The Pennsylvania State University

The Graduate School

Eberly College of Science

INDIVIDUAL DIFFERENCES AND PERFORMANCE IN A COLLEGE BIOLOGY COURSE

A Thesis in

Biology

by

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Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

May 2018

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ABSTRACT

Biology undergraduate students are struggling academically to learn and understand the material that is presented to them. Educational psychologists have identified a number of individual differences that are related to learning, task performance, and task choice. Undergraduate students enrolled in an introductory biology course completed surveys measuring three individual difference measures: self-efficacy, goal orientation, and metacognition. Scores on the individual difference measures were analyzed against course exam performance to understand the relationship between individual differences and biology course performance. There were 218 undergraduate participants, recruited from an introductory biology course. Individual difference data was collected at two-time points during the semester. Self-efficacy was significantly correlated to exam performance at both time points. Metacognition scores from the second-time point were significantly correlated to exam performance. Goal orientation scores were not significantly correlated to exam performance. Lastly, several strategies are discussed that may improve students' self-efficacy, goal orientation, and metacognition.

Keywords: goal orientation, individual differences, metacognition, self-efficacy

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Introduction

There is a clear need to increase retention rates for college biology majors and improve the learning outcomes for those graduating with these degrees. Fewer than half of all students who begin college with the intention to pursue science degrees actually graduate with a science degree (Higher Ed Research Institute, UCLA, 2010) and those that do graduate often exhibit deficiencies in biological knowledge and skills (Lozano & Tilman, 2016). Against this backdrop, undergraduate biology educators have begun to seek ways of enhancing their students' academic success. These efforts have included curricular reform (Diesterhaft & Jaus, 1997), innovative instructional practices (Tanner, 2012; Young & Fry, 2008), and greater attention to assessment practices (Tanner, 2012). The current study contributes to these efforts by exploring the relationships between a set of individual differences and biology students' course performance.

Although a substantial number of educational studies have examined the relationship between course performance and student differences (e.g., prior knowledge and motivation) few have considered this question in the specific context of college biology students. A recent review of papers published in *Advances in Physiology Education,* for example, found no studies related to individual differences generally. Only two studies measured students' self-efficacy, and there were no studies that measured metacognition or goal orientation. Individual differences are necessary to consider, because these can affect not only performance within particular courses (Pintrich, 2000a; Schraw, 1998; Zimmerman, 2000) but also overall academic success (Hackett, 1995; Pajares, 2003). In this study, we examine how a set of individual differences relate to one another, change over time in a course, and predict course performance. The specific individual differences studied are metacognitive awareness, goal orientation, and self-efficacy. We selected these individual differences because each one is both related to college students' course performance (Andrew, 1998; Burgoon, Meece, & Granger, 2012; Chemers, Hu, & Garcia, 2001; Coutinho, 2008; McCabe, 2011) and responsive to instructional actions. Instructors, can benefit from not only knowing about these individual differences but also understanding that those individual differences can be a positive influence in a course. The present study has identified three individual differences to examine: self-efficacy, goal orientation, and metacognition.

Individual Difference Constructs

Self-Efficacy

Self-efficacy is an individuals' level of perceived confidence in regards to completing a task or exhibiting a particular behavior. Stated more simply, how capable a student thinks they are at successfully completing a task. A student's own belief in their ability to succeed at a task will influence the decisions they make to achieve that task. This can include the amount of time and effort they will spend, as well as how they approach problems that arise with the task (Pajares, 2003; Van Dinther, Dochy, & Segers, 2011). Self-efficacy is a multidimensional construct that is domain-specific (Zimmerman, 2000). Students may feel differently about their capabilities to succeed on a biology exam than a geography exam. Zimmerman (2000) argues that student performance capabilities, not physical or psychological characteristics, are measured through self-efficacy. Self-efficacy is comprised of aspects of self-belief, but also former achievements and experiences, skill, and subsequent achievements (Van Dinther et al., 2011).

A strong sense of self-efficacy has been shown to increase the effort and time a student is willing to devote to a task, their commitment to the task, and academic performance (Bandura, 1989; Pintrich & De Groot, 1990). Bandura (1989) also found that students with low self-efficacy who fail to achieve the goal that they set, will decrease their efforts to meet their goal, and possibly abandon the goal early. Learners with high self-efficacy are actively engaged in learning, spend more time on a task, and use multiple learning strategies (Honicke, & Broadbent, 2016). Students approach learning tasks with various prior experiences and capabilities including interests, attitudes, and task specific skills (Schunk 1985).

Students with higher self-efficacy use more cognitive strategies and have a higher academic performance (Andrew 1998, Burgoon, et al., 2012; Pintrich & De Groot, 1990). It has been demonstrated that self-efficacy can predict academic performance on a variety of assessments. First-year medical students enrolled in a human gross anatomy course were given surveys to assess if self-efficacy predicts academic performance (Burgoon et al., 2012). The results indicated that two written examinations, and four laboratory practical examinations were predicted by scores on a self-efficacy scale. The study used a total of four written examinations and four laboratory examinations as a measure of student academic performance. The study provides a look, longitudinally, at the relationship between self-efficacy and academic performance, as the examinations were distributed throughout the entire duration of the course. Andrew (1998) had similar findings with undergraduate nursing students, in which self-efficacy predicted students' academic performance in science courses. Many nursing students will have had limited exposure to science courses before attending college as an undergraduate. Andrew suggests improving self-efficacy as a potential way to improve academic performance by presenting the scientific material as it applies to daily life. The outcomes of these academic performance assessments exert their own influence on self-efficacy, as failure can decrease self-efficacy, and success can raise it (Schunk, 1985).

Educators can improve students' self-efficacy in a number of ways. One technique is through verbal encouragement (Schunk, 1985; Zimmerman, 2000). Encouraging students makes it clear that they are acquiring knowledge and skills. It can provide feedback to remedy troublesome task aspects and ensure students are grasping all of the pieces in task (Schunk, 1985). A second technique is setting goals. Students with high self-efficacy will set high goals for themselves, and are committed to meeting those goals (Bandura, 1989; Zimmerman, 2000). Zimmerman (2000) discusses a study where goal setting increased students' prediction of their final course grades in a high school social studies class by 31%. Setting goals can be a task that educators assign to their students to increase students' self-efficacy.

Goal Orientation

An individuals' goal orientations seek to explain why and how they are attempting to achieve particular objectives, as well as the reason behind their achievement behavior (Kaplan & Maehr, 2007). There are two core goal orientations that are related to maladaptive and adaptive behaviors. These orientations are *mastery* and *performance* goals. A student with mastery goal orientation has a primary focus is on learning, understanding, and developing competence in the material or subject. These individuals are regularly associated with high levels of self-efficacy (Hsieh, Sullivan, Guerra, 2007; Kaplan & Maehr, 2007). Performance goal orientations are associated with **demonstrating** competence, rather than **developing** competence, and how that individual is seen by others. If an individual is motivated to outperform their peers, and demonstrates competence, they have *performance-approach* goals. On the other hand, individuals who avoid demonstrating competence for fear of failure have *performance-avoidance* goals (Pintrich, 2000b).

