. Tests are always announced and structured reviews are conducted.
4. A mid term is given which counts for 10 percent of quarter ones final grade. A lab practical mid term is given. This counts as 35 percent of the mid term grade. A written mid term exam is given which counts as 65 percent of the mid term grade.
5. A final is given which counts for 10 percent of quarter twos final grade. A lab practical final is given. This counts as 35 percent of the final grade. A written final exam is given which counts as 65 percent of the final exam grade.
6. Help sessions after schools are available weekly by appointment.

**Requirements:**

1. Treat others with respect.
2. Come to class on time and be prepared, bring notebook (2 inch, 3 ring binder), text, assignments, something to write with, and the attitude to have some fun with your learning.
3. Make up work should be completed within one week. Late work loses 7 points (one grade) for each day late. All work should have neat, professional appearance with attention to complete sentences, spelling, and punctuation. Missing work receives a zero and cannot be made up after the marking period. Nothing hurts your average more than a zero. I do not give extra credit assignments. We only walk this path once so give it your best shot the first time! I do not drop the lowest grade(s) on quizzes, tests or labs.
4. Work safely and appropriately in the lab. Lab reports are generally due two class days after we finish collecting data.
5. It is required you keep a binder for all your labs, tests, and notes. This will be invaluable to study for your final and mid term, and for use in your two lab exams.

**Method of evaluation:**

1. Attendance and participation.....required
2. Classwork.....10%
3. Quizzes.....10%
4. Lab reports.....30%
5. Tests.....40%
6. Homework.....10%

Weighted averages may be shifted slightly depending on the number of tests, quizzes, and labs, performed during a quarter. The activities and content reflected here are offered as guidelines and are subject to modification based on the progress of the students in the class. If you have any questions or concerns please feel free to contact me at the school.

APPENDIX B

ADVANCED PLACEMENT BIOLOGY COURSE SYLLABUS

APPENDIX B

## ADVANCED PLACEMENT BIOLOGY COURSE SYLLABUS

**Course Outline:** Advanced Placement Biology

**Instructor:** Jeremy Fuller

**Length of course:** 180 days, 45 minutes per day

**Web Site:** [www.geocities.com/krhsbiology](http://www.geocities.com/krhsbiology)

**General outline:**

Advanced Placement Biology is a course designed to let students earn college credit and or advanced placement in college above the introductory level. It aims to provide students with the conceptual framework, knowledge, and analytical skills necessary to deal critically with the rapidly changing science of biology. Emphasis is given on the application of biological knowledge and critical thinking to environmental and social concerns. The course is organized into three major topic areas (I. Molecules and Cells, II. Genetics and Evolution, III. Organisms and Populations). These three major topic areas emphasize the eight major themes of biology they include Science as Process, Evolution, Energy and Transfer, Continuity and Change, Relationship of Structure to Function, Regulation, Interdependence in Nature, and Science, Technology, and Society.

**Text:** Biology: Sixth Edition, Campbell and Reece; Benjamin and Cummings: Copyright 2002

**Lab Manual:** College Board Advanced Placement Biology Lab Manual: Copyright 2001

**Instructional Strategies:** The following instructional strategies are used to foster student understanding of the eight major biological themes. These strategies include but are not limited to: Lecture, laboratory investigations, laboratory demonstrations, online labs, videos, projects, presentations, discussions, current event reading, formative assessments, and summative assessments. Approximately 25 percent of the class is devoted to hands on laboratory work. All labs listed are student conducted unless otherwise noted.

**Core Competencies:**

1. Students are to complete the following labs recommended by the College Board and described in the AP Biology Lab Manual: Diffusion and Osmosis, Enzyme Catalysis, Mitosis and Meiosis, Plant Pigments and Photosynthesis, Cell Respiration, Molecular Biology, Genetics of Organisms, Population Genetics and Evolution, Transpiration, Physiology of the Circulatory System, and Dissolved Oxygen and Aquatic Primary Productivity
2. Receive a 65% or higher grade average on all course assignments.

**Content outline:**

**Part I Molecules and Cell:** Major biological themes covered: Science as Process, Evolution, Energy and Transfer, Continuity and Change, Relationship of Structure to Function, Regulation, and Science, Technology, and Society.

## Unit I: Molecules 4 Weeks

### A. Chemistry:

1. PowerPoint lecture notes on basic chemistry (atomic structure and bonding) and water
2. Readings in text
  - a. Chapter 2 The chemical context of life (Page 26 – Page 40) Chapter Questions
  - b. Chapter 3 Water and the fitness of the environment (Page 41 – Page 51) Chapter Questions
3. Classwork
  - a. Essay on the chemistry of water
4. Quiz
  - a. Basic Chemistry
  - b. Water

### B. Biochemistry

1. PowerPoint lecture notes on carbon, the four main organic macromolecules, functional groups, enzyme structure and function, and reaction rates.
2. Readings in text
  - a. Chapter 4 Carbon and the molecular diversity of life (Page 52 – Page 61) Chapter Questions
  - b. Chapter 5 The structure and function of macromolecules (Page 62 – Page 86) Chapter Questions
  - c. Chapter 6 An introduction to metabolism (Page 87 – 105) Chapter Questions
3. Classwork
  - a. Worksheets on carbohydrates, lipids, proteins, and nucleic acids.
4. AP Lab #2 Enzymes
5. Quiz
  - c. Four main organic macromolecules
  - d. Enzymes
6. Unit Test

