B. PROJECT SUMMARY

Recent evidence demonstrates that inquiry-based physiology laboratories improve students' critical and analytical thinking skills (Myers and Burgess, 2003). Furthermore, learning is most effective when carried out in small groups where students see the results of experiments for themselves (Springer, et al., 1999). The Biology department at West Chester University (WCU) offers three courses in physiology: Comparative Vertebrate Physiology (Bio 468) for our majors, Human Physiology (Bio 469) for students in our Pharmaceutical and Product Development and Pre-Professional programs, and Human Anatomy and Physiology II (Bio 269) for allied health majors. Students in these courses struggle to understand important physiological concepts because the labs are designed with step-by-step instructions yielding expected results and taught using a traditional teacher-centered approach. This method of teaching is necessary because students rely on using outdated physiographs to generate much of their data. These instruments, purchased in 1987, are technically difficult to use, frequently break down during experiments, and require constant trouble-shooting. As a result, student creativity and independent investigation is impeded. Our primary goal is to modify our physiology laboratory curricula to incorporate inquiry-based learning that will allow students to test their own ideas, thereby teaching them to be independent problem solvers and critical thinkers. To facilitate these curricular goals, funding is requested to purchase data acquisition and analysis hardware and software (PowerLab) that will allow students to collect and analyze data easily. The success of the program will be evaluated using formative and summative assessment instruments developed and analyzed by Dr. Loretta Rieser-Danner (recent University Assessment Coordinator), and the Biology faculty team.

Intellectual merit: This proposal encourages student-led initiatives in the classroom. We currently use a teacher-centered approach to learning and plan, with the aid of computer technology, to implement a student-centered model. Students will design their own experiments with the professor's input, and active learning will be enhanced. To achieve our goals, we plan to organize teaching workshops at WCU emphasizing novel pedagogy in physiology and present at meetings, such as the Experimental Biology/ International Union of Physiological Sciences (IUPS) Teaching Workshop, and the Human Anatomy and Physiology (HAPS) teaching workshops that features innovative strategies for teaching and learning physiology. In this proposal, we detail examples of our proposed curricular changes, and evaluation instruments to measure the success of our curricular integration. The investigators in this proposal have a combined total of 45 years experience in teaching physiology. Another of the co-PI's has extensive experience in the assessment of student learning outcomes.

Broader impacts: The student-centered learning approach has proven to enhance learning among college level students. Students learn best through scientific discovery, using ideas that they themselves formulate, once provided with a basic understanding of concepts by their teachers. Formulation of ideas is a key concept in science and necessary to enhance the research potential of students entering graduate and professional schools, or careers in industry. Part of WCU's Strategic Plan aims to enhance the success of women and minorities in the sciences. These groups currently comprise on average 85% of the student population in our physiology courses. Our curricular reforms will enhance success in the work place in these traditionally under-represented groups. Our curricular integration will be disseminated to the scientific community in several ways. We will publish the results of our curricular reforms and assessment data in the journal *Advances in Physiology Education*. We will present the results of our curricular modifications at pedagogical teaching workshops at WCU, and at the annual meetings of the American Physiological Society, the National Science Teachers Association, and the Human Anatomy and Physiology Society (founded to promote communication among teachers at universities nationwide). The experiments we design will also be posted on the ADInstruments, PowerLab website for other institutions to use in their classes.

C. TABLE OF CONTENTS

D. PROJECT DESCRIPTION

GOALS AND OBJECTIVES

Laboratory courses in Biology are generally believed to play an important role in student learning. This is certainly true in student learning of physiology. Laboratory demonstration of important physiological concepts helps to consolidate student understanding of material covered in lecture sections. At WCU, laboratory sections for our upper division physiology courses (Bio 468 and 469) are designed to closely follow material covered in the lecture and are used to re-emphasize the concepts taught in lecture. The usefulness of this approach is supported by student perceptions. In a survey conducted in Spring '04 in Bio 468 (n = 13), 100% of students responded positively (strongly agreed or agreed) with the statement "lab activities enhanced my ability to understand lecture material". In contrast, labs for our lower division course, Human Anatomy and Physiology (Bio 269), do not follow lecture closely, and student perceptions suggest that they are less useful to learning physiological concepts, with only 57% of students agreeing that "lab activities enhanced my ability to understand lecture material". Other items from our Spring '04 surveys also indicate that students in Bio 269 view the laboratory experience negatively, primarily because lab topics do not correspond to lecture topics. Thus, the first goal of the proposed project is to address this problem in Bio 269 laboratories by incorporating a set of interactive laboratory activities that directly correspond to lecture topics.