Performance-avoidance goals have been associated with low self-efficacy, an avoidance to seek help, self-handicapping strategies, and other maladaptive learning traits (Kaplan & Maehr, 2007; Pintrich, 2000b). There is disagreement in the field as to the affects performance-approach goals have on learning. Several studies have found positive learning behaviors associated with performance-approach, such as self-efficacy, motivation, and increased strategy use (Kaplan & Maehr, 2007; Pajares, Britner, & Valiante, 2000; Pintrich 2000); while others have demonstrated its association with anxiety, disruptive behavior, and low retention of knowledge (Kaplan & Maehr, 2007; Midgley, Kaplan, & Middleton, 2001; Pintrich 2000). Pintrich (2000) suggests that individuals with performance-approach goal orientation could have an increased motivation to prove their knowledge to others, but as a consequence increase their anxiety, and cause them to avoid strategies that would be beneficial (for example, help seeking). This may help in understanding the discrepancy in the field of the exact effect performance-approach goals have on learning and learning behaviors. Mastery goals have been shown to increase achievement-based behaviors and engagements with the task. Individuals who are mastery-oriented have shown to be self-regulated learners who adapt problem-solving behaviors to specific tasks. Prior successes in learners' completion of tasks have been shown to increase mastery goals (Ames, 1992; Kaplan & Maehr, 2007; Pintrich, 2000a).

Previous research has indicated a relationship between goal orientation and other individual differences, such as metacognition and self-efficacy (Coutinho, 2007; Hsieh, et al., 2007). A study by Hsieh, Sullivan, and Guerra (2007) explored the relationship between college students' self-efficacy, goal orientation, and the relationship between these measures. Participants in the study were 112 undergraduate students, 60 of which were on academic probation (GPA under 2.0), and 52 who were not. They found that students with high self-efficacy, and in good academic standing, did not have performance-avoidance goals, which is consistent with previous research (Pajares et al., 2000). Unexpectedly, students who were on academic probation and had high self-efficacy adopted performance-avoidance goals more so than students with low self-efficacy. The study emphasizes the complex relationship between performance goals and self-efficacy, as well as academic achievement and goal orientations.

Several studies have explored the adaptive and maladaptive effects goal orientations have on learning in children (Ames & Archer, 1988; Pintrich, 2000a; Wolters, Yu, & Pintrich, 1996). Although there is a gap in the literature on the roles of goal orientation and academic performance (Coutinho, 2007), the roles of goal orientation on behavior, motivational beliefs, learning strategies, and other individual differences such as metacognition and self-efficacy have been studied. Previous research has found either a complex relationship between goal orientation and academic performance, or no relationship (Butler, 1993; Coutinho, 2007).

Metacognition

Metacognition is both the *knowledge of cognition* and *regulation of cognition*. Basically, what students know about their own cognition, and how knowledge is controlled (Schraw, 1998). Knowledge of cognition includes knowledge of self and strategies, how to use those strategies, and when or why to use strategies while learning. These strategies can impact an individual's performance on tasks. The knowledge of when and how to use a strategy can allow an individual to better allocate their time and resources and adjust to the demands of a particular task by monitoring their success (Pintrich & De Groot, 1990; Schraw, 1998; Schraw & Dennison, 1994). Schraw (1998) states that there are two key components of metacognition. First, that *cognition* and *regulation of cognition* are related, and second, that metacognition is domain-general. In a 1994 study, Schraw reported that ability of an individual to accurately monitor their comprehension was significantly related to test performance. Finally, the domain-general component of metacognition refers to the transferability of metacognitive skills across domains (Schraw, 1998).

Learning behaviors such as panning, monitoring, and evaluating are linked to metacognition (Schraw, 1998; Schraw & Dennison, 1994). Planning involves selecting appropriate strategies, making predictions before attempting the task, and allotting time and resources to the task. Monitoring is assessing the progress of the task, such as quizzing oneself on the learning materials. One's ability to monitor learning has been shown to increase with practice and training. Evaluation refers to appraising the final learning outcome and gauging how closely the outcome matches the goals set in the planning stage (Schraw, 1998; Young & Fry, 2008).

Multiple studies have found a significant relationship between college students' metacognitive awareness and academic performance (Coutinho, 2008; Young & Fry, 2008). Coutinho (2008) and Young & Fry (2008) used a metacognitive awareness inventory (MAI; which is also used in the present study) to measure metacognition. Young & Fry (2008) found a significant correlation of metacognition and broad measures of academic achievement, such as GPA and course grade. Participants for the study were recruited from fifteen different courses, which further demonstrates the domain-general nature of metacognition. Coutinho (2008) measured self-efficacy as well as metacognition. While both individual differences were correlated with GPA, self-efficacy had a stronger correlation with GPA performance than metacognition. An individual's academic performance is influenced through a number of factors, and metacognition has been shown to be significantly correlated to learning and academic performance.

Previous research has shown that individuals with low metacognitive awareness perform less well in academic settings than individuals with high metacognitive awareness (Schraw, 1998). There are a number of ways instructors can increase metacognitive awareness in their students. Firstly, instructors can take time out of class to explicitly show students different metacognitive strategies. It can be time consuming for instructors to develop metacognitive strategies about learning to give students. Tanner (2012) developed her own matrix instructors can use to demonstrate metacognitive awareness, based on research from educational psychologists studying metacognition. McCabe (2011) found that students who received targeted instruction outperformed students who did not receive targeted instruction. Secondly, instructors can simply inform students when a topic that has confused previous students is being presented (McCabe, 2011; Tanner, 2012). This allows students to prepare themselves mentally for the challenging topic ahead, and also gives them permission to discuss their confusion without feeling uncomfortable (Tanner, 2012). It can be extrapolated that informing students in this manner will not only increase students' metacognitive awareness, but potentially their self-efficacy as well.

Present research

This study explores the relationships between college biology students' course performance and the three individual differences; self-efficacy, goal orientation, and metacognitive awareness. Although these individual differences have all been explored in previous research, little research has considered the role of individual differences in college biology courses. The introductory biology course that was chosen for this study includes a diverse population of students at varying points in their academic career.