## Unit II: Cell Structure and Function 4 Weeks

### A. The Cell:

1. PowerPoint lecture notes on membrane structure and function, cell wall structure and function, cell transport, cell organelles, and the evolution of eukaryotic cells.
2. Readings in text
  - a. Chapter 7 A tour of the cell (Page 108 – Page137) Chapter Questions
  - b. Chapter 8 Membrane structure and function (Page 138 – Page154) Chapter Questions
  - c. Chapter 11 Cell Communication (Page 197 – Page 214) Chapter Questions
3. Classwork
  - a. Student Project: Cell Catalog

- b. Worksheets on active and passive transport, and animal and plant cell structure.
- 4. AP Lab # 1 Diffusion and Osmosis
- 5. Quiz
  - a. Cell transport
  - b. Cell Organelles
- 6. Unit Test

### Unit III: Bioenergetics 4 Weeks

#### A. Respiration

- 1. PowerPoint lecture notes on respiration (glycolysis, Krebs cycle, and electron transport chain) and ATP.
- 2. Readings in text
  - e. Chapter 9 Cellular respiration: harvesting chemical energy (Page 155 – Page 175) Chapter Questions
- 3. Classwork
  - a. Worksheets on fermentation and aerobic respiration
- 4. AP Lab # 5 Cell Respiration
- 5. Quiz
  - a. Respiration

#### B. Photosynthesis

- 1. PowerPoint lecture notes on photosynthesis (light reaction and the Calvin cycle)
- 2. Readings in text
  - a. Chapter 10 Photosynthesis (Page 176 – Page 196) Chapter Questions
- 3. Classwork
  - a. Worksheets on the light reaction and Calvin cycle
- 4. AP Lab # 4 Plant Pigments and Photosynthesis
- 5. Quiz
  - a. Photosynthesis
- 6. Unit Test

***Part II Genetics and Evolution:*** Major biological themes covered: Science as Process, Evolution, Energy and Transfer, Continuity and Change, Relationship of Structure to Function, Regulation, Interdependence in Nature, and Science, Technology, and Society.

### Unit IV: Molecular Genetics 2 Weeks

- 1. PowerPoint lecture notes on DNA and RNA structure, discovery of DNA replication, transcription, translation, and mutation.
- 2. Readings in text
  - a. Chapter 16 The molecular basis of life ( Page 287 – Page 301) Chapter Questions
  - b. Chapter 17 From gene to protein (Page 303 – Page 327) Chapter Questions
  - c. Chapter 18 Microbial models: the genetics of viruses and bacteria ( Page 328 – Page 353) Chapter Questions

- d. Chapter 19 The organization and control of eukaryotic genomes (Page 354 – 374) Chapter Questions
- 3. Classwork
  - a. Worksheets on replication, transcription, and translation
  - b. Video on replication, transcription, and translation
- 4. Quiz
  - a. DNA, transcription, and translation
  - b. Bacterial genome
- 5. Unit Test

#### Unit V: Heredity 3 Weeks

- 1. PowerPoint lecture notes on the cell cycle, mitosis, meiosis (including nondisjunction), Mendelian genetics, probability, independent assortment, segregation, co dominance, incomplete dominance, sex-linked traits, autosomal linkages, and Chi square analysis.
- 2. Readings in text
  - a. Chapter 12 The cell cycle (Page 215 – Page 231) Chapter Questions
  - b. Chapter 13 Meiosis and sexual life cycle ( Page 234 – Page 246) Chapter Questions
  - c. Chapter 14 Mendel and the gene idea (Page 247 – Page 268) Chapter Questions
  - d. Chapter 15 The chromosomal basis of inheritance (Page 269 – Page 286) Chapter Questions
- 3. Classwork
  - a. Worksheets on mitosis, meiosis, genetics, and chi square analysis
  - b. Journal reading and questions on cancer.
  - c. Genetics problem set (mono and dihybrid crosses)
  - d. Virtual fruit fly lab
- 4. AP Lab # 3 Mitosis and Meiosis  
AP Lab # 7 Genetics of Organisms (6 days over 4 weeks)
- 5. Quiz
  - a. The cell cycle and mitosis
  - b. Meiosis
  - c. Mendelian crosses
- 6. Unit Test

#### Unit VI: Genetic Technology 3 Weeks

- 1. PowerPoint lecture notes on bacterial transformations, gel electrophoresis PCR, and RFLP analysis.
- 2. Readings in text
  - a. Chapter 20 DNA technology (Page 375 – Page 401) Chapter Questions
  - b. Chapter 21 The genetic basis of development (Page 402 – Page 425) Chapter Questions
- 3. Classwork
  - a. Ethics paper on genetic screening and the social concerns with this technology.

4. AP Lab # 6 Molecular Biology  
Bio-Rad protein extraction and purification lab
5. Quiz
  - a. Transformation
  - b. Gel electrophoresis
6. Unit Test

#### Unit VII: Evolution 3 Weeks

1. PowerPoint lecture notes on Darwin's voyage, evidence of evolution, Hardy Weinberg equilibrium, natural selection, micro evolutionary events, variation, speciation, pre and post zygotic mechanisms, allopatric and sympatric speciation and origin of life.
2. Readings in text
  - a. Chapter 22 Decent with modification (Page 428 – Page 444) Chapter Questions
  - b. Chapter 23 The evolution of populations ( Page 445 – Page 463) Chapter Questions
  - c. Chapter 24 The origin of species ( Page 464 – Page 483) Chapter Questions
  - d. Chapter 26 Early earth and the origin of life (Page 510 – Page 525) Chapter Questions
3. Classwork
  - a. Hardy Weinberg problem sheet
  - b. Why Sex? Video
  - c. Origin of life Video
4. AP Lab # 8 Population Genetics and Evolution
5. Quiz
  - a. Decent with modification and evolution of populations
  - b. Speciation
  - c. Origin of life
6. Unit Test