Students in our upper division physiology courses (Bio 468, 469) often find it difficult to understand the scientific approach to problem solving as it applies to physiology. Students fail to see how scientists define a problem, develop a testable hypothesis, generate the appropriate data to test their hypothesis, and interpret the results and their significance. This is evident in low scores on inquiry-based questions in lab exams. Problems in understanding the scientific approach are also evident in our lower division course (Bio 269). In a survey conducted in Spring '04 in Bio 269 (n = 95), only 37% of students responded positively (strongly agreed or agreed) with the statement "I learned how to design an experiment to test my predictions during the lab". Thus, the second goal of the proposed project is to revise the laboratory curriculums in order to emphasize the development of scientific problem solving to students. Furthermore, curriculums will be revised in ways to encourage creative and critical thinking in the scientific process, the third goal of the proposed project.

In an effort to stimulate learning of physiology and the scientific approach, we plan to adopt a modified version of an inquiry-based curriculum, initially developed for an exercise physiology course at San Diego State University (DiPasquale, et al., 2003; CCLI DUE-9950622). This model proved very successful with instructors reporting an increase in independent thinking, improved integration of information, and an increase in student ability to answer their own questions. Students reported a "tremendous ownership" toward their group projects, they valued the independence offered to them, and most importantly, the curriculum has sparked an interest in scientific research and graduate programs (DiPasquale, et al., 2003). In their model, students participated in traditional teacher-oriented classes for the first third of the semester. Thereafter, students worked in small groups, using the knowledge they had gained in the first third of the course, to complete independent research projects. In our model, laboratories throughout the semester will be inquiry-based (not just the latter portion), with the instructor providing students with a basic outline of the physiological principles. Students will then formulate their own hypotheses to test, design their own experiments, and analyze and interpret their data. In the case of the upper division courses, students will be challenged to read articles in the primarily literature prior to entering the lab and use this additional background knowledge to design their own experiments.

We believe the major reason for students' difficulty in understanding the scientific approach is that we use an instructor-centered model, one in which instructors provide rigid experimental parameters for students to follow and experimental results are both predictable and consistent across all student teams. Unfortunately, we are forced to use this model (which gives the students little flexibility) because many of our labs involve the use of outdated Narco physiographs (purchased in 1987) for data collection. Our physiographs are technically difficult for students to use, even with supervision. A survey conducted in Spring '04 in Bio 468 showed that 77% of our students found the instruments difficult to use, and 92% experienced some sort of trouble throughout the semester. As a result of difficulty with instrumentation, students often obtain erroneous experimental results, causing *confusion and frustration* for both the student and the professor. Thus, the limitations of our laboratory equipment directly affect our teaching approach and severely limit the ability of students to collect physiological data, and to explore their own ideas or test their own hypotheses. Student learning is adversely affected. The proposed project will, in part, involve the development of sets of laboratory problems that will allow increased flexibility in the laboratory, increasing student participation in the scientific process itself and encouraging the development of critical thinking and scientific problem solving. This will be achieved by replacing our existing equipment with a computer data acquisition and analysis system called PowerLab (manufactured by ADInstruments Inc.). PowerLab provides life science teaching laboratories with research quality data collection and analysis. With the system, students focus on investigating scientific principles rather than configuring equipment or software. The system enables students to use recording devices to collect data from each other or from animals, and is capable of measuring such parameters as an electrocardiogram, heart sounds, peripheral circulation and pulse, blood pressure, electromyography, reflexes and reaction times, the diving response, electroencephalography, respiratory air flow and volumes, and nerve activity.

Revision of the laboratory curriculums will include a more student-centered approach to teaching, as well as inclusion of flexible problem sets to encourage creative and critical thinking in scientific problem solving. These revisions, in conjunction with the appropriation of more up-to-date laboratory equipment, will be used to encourage the development of *three specific student-learning outcomes*:

1. *Students will learn physiological concepts*: Laboratories will give students a practical, hands-on experience of material covered in lecture. The lab curriculum will closely follow the topics covered in lecture. Since students are computer literate, the new PowerLab computer technology we purchase will be a friendly and familiar interface to them, and the new laboratories that we develop using PowerLab will be designed to encourage inquiry-based learning. The equipment acquisition will enhance the learning of physiology.

2. *Students will develop an understanding of the scientific approach*: In Bio 468/469, this goal will be accomplished by introducing 3 new labs. The first lab will discuss how scientists identify and solve problems using the scientific approach. A second lab will be designed to show students how scientists can effectively communicate their ideas. The final lab will require all students to demonstrate how well they have mastered each of the 3 goals in this proposal, by asking them to present the results of their experiments during the course of the semester to the rest of the class. In Bio 269, students will have opportunities to explore the inquiry process through the incorporation of "inquiry-based challenges". These challenge activities will allow students to develop and test their own hypotheses within the context of a specific problem.