Participants' scores on the individual difference measures were collected through online surveys given at two-time points during the semester. The time points were selected because they fall during the first and second half of the course. The first hypothesis predicts that there will be significant, positive correlations between participants scores on course exams and their scores on the individual difference measures, except for performance-avoidance goals. The hypothesis assumes that some differences might correlate and others not. The scores on performance-avoidance goal orientation are not predicted to have a significant correlation with exam performance, based on previous research. This hypothesis is tested by looking at the correlations between the individual measures at both time points and participants scores on the five course exams. If positive correlations are observed, it indicates that as scores on the exams and scores on the individual difference measure are increasing, or decreasing, together. A negative correlation would indicate that as one score increases, the other decreases.

The second hypothesis is that scores from the individual difference measures, from both time points, combine to significantly predict specific exam scores. Again, scores from performance-avoidance goal orientation are not hypothesized to predict exam scores. This hypothesis will be tested through a series of multiple regression equations that analyze the scores from the first individual difference measures and the second exam, and scores from the second individual difference measures and the fourth exam. The first individual difference measures presented to the participants occurred after the first exam, whereas the second individual difference measure was presented to the students after the third exam. The results from the first hypothesis will inform which individual difference measures are chosen for this regression model. Only the measures that are significantly correlated can be added to the regression model.

The third and final hypothesis predicts a significant difference in the scores of the individual difference measures between the two-time points. This hypothesis is tested by looking at the differences in means of the individual difference measures. It is predicted that for adaptive individual differences (self-efficacy, metacognitive awareness, mastery goals, and performance approach goals) scores on these measures will increase from Time 1 to Time 2. We predict that as the students become more familiar with the course, the material, and the types of questions on the exam, this will positively influence the development, and scores, on their individual difference measures.

Methods

Participants

In Time 1, 23 participants' responses included missing data and there was missing data for 32 participants in Time 2. These numbers include 23 participants who were missing data in only Phase 1, 30 participants who were missing data in only Phase 2, and 2 participants who were missing data in both phases. Of these 55 participants, 18 were missing responses to more than 5% of the items and thus, were removed from the data set. For the remaining 37 participants, mean replacement was used to address the missing values and these participants were retained. The data was analyzed and outliers on individual difference measures were identified. There were 11 participants who had Time 1 or Time 2 outliers on the individual difference measures, and these individuals were removed. This resulted in a final sample of 189 participants used for analysis.

The participants included 116 students in their first year of college, 50 students in their second year, and 11 students who were in their fourth year or higher of college. An additional three participants did not respond to this question. The sample included 133 female, 55 male, and one other participants. Participants could select more than one ethnicity on the demographics survey. The ethnicities of the participants included: Caucasian (82%), Asian (10.1%), Hispanic (6.9%), African-American (2.1%), and other (1.1%). Participants reported their current major. The sample represented colleges from across the university: 38.6% of the sample was enrolled in majors from the College of Science (Pre-Medicine and Biology majors), 23.3% from the College of Health and Human Development (Biobehavioral Health major), 13.2% from the College of Agricultural Science (Pre-Veterinary and Animal Science majors), 6.9% from the College of

Liberal Arts (Psychology and Anthropology majors), 4.8% from the College of Earth and Mineral Science, 2.6% from the College of Engineering, and 1.1% from the College of Education. A major had not been chosen for 9% of the sample and one participant did not answer. None of the participants dropped the course.

The participants in this study were part of a larger research project in which we tested the efficacy of a self-explanation strategy trainer in the context of a college biology course. That study included a business-as-usual control condition in which participants completed all study measures but did not receive any additional treatment. This subsample of the larger study provides an opportunity to examine the relationships among individual differences and course performance with a sample of students enrolled in a typical undergraduate, large lecture, biology course. Participants were enrolled in one of five lecture sections. Two biology instructors taught two lecture sections each, and a third instructor taught one section. Lecture slides, learning materials, and the examinations were exactly the same for all five sections. Instructors met once a week to discuss the course content and materials for the upcoming week. Average exam scores for each section were analyzed, and there were no significant differences between the sections. Participants electronically signed an informed consent before data was collected during phase one. All participants were over 18 years of age and received extra credit for participating in the study.

This study is a correlational design of individual differences and exam scores. All participants completed a set of individual difference measures at two-time points. Time 1 was during the fifth week of the semester and came just after the first exam. Time 2 was during the 11th, and 12th week and came just after the third exam. The semester had a total of 15 weeks.

Materials

Individual difference measures. The individual difference measures were answered on a Likert-scale. Once missing data was replaced, or a participant was removed, questions from each individual difference measure were summed to calculate a total score. Goal orientation was further broken down by subscale: mastery, performance-approach, and performance-avoidance. Prior knowledge scoring of each question was dichotomous: 1 for a correct answer, 0 for incorrect or missing answers. No participant was removed for missing prior knowledge data. The unanswered question was given a zero.

PALS Goal Orientation: The *Patterns of Adaptive Learning Scales (PALS;* Midgley et al., 2000*)* is a 14-item assessment of participants' goal orientation, scored on a 5-point Likert scale. The questions were from three subscales from PALS: mastery oriented, performance-approach, and performance-avoidance. The subscales were scored separately, as they each measure a different goal orientation. The mastery orientation scale consisted of five items, and had a high level of internal consistency, as determined by a Cronbach's alpha of 0.885 for Time 1, and 0.921 for Time 2. The performance-approach orientation scale consisted of five items and had a high level of internal consistency as determined by a Cronbach's alpha of 0.880 for Time 1, and 0.928 for Time 2. The final subscale, performance-avoidance orientation consisted of four items. It too had high levels of internal consistency as determined by a Cronbach's alpha of 0.834 for Time 1, and 0.893 for Time 2. A complete list of questions used from the PALS assessment can be found in Appendix A.

Metacognitive awareness: The *Metacognitive Awareness Inventory (MAI;* Schraw & Dennison, 1994) is a 52-item assessment measuring two major components of metacognition: *knowledge,* and *regulation* of cognition. Items were structured in a way that participants could answer specifically for the current course and included questions on knowledge of strategies and control of information. Participants responded to each item on a 5-point Likert scale. A single score was derived for metacognitive awareness. The scale consisted of 52 items, and had a high level of internal consistency, as determined by a Cronbach's alpha of 0.951 for Time 1, and 0.966. A complete list of the metacognitive awareness measure can be found in Appendix B.

Self-Efficacy: The *Biology Self-Efficacy Scale* is an instrument that was developed to measure participants' confidence with succeeding in a biology course (Baldwin et al., 1999). Participants answered SE questions on a 5-point Likert scale. A single score was derived for self-efficacy, consisting of 15 items. Self-efficacy had a high level of internal consistency, as determined by a Cronbach's alpha of 0.911 for Time 1, and 0.930 for Time 2. The questions used in the self-efficacy measure can be found in Appendix C.