***Part III: Organisms and Populations:*** Major biological themes covered: Science as Process, Evolution, Energy and Transfer, Continuity and Change, Relationship of Structure to Function, Regulation, Interdependence in Nature, and Science, Technology, and Society

#### Unit VIII: Taxonomy, Bacteria, and Protists 2 Weeks

1. PowerPoint lecture notes on classification (important terms used in classification, bacteria, and protists).
2. Readings in text
  - a. Chapter 25 Phylogeny and systematics (Page 484 – Page 507) Chapter Questions
  - b. Chapter 27 Prokaryotes and the origins of metabolic diversity ( Page 526 – 543) Chapter Questions
  - c. Chapter 28 The origins of eukaryotic diversity ( Page 545 – 574) Chapter Questions

3. Classwork
  - a. Journal article reading on antibiotics and the evolution of resistance.
  - b. Worksheets on classification, gram staining, bacterial diseases, and protozoan diseases.
4. Lab
  - a. Gram staining unknown bacterial samples
5. Quiz
  - a. Bacteria
  - b. Protista
6. Unit Test

#### Unit IX: Plants Their Diversity, Anatomy, and Physiology 4 Weeks

1. PowerPoint lecture notes on plant evolution and life cycles, structure and function, fertilization, seeds, flowers, fruit, transport, nutrition, and communication.
2. Readings in text
  - a. Chapter 29 Plant diversity I: how plants colonized land (Page 575 – Page 596) Chapter Questions
  - b. Chapter 30 Plant diversity II: The evolution of seed plants (Page 597 – Page 615) Chapter Questions
  - c. Chapter 35 Plant structure and growth (Page 720 – Page 747) Chapter Questions
  - d. Chapter 36 Transport in plants ( Page 748 – Page 766) Chapter Questions
  - e. Chapter 37 Plant nutrition ( Page 767 – Page 781) Chapter Questions
  - f. Chapter 38 Plant reproduction and biotechnology ( Page 783 – 801) Chapter Questions
  - g. Chapter 39 Plant responses to internal and external signals (Page 802 – Page 831) Chapter Questions
3. Classwork
  - a. Worksheets on bryophytes, plant life cycles, xylem, phloem, seeds, fruits, flowers, stem structure, root structure, and transpiration
4. Fern lab
  - AP Lab # 9 Transpiration
  - Flower dissection
  - Fruit dissection
5. Quiz
  - a. Plant evolution
  - b. Flower, seed, fruit structure
  - c. Plant hormones
6. Unit Test

#### Unit X: Ecology 3 Weeks

1. PowerPoint lecture notes on the major biomes aquatic and terrestrial, population ecology, succession, tropic structure, productivity, human impact.
2. Readings in text
  - a. Chapter 50 An introduction to ecology and the biosphere (Page 1092 – Page 1120) Chapter Questions

- b. Chapter 51 Behavioral biology (Page 1121 – Page 1150) Chapter Questions
  - c. Chapter 51 Population ecology ( Page 1151 – Page 1173) Chapter Questions
  - d. Chapter 53 Community ecology ( Page 1174 – Page 1197) Chapter Questions
  - e. Chapter 54 Ecosystems (Page 1198 – Page 1223) Chapter Questions
  - f. Chapter 55 Conservation biology ( Page 1224 – Page 1247) Chapter Questions
- 3. AP Biology Lab # 12 Dissolved oxygen and aquatic primary productivity
  - 4. Unit Test

#### Unit XI: Exam Review 2 Weeks

- 1. PowerPoint lecture notes on test taking strategies, review of the eight major biological themes.
- 2. Students will take two old AP exams scoring themselves using the AP rubrics.

#### Unit XII: Animals Their Diversity Anatomy and Physiology 4 Weeks

- 1. Lecture notes on invertebrate zoology, vertebrate zoology, circulatory system, nervous system, immune system, endocrine system, muscular system, digestive system, and reproductive system (including: embryological development and evolutionary similarities between other organisms)
- 2. Readings in text
  - a. Chapter 32 Introduction to animal evolution (Page 633 – Page 645) Chapter Questions
  - b. Chapter 33 Invertebrates (Page 646 – Page 677) Chapter Questions
  - c. Chapter 34 Vertebrate evolution and diversity ( Page 678 – Page 717) Chapter Questions
  - d. Chapter 40 An introduction to animal structure and function ( Page 834 – Page 849) Chapter Question
  - e. Chapter 41 Animal nutrition (Page 850 – Page 870)
  - f. Chapter 42 Circulation and gas exchange ( Page 871 – Page 899)
  - g. Chapter 43 The body's defense ( Page 900 – Page 924)
  - h. Chapter 44 Regulating the internal environment (Page 925 – Page 954)
  - i. Chapter 45 Chemical signals in animals (Page 955 – Page 974)
  - j. Chapter 46 Animal reproduction ( Page 975 – Page 997)
  - k. Chapter 47 Animal development ( Page 998 – Page 1021)
  - l. Chapter 48 Nervous system ( Page 1022 – Page 1056)
  - m. Chapter 49 Sensory and motor mechanisms (Page 1057 – Page 1089)
- 3. Classwork
  - a. Student PowerPoint presentation on an inner tidal zone animal
- 4. AP Lab # 10 Physiology of the circulatory system  
AP Lab # 11 Animal behavior  
Frog Dissection  
Intertidal zone field trip
- 5. Unit Test

**Class Information:**

7. Homework typically includes chapter reading, vocabulary, chapter review questions, lab report writing, test and quiz preparation. Usually 5 nights a week.
8. Formal lab report must include a title, purpose, hypothesis, procedure, data section, analysis and conclusion section. They will be graded with a lab report rubric.
9. Tests are always announced and structured reviews are conducted.
10. A mid term is given which counts for 10 percent of your final grade
11. A final is given which counts for 10 percent of your final grade.
12. Help sessions after schools are available weekly by appointment.

**Requirements:**

6. Treat others with respect.
7. Come to class on time and be prepared, bring notebook (2 inch, 3 ring binder), text, assignments, something to write with, and the attitude to have some fun with your learning.
8. Make up work should be completed within one week. Late work loses 7 points (one grade) for each day late. All work should have neat, professional appearance with attention to complete sentences, spelling, and punctuation. Missing work receives a zero and cannot be made up after the marking period. Nothing hurts your average more than a zero. I do not give extra credit assignments. I do not drop the lowest grade(s) on quizzes, tests or labs.
9. Work safely and appropriately in the lab. Lab reports are generally due two class days after we finish collecting data.
10. It is required you keep a binder for all your labs, tests, and notes. This will be invaluable to study for your final and mid term.

**Method of evaluation:**

- |                                      |          |
|--------------------------------------|----------|
| 7. Attendance and participation..... | required |
| 8. Homework.....                     | 10%      |
| 9. Quizzes.....                      | 10%      |
| 10. Lab reports.....                 | 30%      |
| 11. Tests.....                       | 50%      |

Weighted averages may be shifted slightly depending on the number of tests, quizzes, and labs, performed during a quarter. The activities and content reflected here are offered as guidelines and are subject to modification based on the progress of the students in the class. If you have any questions or concerns please feel free to contact me at the school.

APPENDIX C  
STUDENT SURVEY

APPENDIX C

## STUDENT SURVEY

Acknowledgment: This survey was adapted from Coral Hanson's student survey used in her research at Brigham Young University regarding student opinions on the effectiveness of clickers.

Please circle the correct answer

1. What is your current grade level?  
 9<sup>th</sup>            10<sup>th</sup>            11<sup>th</sup>            12<sup>th</sup>

2. In which class are you currently enrolled?  
 Honors Biology            Advanced Placement Biology

Using the Likert Scale listed below (1-5), please answer questions 3-11 by circling the appropriate number regarding the helpfulness and effectiveness of the clickers as an instructional method in your class.

5- Very Helpful   4-Helpful   3-Somewhat Helpful   2-Not Too Helpful   1- Not Helpful At All

3. How helpful was the use of the clickers in asking questions to test how well you understand the material?

5   4   3   2   1

4. How helpful was the use of the clickers in asking questions to identify prior knowledge?

5   4   3   2   1

5. How helpful was the use of the clickers in asking questions to get the discussion started in class?

5   4   3   2   1

6. Were the clickers helpful when the teacher told you to work with your neighbor to answer the clicker questions?

5   4   3   2   1

7. Was the use of the clickers useful in receiving feedback (seeing if you got the answer right or wrong) about how well you understood the material?

5   4   3   2   1

How do you feel using the student response system in your class has increased the following?

5- Greatly Increased 4-Increased 3-Has Remained The Same 2-Slightly Decreased  
1-Greatly Decreased

8. How do you feel the use of the clickers impacted your comprehension of course material?

5 4 3 2 1

9. How do you feel the use of the clickers influenced your attentiveness/engagement in lecture?

5 4 3 2 1

10. How do you feel the clickers impacted your participation in lecture?

5 4 3 2 1

11. What effect do you feel clickers had on your achievement in the course?

5 4 3 2 1

Open-ended questions

12. What problems (including technical problems) have you experienced with clickers?

13. What are the advantages of using a student response system in class?

14. What are the disadvantages of using a student response system in class?

15. Yes or No: Would you like to see clickers used in some of your other classes?

APPENDIX D

STUDENT INTERVIEW QUESTIONS

APPENDIX D

## STUDENT INTERVIEW QUESTIONS

Note: Much of the protocol and some questions have been adopted from Coral Richards Hanson's paper on An Evaluation of a student Response System Used at Brigham Young University

## Protocol for student interviews

1. You have been asked to participate in this interview to help me understand if clickers are beneficial to student learning. I want you to help me understand any problems you had with the system or any benefits you gained from using them.
2. I want you to feel comfortable sharing your thoughts and experiences.
3. Participation is completely voluntary and you may choose to leave at anytime. Everything that is said whether it be tape recorded or written down will remain confidential. No individual or group names will be used in the report. I am taping it so that I can transcribe and analyze the results.

## Questions

1. Has using a student response system in class increased your comprehension of material?
2. Has using a student response system in class increased you engagement/attention to lecture?
3. Has the use of clickers increased your participation in lecture?
4. What type of clicker questions did you find the most useful?
5. What problems did you have with the clickers?
6. Would you like to see their use continue?

APPENDIX E

FACULTY INTERVIEW QUESTIONS

APPENDIX E

## FACULTY INTERVIEW QUESTIONS

## Faculty Interview Questions

Note: much of the protocol and some questions have been adopted from Coral Richards Hanson's paper on An Evaluation of a student Response System Used at Brigham Young University]

## Protocol for faculty interviews

1. You have been asked to participate in this interview to help me understand if clickers are beneficial to student learning. I want you to help me understand any problems you had with the system or any benefits you and your students gained from using them.
  2. I want you to feel comfortable sharing your thoughts and experiences.
  3. Participation is completely voluntary and you may choose to leave at anytime. Everything that is said whether it be tape recorded or written down will remain confidential. No individual or group names will be used in the report. I am taping it so that I can transcribe and analyze the results.
- 
1. What advantages did you notice from using the student response system?
  2. What disadvantages did you notice from using the student response system?
  3. Do you feel the advantages of using a Student Response System outweigh the disadvantages?
  4. How easy was it to use the student response software and hardware?
  5. Do you think the use of clickers helped your students understand and retain course information?
  6. Do you think the use of clickers helped students test taking skills?
  7. Will you continue to use a student electronic response system?