Prior Knowledge: A 21-question assessment of the participants' biology knowledge was given at the start of the study. The prior knowledge test was written by a Biology instructor and includes a variety of general biology topics covered in the introductory biology course. The measure was found to have poor reliability, with a Cronbach's alpha of 0.347, and was therefore not considered further in the study. Prior knowledge questions used in the present study can be found in Appendix D.

Course Exams: There were five exams distributed throughout the semester, with a final, cumulative exam given during the final week of the semester. Exams were distributed electronically at an exam center on campus. Students had 50 minutes to complete exams one through four. The fifth exam (non-cumulative) and final exam (cumulative) were given as paper exams and students were allotted two hours to complete both exams in the same session. All of the exams consisted of 40 multiple choice questions. Question type ranged from simple fact recall to more advanced application-based questions, with an emphasis on application questions. The exam policy in this course allowed each student to drop their lowest exam score for the final grade calculation. All students were aware of this policy from the beginning of the semester. As a result, it is not possible to know if a student's lowest score is representative of his or her typical exam preparation and course performance. We addressed this by also dropping each participant's lowest exam score. Each analysis in which exam scores are considered includes only those participants for whom that score does not represent the lowest exam grade.

Procedure

An experimenter visited each of the lecture sections to recruit participants to the larger study. All students were told that they could sign up by logging on to their course management site and joining a group opened for study participants. The group had a password that was given during the recruitment, as well as instructions on accessing the group. The study design included three phases of data collection.

In phase one, all participants completed the demographic survey and the set of individual difference measures online. In phase two, the control condition participants comprising the current sample attended experimental sessions held in on-campus computer labs. During these sessions, control condition participants were presented with newspaper articles that were topically related to biology, including medicine, health, genetics, plants, microbiology, and animals. There were no minimum or maximum number of articles participants had to read.

In phase three, participants in all conditions attended experimental sessions in an on-campus computer lab, but control condition participants did not experience any experimental manipulations during these sessions. All participants completed the set of three individual difference measures a second time.

Experimenters recruited participants during the third week of the semester, before any exams were given. Experimenters used Excel to randomly assign participants to a treatment group, with a random number generator. Phase one took place during the fifth week of the semester, the week after participants had taken their first exam. The surveys and individual difference measures were distributed through Qualtrics, an online survey system, and completed at home.

All materials in phase two and three were delivered using Qualtrics during an experimental session in an on-campus computer lab. Experimenters allotted two hours for participants to complete phases two and three, however, participants could leave once they had completed their assigned task and therefore, spent varying amounts of time in the computer lab. Phase two occurred during the sixth week of the semester, a week before the second exam and four weeks before the third exam. The third phase took place during week 11 and the start of week 12. Participants completed the fourth exam at the end of week 12, and the fifth and final exams during the week after classes ended (week 16).

Results

Participants completed the individual difference measures twice; at Time 1 and Time 2. The individual difference measures were used as the independent variables and exam scores as the dependent variables. There was a total of 218 participants in the sample before analysis began. Participants missing individual difference values were identified. In Time 1, 23 participants' responses included missing data and there was missing data for 32 participants in Time 2. These numbers include 23 participants who were missing data in only Phase 1, 30 participants who were missing data in only Phase 2, and 2 participants who were missing data in both phases. Of these 55 participants, 18 were missing responses to more than 5% of the items and thus, were removed from the data set. For the remaining 37 participants, mean replacement was used to address the missing values and these participants were retained. The data was analyzed and outliers on individual difference measures were identified. Outliers were identified and removed from the data. There were 11 participants in total which were removed, resulting in 189 participants who were used for the final data analysis.

Data was examined to ensure that the assumptions for the statistical analyses were met. The data were normally distributed for metacognitive awareness, self-efficacy, and a combined total goal orientation measure, as assessed by a Shapiro-Wilk's test $p < 0.05$, for both Time 1 and Time 2. The separate subscales of the goal orientation measure were not normally distributed for either Time 1 or Time 2. Before the relationships between the individual difference scores and exam performance could be analyzed, a Pearson's correlation was run to assess the relationship among the individual difference variables. The scores for each measure are presented in Table 1.

There was a moderate positive correlation between metacognition and mastery goal orientation, $r(187) = 0.386$, $p < 0.01$, and a larger positive correlation between metacognition and self-efficacy, $r(187) = 0.548$, $p < 0.01$, between the Time 1 individual difference measures. Mastery goal orientation showed a strong positive correlation between performance approach and performance avoidance goal orientation, $r(187) = 0.696$, $p < 0.05$, between the Time 1 individual difference measures. Performance approach goal orientation statistically explains 48% of the variance in performance avoidance Time 1 individual difference measures. The Time 2 individual difference measures showed there was a strong positive correlation between metacognition and self-efficacy, $r(187) = 0.693$, $p < 0.05$, and a moderate positive correlation between metacognition and mastery goal orientation, $r(187) = 0.468$ $p < 0.05$. Metacognition statistically explains 48% of the variability in self-efficacy, and 22% of the variability in mastery goal orientation. There was a strong positive correlation between performance approach and performance avoidance goal orientation, *r(187)* = 0.803, $p < 0.05$, with performance approach explaining 64% of the variability of performance avoidance Time 2 individual differences.

Table 1

Descriptive statistics of scores on individual difference measures

Measure	Minimum Score	Maximum Score	*M (SD)*
Self-Efficacy (Time 1)	29	75	53.79 (0.65)
Metacognitive Awareness (Time 1)	118	246	187.48 (1.84)
Mastery Goal Orientation (Time 1)	14	25	22.42 (2.78)
Performance Approach Goal Orientation (Time 1)	5	25	11.66 (4.61)
Performance Avoidance Goal Orientation (Time 1)	4	20	10.38 (3.83)
Self-Efficacy (Time 2)	30	75	54.87 (0.69)
Metacognitive Awareness (Time 2)	121	260	192.77 (2.04)
Mastery Goal Orientation (Time 2)	14	25	21.44 (3.34)
Performance Approach Goal Orientation (Time 2)	5	25	12.44 (5.22)
Performance Avoidance Goal Orientation (Time 2)	4	20	10.44 (4.32)

Individual differences and exam performance

The first hypothesis predicted that each of the scores on the Time 1 individual difference measures would predict exam performance. This was tested using Pearson’s correlation analysis that examined the relationship between each individual difference variable and exam scores.

Time 1 individual difference data were collected the week after the first exam, and before any of the other exams took place. Table 2 summarizes the results. It is important to remember that participants had their lowest exam scores removed for analysis, so the sample size for each examination is different. Neither mastery nor performance approach goal orientation were significantly correlated with any of the exam scores. Performance avoidance goal orientation and metacognitive awareness had small correlations with the first two exam scores. Self-efficacy was significantly correlated with all of the exam scores, and showed a moderate correlation with Exams one, two, and four.

Table 2

Pearson's correlation analysis of Time 1 individual differences and exam scores

Individual Difference Measure	Exam 1 *n =182*	Exam 2 *n =178*	Exam 3 *n =180*	Exam 4 *n =157*	Exam 5 *n =27*	Final Exam *n =189*
Self-Efficacy	.356**	.330**	.190*	.337**	.264*	.287**
Metacognitive Awareness	.165*	.184*	.100	.140	.076	.133
Mastery GO	-.025	-.021	-.099	-.018	.044	.049
Performance Approach GO	.083	.045	.040	.022	-.027	.011
Performance Avoidance GO	.171*	.196**	.129	.089	.230	.120

Note. ** = statistically significant at $p < 0.01$ level, * = statistically significant at $p < 0.05$ level.

It was also predicted that each of the Time 2 individual difference measures would predict exam performance. This was also tested using a Pearson's correlation analysis that examined the relationship between each individual difference variable and exam scores. Time 2 individual difference data were collected during the 11th week of the semester; after Exams one through three, and before the other remaining exams. Table 3 presents the results from the analysis. Key findings of the analysis are the statistically significant correlations for all exams and self-efficacy, as well as the significant correlation between metacognition and all exams (excluding Exam five). Performance approach goal orientation had small correlations with Exam two, three, and the final exam. Performance avoidance had one small correlation with Exam three, whereas mastery goal orientation had no significant correlations with any exams.

Table 3

Pearson's correlation analysis of Time 2 individual difference measures and exam scores

Individual Difference Measure	Exam 1 *n =182*	Exam 2 *n =178*	Exam 3 *n =180*	Exam 4 *n =157*	Exam 5 *n =27*	Final Exam *n =189*
Self-Efficacy	.384**	.401**	.288**	.418**	.289*	.355**
Metacognitive Awareness	.304**	.304**	.204**	.318**	.105	.308**
Mastery GO	.105	.073	-.048	.048	.152	.142
Performance Approach GO	.134	.166*	.178*	.074	.097	.143*
Performance Avoidance GO	.124	.129	.184*	.078	.115	.112

Note. ** = statistically significant at $p < 0.01$ level, * = statistically significant at $p < 0.05$ level.

Combination of individual differences and exam performance

The second hypothesis explored whether exam performance could be predicted by multiple individual differences, and how much variance the individual differences explained. We begin with the first part of this hypothesis, which was that the second exam could be predicted from the scores on the Time 1 individual difference measures. The second exam was chosen because participants completed the Time 1 individual difference measures just prior to completing their second exam. Metacognitive awareness and self-efficacy were used as the Time 1 individual difference measures, based on the results of the first hypothesis. These measures were significantly correlated to the second exam. A standard multiple linear regression analysis was used. To use multiple linear regressions, five assumptions were tested: normality, independence, linearity, equivalence of error variance (homoscedasticity), and multicollinearity.

Table 4

Multiple regression analysis of Time 1 individual difference measures (MA and SE) and exam two scores

Variable	*B*	SE_B	β
Intercept	47.939	7.751	*
Metacognitive Awareness	0.006	0.046	0.010
Self-Efficacy	0.507	0.132	0.324*

Note. * = statistically significant at $p < 0.05$ level.

As previously stated, the Time 1 and Time 2 individual difference measures were approximately normal as assessed by a Shapiro-Wilk's test $p < 0.05$, for each time point. The Durbin-Watson statistic was 2.037, which shows there was an independence of residuals for Time 1 individual differences and the second exam. On a visual inspection of scatter plots of the data, the data plots were linear and showed homoscedasticity. Both assumptions were met. The data met the assumption of collinearity with a Tolerance value greater than 0.1. Table 4 presents the unstandardized regression coefficient, standard error of the coefficient, and the standardized coefficient from the analysis. The second exam scores were statistically significantly predicted from the model, $F(2,175) = 10.694$, $p < 0.05$, adj. $R^2 = 0.099$. Self-efficacy significantly contributed to the prediction, $p < 0.05$, and metacognitive awareness did not, $p = 0.904$.

The second part of this hypothesis was that the fourth exam could be predicted from scores on the Time 2 individual difference measures. The fourth exam was chosen because it occurred the week after Time 2 data were collected. Based on the findings of the first hypothesis, Time 2 individual difference measures chosen for the analysis were metacognitive awareness and self-efficacy. The statistical assumptions for the second hypothesis were re-tested using the Time 2 individual difference measures and the fourth exam. The data met the assumptions, with a Shapiro-Wilk's test $p < 0.05$, a Durbin-Watson statistic of 1.797, linear plots with homoscedasticity, and a tolerance value greater than 0.1.

Table 5

Multiple regression analysis of Time 2 metacognitive awareness, self-efficacy, and exam four scores

Variable	*B*	SE_B	β
Intercept	34.689	7.845	*
Metacognitive Awareness	0.034	0.054	0.063
Self-Efficacy	0.600	0.159	0.376*

Note. * = statistically significant at $p < 0.05$ level.

Table 5 presents the unstandardized regression coefficient, standard error of the coefficient, and the standardized coefficient from the analysis. Exam four scores were statistically significantly predicted from the model, $F(2,154) = 16.586$, $p < 0.05$, adj. $R^2 = 0.167$. Self-efficacy significantly contributed to the prediction, $p < 0.05$, and metacognitive awareness did not, $p = 0.529$.

Time 1 vs. Time 2 individual difference scores

Individual difference scores for metacognitive awareness, goal orientation subscales, and self-efficacy were taken at two-time points during the semester, 7-weeks apart. The third and final hypothesis was that there was a significant difference in the two-time points. Paired samples t-test analyses were performed to identify if there was a significant difference in the means of the scores of Time 1 and Time 2 individual difference measures. The subscales of the goal orientation measure were combined for a total goal orientation score. Outliers had already been identified and removed from the data at the start of the analysis, and there was no missing data. The results from the dependent t-test are presented in Table 6.

Table 6

Dependent t-test of scores on Time 1 and Time 2 individual difference measures

Individual Difference Pair	*t*(188)	*p*	Cohen's *d*
Self-Efficacy	2.05	0.041*	0.15
Metacognitive Awareness	3.56	0.000*	0.26
Performance Avoidance GO	0.23	0.822	0.02
Performance Approach GO	2.90	0.004*	0.21
Mastery GO	-4.97	0.000*	-0.36
GO Total	-0.32	0.749	-0.02

Note. * = statistically significant at $p < 0.05$ level.