APPENDIX F

HONORS BIOLOGY MIDTERM EXAM

APPENDIX F

HONORS BIOLOGY MIDTERM EXAM

**Honors Biology – Midterm Exam**

**Mr. Fuller**

**October 2009**

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*Student Name*

**Scoring**

**Written Exam**

70 possible points

\_\_\_\_\_ points earned

**Lab Practical**

30 possible points

\_\_\_\_\_ points earned

Total Score \_\_\_\_\_

*Part I: True False*

1. T F Electrons are shared equally in a polar covalent bond.
2. T F ATP essential to living things.
3. T F Water is an organic compound.
4. T F Most scientific measurements are made using the English System of Units.
5. T F Chemical reactions that involves a net release of energy are called exothermic.
6. T F All cells have the same basic shape.
7. T F Eukaryotic cells evolved from prokaryotic cells.
8. T F Quantitative data is measured numerically.
9. T F The chemical breakdown of sugar to release energy is called photosynthesis
10. T F DNA is a type of nucleic acid.
11. T F A concentration gradient is the difference in concentrations of a substance across a space.
12. T F The nucleus of the cell contains mitochondria.
13. T F Ribosomes make protein.
14. T F Enzymes decrease reaction rates.
15. T F Eukaryotes probably existed before prokaryotes.
16. T F The energy in ATP is stored in its phosphate bonds.
17. T F Homeostasis is the process by which molecules move toward an area of lesser concentration.
18. T F Heterotrophs carry out respiration.
19. T F Water is considered to be the universal solvent because it can dissolve many substances.

20. T F Aerobic respiration is the process by which plant cells store chemical energy.
21. T F The main difference between prokaryotes and eukaryotes is that one of them lacks a cell membrane.
22. T F Osmosis is diffusion of any substance through a membrane.
23. T F Lipids are found in the cell membrane.
24. T F The sharing of electrons is characteristics of ionic bonds.
25. T F Including saturated fats in the diet may help to prevent heart disease.
26. T F Individual monomers of nucleic acids are known as nucleotides.
27. T F Polysaccharides are split apart to form monosaccharides in a reaction called hydrolysis.
28. T F DNA and RNA are nucleic acids.
29. T F The light reactions occur inside the thylakoid membrane.
30. T F Glycolysis is an aerobic process that breaks down food molecules to produce energy.

*Part II Multiple Choice*

31. A scientific theory results when experiments and results:
- are published in scientific magazines
  - answer questions
  - are confirmed by other scientists
  - help predict new experiments
32. Which of the following pieces of information is an example of quantitative data?
- image of a cell
  - height of a plant
  - sketch of a bird
  - description of a macromolecule
33. The odor of barbecued chicken coming into the house from an outdoor grill is an example of:
- diffusion
  - active transport
  - plasmolysis
  - osmosis

34. The process of breaking chemical bonds or forming new bonds is called a chemical:
- equation
  - activation
  - reaction
  - compound
35. Animals store energy most efficiently in the form of:
- RNA
  - carbohydrates
  - polypeptides
  - lipids
36. Elements are made up of
- only one kind of atom
  - two or more kinds of atoms
  - two or more compounds
  - only one molecule
37. An element that has the atomic number of 8 would have
- an atomic mass of 4
  - 4 electrons
  - 8 protons
  - 6 neutrons
38. Any cell component that performs specific functions is called:
- a eukaryote
  - a nucleus
  - a microorganism
  - an organelle
39. Each element has its own characteristic atom in which:
- the atomic weight is constant
  - the atomic number is constant
  - the electrons are constant
  - two of the above are correct
40. The control in an experiment is the
- point at which variables are introduced
  - careful measuring and recording of data
  - point at which observations are made
  - standard against which changes, if any, are made

41. How many covalent bonds is a sulfur atom most likely to form? (if it bonds to hydrogen)
- 1
  - 2
  - 3
  - 4
42. Which of the following steps in a scientific investigation is taken first?
- experimenting
  - communicating
  - analyzing
  - hypothesizing
43. Glucose is a
- carbohydrate
  - lipid
  - protein
  - nucleic acid
44. Ice floats because:
- air is trapped in the crystalline lattice.
  - the formation of hydrogen bonds releases heat; warmer objects float.
  - It has a smaller surface area than liquid water.
  - Hydrogen bonding spaces the molecules farther apart, creating a less dense structure.
45. The semifluid material that fills most of the cell outside of the nucleus is called:
- cellulose
  - cytoplasm
  - nucleoplasm
  - pectin
46. Data gathering under controlled conditions that eliminates extraneous influences is known as:
- classifying
  - inferring
  - experimenting
  - predicting
47. Why is water such an excellent solvent?
- As a polar molecule, it can surround and dissolve ionic and other polar molecules.
  - It forms hydrogen bonds with itself.
  - It has a high specific heat and heat of vaporization.
  - It is wet and has a great deal of surface tension.