The scores on performance avoidance and goal orientation total were not significantly different between Time 1 and Time 2 individual difference measures. There was a significant increase in scores of performance approach and mastery goal orientation, as well as metacognitive awareness and self-efficacy. Cohen's *d* is the effect sizes of the individual difference measure from the analysis, the measure's practical significance. The effect sizes are small and are further examined in the discussions section. The negative value for the dependent *t* for mastery goal orientation indicates that scores from the Time 1 and Time 2 individual difference measures did not increase, but instead decreased as the course proceeded.

Discussion

Data was collected from 218 participants. Exam performance and scores on individual difference measures were collected in an undergraduate biology course. The data was analyzed using SPSS statistical software to test three hypotheses. The first hypothesis predicted a significant, positive correlation between participants scores on course exams, and the scores on the individual difference measures, excluding performance-avoidance. This hypothesis was tested by looking at the correlations between the variables. The second hypothesis was that scores on the individual difference measures, from both times points, will interact and significantly predict exam scores. Performance-avoidance goal orientation was not hypothesized to be a significant predictor of exam scores. A series of simple multiple regression equations were used to analyze the data. The third and final hypothesis predicted a significant difference in the scores of the individual difference measures between the two-time points. This hypothesis was tested by looking at the mean rank differences of the individual difference measures.

The first hypothesis was partially supported by the results. While there was a significant correlation between self-efficacy scores at Time 1 and exam performance, no other individual difference showed a significant correlation to exam performance throughout all exams. The findings for self-efficacy are supported by previous research exploring the influence of self-efficacy and academic performance (Burgoon et al., 2012; Andrew, 1998).

The second hypothesis was not supported by the results as no statistical interactions were found. The metacognitive awareness scores and self-efficacy scores taken at Time 2 were significantly correlated with exam performance. None of the goal orientation subscales were significantly correlated. Previous studies have failed to show a consistent relationship between performance-approach goal orientation and performance, and our results support that (Hsieh, et al., 2007). Metacognitive awareness was not correlated with performance on the fifth exam, which could be due to the low number of students used in the analysis (n=27). Students in the biology course had their lowest exam scores dropped from their final grade calculation, and for a majority of students this was done to the fifth exam. As stated earlier, the results on self-efficacy and course performance supports findings from previous research (Andrew, 1998; Burgoon, et al., 2012; Chemers, Hu, & Garcia, 2001; Hsieh, et al., 2007). A student's metacognitive awareness, the strategies they use, and the new ones they can develop, can fluctuate from one time point to the next. The time that elapsed from data collection on Time 1 and Time 2 individual difference measures could explain the significant correlation between metacognition and exam performance. The experience students gained in the learning materials used in the course, types of questions asked on an exam, and style in which the instructor presents the course material could have improved their performance on exams by developing their metacognitive strategies (Schraw, 1998; Schraw et al., 2006; Tanner, 2012).

Learning is multidimensional, and individual differences will interact and affect one another (Coutinho, 2008; Hsieh, et al., 2007). The second hypothesis explored the relationship multiple individual differences have on learning outcomes. Interestingly, metacognitive awareness, from Time 1 or Time 2 individual difference measures, was not a significant predictor of performance on the second exam and did not support our hypotheses. Our findings are consistent with research done by Coutinho (2008). Their analyses suggest self-efficacy was a full mediator between metacognition and performance, meaning that metacognitive awareness no longer contributed to their assessment once self-efficacy was controlled. Self-efficacy has consistently been shown to be a significant predictor of academic performance (Andrew, 1998; Burgoon, et al., 2012; Chemers, Hu, & Garcia, 2001; Hsieh, et al., 2007).

The third hypothesis, that there is a significant difference between Time 1 and Time 2 individual difference measures, was supported by our results with the exception of performance avoidance goal orientation. Goal orientation performance approach and performance avoidance are considered maladaptive to student learning. An instance when performance approach would be adaptive is if the student were approaching a learning task to outperform other students in the course, causing an increase in performance and achievement (Pintrich, 2000a). Our data shows increase in performance approach goal orientation scores from the two-time points. Unexpectedly, the mastery goal orientation scores decreased from Time 1 and Time 2. Mastery goal orientation is considered the most adaptive of the three subscales, as is related to a better performance through increases in efficacy and metacognitive strategies (Pintrich, 2000a). With the significant increase in self-efficacy and metacognition, it is unusual to see the decrease in mastery goal orientation. Fewer than half of all students who begin college with the intention to pursue science degrees actually graduate with a science degree. There was a large quantity of first year students in the sample who could have decided to change their major or pursue non-biology material. This would have an effect on their mastery goal orientation from Time 1 and Time 2. A future study could ask demographics questions, such as major or career path, at the start and end of the semester.

Teachers play an important role in encouraging confidence and competence in their students, and help students develop positive self-efficacy as they progress through a course, major, or career field (Pajares, 2003). One way to develop this in a course is to provide students opportunities or tasks that can easily be mastered early on in the semester. This will not only build confidence in the student in their ability to complete a task but increase their motivation to tackle the next obstacle in the course. It will also demonstrate to the student they are capable of succeeding in a course that they may not have thought possible before. Self-efficacy beliefs play a strong role in choice of college major and career decisions made my college students (Hackett, 1995). Consequently, it is important to nurture and develop a sense of self-efficacy and confidence in our students.

Performance-avoidance goals have negative learning impacts, and interventions for these students are critical (Hsieh et al., 2007). Setting these students up with resources such as an academic advisor or peer counselor could help them learn to work through these feelings of self-doubt, and be productive, successful students in any course. In addition, students with performance avoidance goals will avoid tasks to prevent appearing incompetent (Pintrich, 2000a). Students' goal orientations are domain-specific and will change from subject to subject. Future studies should consider how goal orientation changes from a general biology course to more specific biological domains such as plant development, or human anatomy.

Research has shown a connection between self-efficacy and goal orientation. Students who have a higher self-efficacy will attempt tasks they know they can succeed at, creating a positive feedback loop (Schunk, 1990; Hsieh, et al., 2007). Instructors in classrooms can artificially provide this for students in the form of easy-to-accomplish tasks at the beginning of a course or evaluation, to increase their self-efficacy and mastery goal orientation. This strategy could impact students coming into a course with performance avoidance goal orientations and may prevent those maladaptive strategies from being applied to their current course.

There are numerous metacognitive strategies that can improve student learning. Alerting students to areas in the material, or topics, that previous students have struggled with will prepare them better to tackle the material (Tanner, 2012). Explaining why an exam question was correct is important, but just as important is to explain why an answer was incorrect. Allowing students to reflect on their performance will elicit problem solving and critical thinking (McCabe, 2011; Schraw et al., 2006; Tanner, 2012). It can be challenging for a student to tackle a complex problem, so much so they will not attempt an answer at all (Schraw 1998). By demonstrating how you, an experienced scientist, would break down the problem and construct your answer, is an example of metacognitive modelling (McCabe, 2011; Schraw, 1998; Schraw et al., 2006; Tanner, 2012). Each of these strategies can be applied alone, or together, and is therefore easier to implement in a classroom.