48. A base is:
- something that contains a high concentration of hydroxide ions
  - something that is dissolved in pure water
  - something that contains a high concentration of hydrogen ions
  - distilled water
49. When boiled most enzymes
- work faster
  - don't work
  - work slower
  - work at varying rates
50. Micrometers are measures of
- length
  - mass
  - volume
  - temperature
51. Organisms that acquire energy from other organisms are called:
- autotrophic
  - heterotrophic
  - unicellular
  - multicellular
52. Which of the following is / are not found in a prokaryotic cell?
- chloroplast
  - plasma membrane
  - mitochondria
  - a and c
53. Proteins to be used within the cytosol are generally synthesized
- by ribosomes
  - by the nucleolus
  - within the Golgi apparatus
  - by mitochondria and chloroplasts
54. Enzymes are composed of:
- proteins
  - nucleic acids
  - lipids
  - carbohydrates

55. Chemical reactions in living cells can occur very quickly even at room temperatures because of the action of
- sugars
  - amino acids
  - ATP
  - enzymes
56. A meter is to length what a kilogram is to
- mass
  - temperature
  - time
  - area
57. A freshwater Paramecium is placed into salt water. Which of the events would occur?
- an increase in the action of its contractile vacuole
  - swelling of the cell until it becomes turgid
  - swelling of the cell until it lyses
  - shriveling of the cell
58. A carbohydrate consists of hydrogen, carbon and \_\_\_\_\_ in a 1:2:1 ratio.
- helium
  - carbon dioxide
  - oxygen
  - H<sub>2</sub>O
59. \_\_\_\_\_ Which of the following is not a reactant in the light reaction?
- Water
  - Glucose
  - Water
  - ADP
60. The organelle that is used for digestion is the
- ribosome
  - vacuole
  - lysosomes
  - plastid
61. Generally, the first process a scientist uses to obtain knowledge about nature is:
- collecting
  - observing
  - predicting
  - measuring

62. Watering a house plant with too concentrated a solution of fertilizer can result in wilting because
- the uptake of ions into plant cells makes the cell hypertonic.
  - the soil solution becomes hypertonic, causing the cells to lose water.
  - the plant will grow faster than it can transport water and maintain proper water balance.
  - Diffusion down the electrochemical gradient will cause a disruption of membrane potential and accompanying loss of water.
63. Which of the following is part of a nucleotide?
- amino acid
  - phosphate group
  - fatty acid
  - carboxyl group
64. Name the Process:  $\text{CO}_2$  is fixed and joined to a five-carbon sugar, forming a 6-carbon molecule which splits into 2 molecules of PGA, which is further broken down into GAP (using NADPH and ATP). The GAP undergoes a series of chemical transformations and recombination, which require ATP, and eventually regenerate into the 5 carbon starting sugar, RuBP.
- Calvin cycle
  - electron transport chain
  - light reaction
  - Krebs cycle
65. Name the process: the first step in both anaerobic and aerobic respiration. Glucose is broken down into 2 molecules of pyruvic acid. The resulting energy released results in 2 ATPs and 2 NADHs.
- light reaction
  - glycolysis
  - dark reaction
  - Krebs cycle
66. When plants manufacture glucose during photosynthesis, they transform light energy into:
- activation energy
  - heat energy
  - mechanical energy
  - chemical energy
67. How many molecules of  $\text{CO}_2$  are generated for each molecule of acetyl CoA introduced into the Krebs cycle?
- 1
  - 2
  - 3
  - 4

68. Why is glycolysis considered one of the first metabolic pathways to have evolved?
- It relies on fermentation, which is characteristic of the archeobacteria and eubacteria.
  - It is found only in prokaryotes, whereas eukaryotes use their mitochondria to produce ATP.
  - It produces much less ATP than does the electron transport chain.
  - It is nearly universal and does not involve O<sub>2</sub>.
69. The genetic information in a cell is contained in the:
- nucleus
  - ribosome
  - golgi bodies
  - chloroplasts
70. The cell organelle proteins are synthesized at is called:
- The ribosome
  - The Nucleus
  - The Mitochondria
  - The ER
71. Which of the following molecular characteristic would not be giving by the formula C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>
- number of atoms
  - position of atoms
  - kinds of atoms
  - numerical proportion of atoms
72. What are the correct products of photosynthesis
- Carbon Dioxide, Water
  - Water, Sugar
  - Sugar, Oxygen
  - Sunlight, Gold
73. With the development of an oxygen atmosphere
- glucose could be broken down into 2 pyruvic acids
  - photosynthesis could evolve
  - fermentation rates got faster
  - glucose could be broken down to CO<sub>2</sub>
74. Which of these foods have the greatest concentration of H<sup>+</sup> ions?
- apple, pH 2.9
  - corn, pH 6.2
  - bread, pH 5.5
  - milk, pH 6.6

75. Which of these is generally not considered to be organic?
- carbon dioxide
  - carbohydrate
  - protein
  - lipid
76. In a condensation reaction:
- water is released
  - water is added
  - carbon dioxide is added
  - nothing happens
77. In which structure is light energy “trapped” and changed into chemical energy?
- mitochondria
  - chloroplasts
  - ribosomes
  - vacuole
78. Oils are one type of:
- carbohydrate
  - protein
  - nucleic acid
  - lipid
79. The Krebs Cycle occurs in the:
- Thylakoid Membrane
  - Stroma
  - Liquid Matrix
  - Cristae Membrane
80. Which of the following donates electrons to photosystem II in the light reaction?
- Carbon Dioxide
  - ATP
  - Glucose
  - Water

APPENDIX G

MIDTERM NON-CLICKER QUESTIONS

APPENDIX G MIDTERM NON-CLICKER QUESTIONS

Non-Clicker Questions	Spring 09 % correct	Fall 09 % correct
1	50	45
2	100	100
3	73	58
4	86	90
5	73	75
8	86	95
18	82	75
19	100	85
24	77	55
29	95	85
31	77	55
32	82	85
33	95	68
34	95	95
36	41	65
37	86	85
39	27	25
40	91	83
41	64	70
42	86	83
44	86	88
46	77	73
47	82	73
48	64	58
50	91	85
51	95	90
56	95	98
59	100	90
61	64	80
64	82	78
66	68	88
71	73	80
72	100	85
74	60	75
Mean	79.5	77

APPENDIX H:

MIDTERM CLICKER QUESTION

SD	17.29468302	16.12263607
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APPENDIX H: MIDTERM CLICKER QUESTION

Clicker Questions	Spring 09 % Correct	Fall 09 %Correct
6	91	90
7	95	98
9	77	78
10	91	93
12	95	93
16	91	98
17	91	95
20	50	85
21	77	65
22	91	70
23	100	60
25	91	83
26	100	95
27	77	85
28	95	98
30	82	70
35	36	63
38	86	98
45	95	98
49	36	58
54	86	75
55	82	80
58	91	90
60	77	78
62	68	60
63	60	48
65	95	83
67	27	73
69	95	98
70	100	73
73	46	18
75	64	80
77	77	90
78	86	98

Mean	79.44117647	79.91176471
SD	20.18667615	17.77019576

APPENDIX I

HONORS BIOLOGY FINAL EXAM

## HONORS BIOLOGY FINAL EXAM

*Part 1: True / False*

1. T F HIV is a virus.
2. T F Bacteria are single celled eukaryotic organisms
3. T F Plasmids are small circular pieces of human DNA
4. T F Restriction enzymes join DNA fragments together.
5. T F In metaphase chromosomes are pulled by spindle fibers to opposite poles
6. T F Two heterozygous individuals could produce a homozygous recessive individual.
7. T F Evolution is the theory that species change over time.
8. T F Agar is a common antibiotic used to kill bacteria.
9. T F Heterotrophs get their energy from organic molecules.
10. T F One criteria that is used to define the kingdom to which an organism belongs is the type of cell.
11. T F Dichotomous keys are useful in genetic engineering organisms.
12. T F Mitosis results in daughter cells that are genetically different from one another.
13. T F Mass selection is a type of selective breeding.
14. T F In stabilizing selection the two extremes are favored.
15. T F Certain adaptations found in bees and the flowers they pollinate suggests occurrence of coevolution.
16. T F A Punnet Square shows the possible genotypes of offspring.
17. T F Gram positive bacteria stain pink
18. T F Natural selection can cause the spread of an advantageous adaptation throughout a population.

19. T F DNA replicates itself just after cell division.
20. T F All protists are heterotrophic.
21. T F There are four alleles for blood type.
22. T F Viruses are not living things.
23. T F Genetic engineering often requires the use of recombinant DNA.
24. T F Mitosis produces two daughter cells
25. T F During meiosis 4 gametes are formed.

### Part II Multiple Choice

26. Two chromatids are held together by a
- chromosome
  - chromatin
  - centromere
  - clone
27. During the interphase portion of mitosis
- the cell is dormant
  - the cell is dividing
  - the cell is making extra organelles
  - the cell splits into two daughter cells
28. A test cross is a cross between an individual of unknown genotype and an individual whose genotype is:
- homozygous recessive
  - homozygous dominant
  - heterozygous
  - unknown
29. An example of a codominant trait is
- blood type
  - flower color
  - hair color
  - plant height
30. Traits that are caused by the interaction of many genes are said to be:
- polyploid
  - linked
  - autosomal
  - polygenic

31. Which of the following is not a vector?
- pipet
  - gene gun
  - DNA straw
  - plasmid
32. Which of the following is not a viral disease is \_\_\_\_\_.
- E. coli
  - HIV
  - small pox
  - flu
33. \_\_\_\_\_ structures are no longer used by the organism
- vestigial
  - homologous
  - analogous
34. In which phase of interphase are extra organelles made
- M
  - S
  - G1
  - G2
35. Kingdoms can be divided into:
- phyla
  - classes
  - orders
  - species
36. The splitting of a bacterium is called:
- inheritance
  - development
  - sexual reproduction
  - asexual reproduction
37. Which of the following is a heterotroph?
- pine tree
  - grass
  - fungus
  - tulip
38. Natural selection is the process by which:
- evolution occurs
  - organisms reproduce
  - cells divide
  - genes are expressed

39. Which of the following describes what an adaptation is?
- piece of DNA
  - favorable trait
  - complex response
  - group of organisms
40. The diploid number for human cells is:
- 38
  - 23
  - 46
  - 100
41. A test cross is used to determine an individual's:
- phenotype
  - generation
  - genotype
  - strain
42. The 1N cells of a species of a reptile contain 16 chromosomes. How many chromosomes would be found in the cells of a normal healthy adult of the species?
- 8
  - 16
  - 32
  - 64
43. New alleles are introduced into a species through:
- mutation
  - inbreeding
  - segregation
  - cloning
44. In the Hardy Weinberg equilibrium  $P^2$  is the frequency of;
- homozygous dominant organisms
  - heterozygous organism
  - homozygous recessive individuals
45. Competition between individuals of a species occurs primarily because of:
- a scarcity of resources
  - advantageous variations
  - low birth rates
  - acquired characteristics
46. Which of the following is most important in controlled breeding?