The study had several limitations. First of all, no data was collected on SAT scores from the participants. This information could have given the research team a better understanding of the participants initial academic achievement before the course began, especially since the majority of the participants were in their first semester of college. Secondly, the design of the course was not optimal for research on academic performance. The ability to remove and exam from the final course grade decreased the number of examinations used to determine course performance. The fifth exam in particular was a common one that students had removed.

Future studies should identify if the participants had similar scores on the individual difference measures in concurrent courses. The study presented here did not show an effect of the goal orientation individual difference measures on course performance. Based on the published research this was unexpected, and future studies could try to further explore what the role of goal orientation is on introductory biology students course performance. Future studies could identify how individual differences among students change with different interventions, as well as different types of courses (online, or a laboratory setting for example). Another opportunity for future research is to couple individual differences with individual or group interviews to hear exactly how the students interpret their goals, metacognition, and self-efficacy, and brainstorm ways to improve the appropriate areas. Finally, trends in the scores of the individual difference measures should be identified to see if there are different classes of students' scores. Individuals who have high scores on the individual differences will not need interventions from the instructor, whereas low scoring individuals will need more help.

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APPENDIX A

GOAL ORIENTATION MEASURE

Mastery Goal Questions

1. It's important to me that I learn a lot of new concepts this year.
2. One of my goals in class is to learn as much as I can.
3. One of my goals is to master a lot of new skills this year.
4. It's important to me that I thoroughly understand my class work.
5. It's important to me that I improve my skills this year.

Performance-Approach Goal Questions

1. It's important to me that other students in my class think I am good at my class work.
2. One of my goals is to show others that I'm good at my class work.
3. One of my goals is to show others that class work is easy for me.
4. One of my goals is to look smart in comparison to the other students in my class.
5. It's important to me that I look smart compared to others in my class.

Performance-Avoidance Goal Questions

1. It's important to me that I don't look stupid in class.
2. One of my goals is to keep others from thinking I'm not smart in class.
3. It's important to me that my teacher doesn't think that I know less than others in class.
4. One of my goals in class is to avoid looking like I have trouble doing the work.

APPENDIX B

METACOGNITIVE AWARENESS MEASURE

1. I ask myself periodically if I am meeting my goals.
2. I consider several alternatives to a problem before I answer.
3. I try to use strategies that have worked in the past.
4. I pace myself while learning in order to have enough time.
5. I understand my intellectual strengths and weaknesses.
6. I think about what I really need to learn before I begin a task
7. I know how well I did once I finish a test.
8. I set specific goals before I begin a task.
9. I slow down when I encounter important information.
10. I know what kind of information is most important to learn.
11. I ask myself if I have considered all options when solving a problem.
12. I am good at organizing information.
13. I consciously focus my attention on important information.
14. I have a specific purpose for each strategy I use.
15. I learn best when I know something about the topic.
16. I know what the teacher expects me to learn.
17. I am good at remembering information.
18. I use different learning strategies depending on the situation.
19. I ask myself if there was an easier way to do things after I finish a task.
20. I have control over how well I learn.
21. I periodically review to help me understand important relationships.
22. I ask myself questions about the material before I begin.
23. I think of several ways to solve a problem and choose the best one.
24. I summarize what I’ve learned after I finish.
25. I ask others for help when I don’t understand something.
26. I can motivate myself to learn when I need to
27. I am aware of what strategies I use when I study.
28. I find myself analyzing the usefulness of strategies while I study.
29. I use my intellectual strengths to compensate for my weaknesses.
30. I focus on the meaning and significance of new information.
31. I create my own examples to make information more meaningful.
32. I am a good judge of how well I understand something.
33. I find myself using helpful learning strategies automatically.
34. I find myself pausing regularly to check my comprehension.
35. I know when each strategy I use will be most effective.
36. I ask myself how well I accomplish my goals once I’m finished.
37. I draw pictures or diagrams to help me understand while learning.
38. I ask myself if I have considered all options after I solve a problem.
39. I try to translate new information into my own words.
40. I change strategies when I fail to understand.
41. I use the organizational structure of the text to help me learn.

42. I read instructions carefully before I begin a task.
43. I ask myself if what I'm reading is related to what I already know.
44. I reevaluate my assumptions when I get confused.
45. I organize my time to best accomplish my goals.
46. I learn more when I am interested in the topic.
47. I try to break studying down into smaller steps.
48. I focus on overall meaning rather than specifics.
49. I ask myself questions about how well I am doing while I am learning something new.
50. I ask myself if I learned as much as I could have once I finish a task.
51. I stop and go back over new information that is not clear.
52. I stop and reread when I get confused.

APPENDIX C

SELF-EFFICACY MEASURE

1. How confident are you that you will be successful in this biology course?
2. How confident are you that you will be successful in another biology course?
3. How confident are you that you would be successful in an ecology course?
4. How confident are you that you could analyze a set of data (i.e., look at the relationships between variables)?
5. How confident are you that you would be successful in a human physiology course?
6. How confident are you that you could tutor another student for this biology course?
7. How confident are you that you could ask a meaningful question that could be answered experimentally?
8. How confident are you that you could explain something that you learned in this biology course to another person?
9. How confident are you that you could use a scientific approach to solve a problem at home?
10. How confident are you that after reading an article about a biology experiment, you could write a summary of its main points?
11. How confident are you that after reading an article about a biology experiment, you could explain its main ideas to another person?
12. How confident are you that after watching a television documentary dealing with some aspect of biology, you could write a summary of its main points?
13. How confident are you that after watching a television documentary dealing with some aspect of biology, you could explain its main ideas to another person?
14. How confident are you that after listening to a public lecture regarding some biology topic, you could write a summary of its main points?
15. How confident are you that after listening to a public lecture regarding some biology topic, you could explain its main ideas to another person?