- a. selecting parents
  - b. inserting genes
  - c. isolating genes
  - d. inducing polyploidy
47. Organisms of similar classes make up:
- a. phylum
  - b. an order
  - c. a species
  - d. a family
48. Variation is most important to Darwin's theory of evolution because it:
- a. provides material on which natural selection acts
  - b. allows individuals to explore new habitats
  - c. minimizes competition within a species
  - d. allows individuals to make the best use of limited resources
49. Phyla are divided into classes, and a class is divided into:
- a. families
  - b. classes
  - c. orders
  - d. genera
50. If a virus does not cause disease immediately after it enters the organism, it probably went into the:
- a. lytic cycle
  - b. lysogenic cycle
  - c. Krebs cycle
  - d. Calvin cycle
51. What is the second phase of the lytic cycle?
- a. attachment
  - b. reproduction
  - c. assembly
  - d. entry
52. The longest phase of the cell cycle is:
- a. prophase
  - b. interphase
  - c. metaphase
  - d. anaphase
53. Two organisms evolving to look alike is an example of

- a. co evolution
  - b. convergent evolution
  - c. radial evolution
  - d. divergent evolution
54. Collectively, reproductive cells are spoken of as:
- a. ova
  - b. sperm
  - c. gametes
  - d. eggs
55. The phase of meiosis in which homologous chromosomes separate
- a. metaphase 1
  - b. anaphase 1
  - c. metaphase 2
  - d. anaphase 2
56. A piece of DNA that is produced by combining DNA fragments from different sources is called:
- a. hybrid DNA
  - b. cloned DNA
  - c. plasmid DNA
  - d. recombinant DNA
57. To cut a sequence of DNA at a specific place on a DNA molecule a scientist would use a:
- a. restriction enzyme
  - b. sodium chloride solution
  - c. plasmid
  - d. chimera
58. What is the exchange of genes between homologous chromosomes called?
- a. tetrad
  - b. segregation
  - c. independent assortment
  - d. crossing over
59. Which kind of mutation would result if an extra nucleotide were inserted into a gene?
- a. germ
  - b. frameshift
  - c. chromosomal
  - d. deletion
60. What is the fraction of the offspring are homozygous recessive for both traits, resulting from a heterozygous X heterozygous (TtBb) dihybrid cross.
- a.  $\frac{9}{16}$
  - b.  $\frac{1}{4}$

- c. 3/16
  - d. 1/16
61. The closest protest phylum to green plants is \_\_\_\_\_.
- a. chlorophyta
  - b. phaeophyta
  - c. diatoms
  - d. sporazoans
62. In gel electrophoresis small fragments of DNA
- a. move at the same rate as large fragments
  - b. move slower than large fragments
  - c. don't move
  - d. move faster then larger fragments
63. A structure that forms when a bacterium produces thick internal walls that encloses its DNA and part of its cytoplasm is called a (an):
- a. spirillum
  - b. capsid
  - c. prophage
  - d. endospore
64. In the Hardy Weinberg Equation q represents
- a. frequency of the recessive allele
  - b. frequency of homozygous dominant
  - c. frequency of heterozygous
  - d. frequency of homozygous recessive
65. Gel electrophoresis separates DNA fragments by using
- a. an electric field
  - b. light
  - c. magnets
  - d. jello
66. Going back to the diploid number of chromosomes after halving them during meiosis is done by:
- a. synapses
  - b. fertilization
  - c. mitosis
  - d. DNA replication
67. Bacteria that can grow and thrive in extremely hot environments are referred to as:
- a. Thermophiles
  - b. Methanogens
  - c. Acidophiles
  - d. Halophiles

68. Which of the following is one of Lamarck's assumptions?
- variation exists in populations
  - species compete for recourse
  - organisms have a desire to change
  - natural selection chooses the best fit organisms.
69. A karyotype is:
- a genotype of an individual
  - a unique combination of chromosomes found in a gamete
  - blood type determination of an individual
  - a pictorial display of an individual's chromosomes
70. The DNA content of a cell is measured in the G<sub>2</sub> phase. After meiosis I, the DNA content of one of the two cells produced would be
- equal to that of the G<sub>2</sub> cell.
  - twice that of the G<sub>2</sub> cell.
  - one-half that of the G<sub>2</sub> cell.
  - one-fourth that of the G<sub>2</sub> cell.
71. Which of the following is **not** a source of genetic variation in sexually reproducing organisms?
- crossing over
  - mutations
  - replication of DNA during S-phase before meiosis I
  - independent assortment of chromosomes during meiosis
72. Chimpanzees and humans share many of the same genes, indicating that
- the two groups belong to the same species.
  - The two groups belong to the same phylum.
  - The two groups share a relatively recent common ancestor.
  - Humans evolved from chimpanzees.
73. A plant cell has 12 chromosomes at the end of mitosis. How many chromosomes would it have in the G<sub>2</sub> phase of the next cycle?
- 6
  - 9
  - 12
  - 24
74. The presence of mitochondria in cells can be explained by which theory?
- biogenesis
  - endosymbiosis
  - spontaneous generation
  - chemosynthesis
75. Which of the following mutations would be the **least** severe for an organism?

- a. frameshift mutation
- b. point mutation
- c. chromosomal mutation

Match the phrase with the correct word. Write your choice on the line to the left.

- a. adaptation                      b. competition                      c. natural selection

76. \_\_\_\_ Two robins struggle over a worm
77. \_\_\_\_ A long beak of a hummingbird is used to sip nectar
78. Linnaeus put similar species into a larger group called the:
- a. class
  - b. family
  - c. genus
  - d. division
79. Which of the following are not related?
- a. analogous structures – butterfly wing
  - b. evolution – natural selection
  - c. vestigial structures – appendix
  - d. adaptive radiation – convergent evolution
80. Which of the following terms relate to rod shaped bacteria?
- a. cocci
  - b. bacilli
  - c. spirilli