APPENDIX D

PRIOR KNOWLEDGE MEASURE

1. The age of the wooden remains of an Egyptian barge was determined using C14 dating. What is the approximate age of the barge if there is 12.5% of the original concentration of C14 remaining? (The half-life of C14 is about 5600 years).
    a. 2,800 Years
    b. 5,600 Years
    c. 11,200 Years
    d. 16,800 Years

2. What mode of nutrition is used by bacteria that use carbon dioxide as a carbon source and sunlight as an energy source?
    a. Photoheterotrophy
    b. Photoautotrophy
    c. Chemoautotrophy
    d. Chemoheterotrophy

3. Bacteria can receive genetic material from other bacteria in a number of ways. Which of the following describes the ability of a virus to transfer genetic material from one bacterium to another?
    a. Transformation
    b. Binary fission
    c. Conjugation
    d. Transduction

4. Which of the following is the correct order of organelles that participate in the production of a protein destined for export from the cell?
    a. Nucleus – smooth ER – Golgi Apparatus
    b. Free ribosomes – rough ER – nucleus
    c. Nucleus – Golgi Apparatus – rough ER
    d. Nucleus – rough ER – Golgi Apparatus

5. Which of the following statements about meiosis is true?
    a. Crossing over occurs during Prophase II
    b. Independent assortment occurs during Meiosis II
    c. At the end of Meiosis I, the ploidy level of the daughter cells is half that of the parent cell
    d. Meiosis is required for asexual reproduction

6. Stinkhorns are mushrooms that produce a foul-scented, phallus-shaped mushroom and contain gills that release basidiospores. To what phylum do stinkhorns belong?
    a. Chytridiomycota
    b. Zygomycota
    c. Ascomycota
    d. Basidiomycota

7. A woman who is heterozygous for polydactyly (an autosomal dominant trait) marries a man who has the normal 5 fingers. They are thinking of having three children. What is the probability that one of their three children will have polydactyly?
    a. 1/8
    b. 3/8
    c. 4/8
    d. 4/16

8. In a trihybrid cross between DDEeFf x ddEeff parents, what is the probability of having an Ddeeff offspring?
    a. 0
    b. 1/4
    c. 1/8
    d. 1/16

9. How many genetically distinct gametes could be produced by an individual who has the genotype AaBbccddEeff?
    a. 12
    b. 8
    c. 6
    d. 4

10. The recessive alleles for purple eyes (pr) and wingless (wg) identify two autosomal genes on the second chromosome of Drosophila melanogaster. When females, heterozygous at these two genes (pr+pr wg+wg), were crossed with purple-eyed, wingless males, the following classes and numbers of progeny (n=1000) were obtained:

Wild-type eye color, wild-type wings	112
Wild-type eye color, wingless	375
Purple eye color, wingless	126
Purple eye color, wild-type wings	387

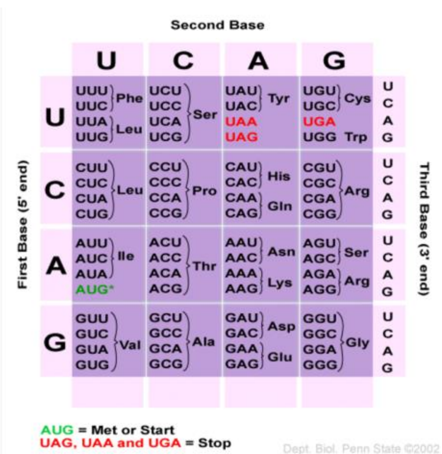
Which of the following crosses could have given rise to the heterozygous females used in the cross described above? (Assume that all individuals are true breeding).

a. Wild-type eye color, wild-type wings X purple eye color, wingless
b. Wild-type eye color, wingless X purple eye color, wild-type wings
c. Purple eye color, wingless X purple eye color, wingless
d. Wild-type eye color, wild-type wings X wild-type eye color, wild-type wings

11. In the Hardy-Weinberg equation, p2 + 2pq + q2 = 1, the term q2 typically refers to the:
    a. Frequency of homozygous recessive individuals in the population
    b. Frequency of the most common allele in the population
    c. Allele frequency of one allele in the population
    d. Frequency of heterozygotes in the population

12. In a population of 1000 people, 250 have Type-O blood. The frequency of the IA allele in the population is 0.3. What is the frequency of people with type B blood?
    a. 0.04
    b. 0.2
    c. 0.24
    d. 0.27

13. Using the genetic code, identify the template strand of DNA that will produce a mRNA encoding the polypeptide TYR – MET – ASP.



a. 5' UAUAUGGAC 3'
b. 5' GTCCATATA 3'
c. 5' ATATACCTG 3'
d. 5' CAGGUAUAU 3'

14. Natural selection is best defined as:
    a. selection by humans for specific traits in a population.
    b. change in the genetic structure of a population over time.
    c. chance factors changing the genetic structure of a population.
    d. differential reproductive success among members of a population

15. Angiosperms that use wind pollination would have:
    a. flowers that produce relatively small amounts of pollen
    b. cones that produce large amounts of pollen.
    c. cones that produce small amounts of pollen and nectar
    d. flowers that produces large amounts of pollen

16. The function of lactic acid or ethanol fermentation is to:
    a. increase the production of ATP in the cell
    b. provide additional energy to the cell
    c. regenerate the cell's supply of NAD+
    d. produce lactate or ethanol for the cell to use immediately

17. In the electron transport chain of cellular respiration, ________________ is the final electron acceptor, while in the electron transport chain of the light reactions of photosynthesis, ____________ is the final electron acceptor
    a. oxygen / NADP+
    b. NAD+ / water
    c. oxygen / ATP
    d. NAD+ / NADP+

18. In the light independent reactions of photosynthesis, _____ is the molecule catalyzing the fixation of CO_2
    a. rubisco
    b. ribulose bisphosphate (RuBP)
    c. water
    d. glyceraldehyde 3-phosphate (G3P)

19. The products of the light dependent reactions of photosynthesis, ____________________, are required for the light independent reactions to take place
    a. oxygen, ATP, and NADH
    b. ATP and NADPH
    c. ATP, NADPH and CO_2
    d. NADPH and $FADH_2$

20. A bifurcation in the tree of animal evolutionary history separates the Radiata from the Bilateria. Which of the following also describes this bifurcation?
    a. Diploblasts vs. triploblasts.
    b. Coelomates vs. pseudocoelomates.
    c. Protostomes vs. deuterostomes.
    d. True tissues vs. no true tissues.

21. Plants and animals in terrestrial environments have evolved mechanisms to protect developing embryos, such as the ____________________, respectively
    a. seed and amniotic egg
    b. spore and keratinized skin
    c. seed and keratinized skin
    d. spore and amniotic egg

APPENDIX E

DEMOGRAPHICS QUESTIONNAIRE

1. What is your name?

2. What is your Penn State user ID? (example: abc1234)

3. Semester standing at Penn State:
    a. 1st - 2nd semester
    b. 3rd - 4th semester
    c. 5th - 6th semester
    d. 7th - 8th semester
    e. 9th - higher semester

4. Major:

5. Ethnicity:
    a. Caucasian
    b. African-American
    c. Asian
    d. Hispanic
    e. Other

6. Gender:
    a. Male
    b. Female
    c. Other

7. Your current GPA:

8. What section of Biol 110 lab are you currently enrolled? (If you are not sure, please look up your section number on Lionpath for lab).

9. What is your expected grade in Biol 110?