3. *Students will engage in creative and critical thinking*: This will be accomplished by re-organizing the way individual labs are taught. We will move away from the instructor-centered model and implement a student-centered approach.

DETAILED PROJECT PLAN

Background

Bio 269: This course is the second in a two semester series designed to teach physiology to Nursing, Sports Medicine, Kinesiology and Nutrition majors. The class enrollment is approximately 300 students per year. Of this total, *93% of the student population last year were women or minorities*. Students are divided into lab groups of 24, and attend 3 hours of lecture and 2 hours of lab per week. Bio 269 is taught by Drs. Judith Greenamyer (JG) in the fall, and Maureen Knabb (MK) in the spring.

Bio 468: This is an upper division elective course typically taken by Biology majors in the concentrations of General Biology, Ecology or Cellular and Molecular Biology. The class is taught by Giovanni Casotti (GC) every spring and has an enrollment of 16 students that attend 3 hours of lecture and 3 hours of lab per week. Of this total, *71% of the student population last year were women or minorities*.

Bio 469: This is a required class of students in our Pre-Professional and Pharmaceutical and Product Development (PPD) programs. These programs prepare undergraduate and post-baccalaureate students for application to the health professional schools of medicine, dentistry, veterinary medicine and the pharmaceutical and biotechnology industry. The class is taught by MK every fall and has an enrollment of 16 students that attend 3 hours of lecture and 3 hours of lab per week. Of this total, *36% of the student population last year were women or minorities*.

Problems with our physiology courses

Many students in our physiology courses fail to understand important physiological concepts and the scientific approach to experimental design. We believe the reason for this is that the labs are taught in a traditional mode of instruction using the teacher-centered approach (NRC, 2000). Our current traditional approach provides students with detailed step-by-step instructions for completing their experiments. As a result, we find that the students are so focused on the instructions that they lose the focus/concept of the experiment. Regimented instructions do not allow students any flexibility to deviate from the experimental protocol; thus student creativity is impeded by the limitations of our current equipment. A recent study by Michael et al. (2002) showed that prevalent misconceptions about cardiovascular and respiratory physiology ranged from 20-81%. We plan to correct these misconceptions by creating a learning environment that provides students with opportunities to practice recognizing and applying their ideas.

Students in our physiology courses are simply repeating experiments that have been done previously by other researchers. Some students cannot see the purpose of performing some of the experiments, especially those involving the sacrifice of animals, and often ask, "Why are we conducting this experiment when we know that the outcome has already been documented?". Students don't appreciate the potential learning that can result from duplicating experiments, specifically learning about the scientific method. On the other hand, mere replication of known results is certainly not the best way to encourage critical thinking and scientific problem solving in our students.

Students do not understand how to communicate their ideas in a scientific report. Lab reports submitted for grading do not show a logical scientific progression, from generating a hypothesis to explaining and interpreting data in the discussion of the paper. For example, students discuss why the rate of respiration was irregular when the subject was asked to complete a difficult math problem in the discussion section of their paper, without first mentioning the neural control mechanism of respiration in the introduction to their paper. Although our majors are taught the principles of scientific design and implementation in other courses, we find that this principle must be reinforced.

The solution

Goal #1: Design and incorporate laboratory activities to help students learn physiological concepts.

Laboratories are integral to any physiology course. They provide students with practical, hands-on experience, and a better appreciation and understanding of important physiological principles.

To ensure that labs increase student learning of physiology, the lab topics should closely follow the topics covered in lecture. In Bio 468 and Bio 469, this is already being done (see appendix, p. 3-5, 9-10). The lab curriculum for Bio 269 does not closely follow the topics covered in the lecture (see appendix, p. 1). Therefore, students in Bio 269 find laboratory challenging. The main reason for this discontinuity between lecture and lab, is that the students use the physiographs only for one lab on cardiovascular physiology, even though the machines are able to record other parameters that could be used in Bio 269. Use of the physiographs is avoided because they are too technically difficult for lower level non-majors to use, thus limiting the range of experiments that our students can perform.

Instead of using physiographs, students rely on using computer simulations to mimic experimental conditions. Simulations, while useful, have two main disadvantages. First, they do not adequately create an environment that stimulates learning because the students perform the simulations by themselves without interaction with their fellow classmates. Studies on pedagogical practices have demonstrated that group learning enhances student understanding (McNeal and D'Avanzo, 1997; Springer et al., 1997; Kenny, 1998; NRC, 1999; 2002). Second, simulations always work on the computer, which is a problem because this does not accurately mimic the real world condition. Organ systems do not always behave as expected because all organ systems interact with one another and can affect each other's functioning. Computer simulations do not teach this critical concept of homeostasis.

One of the goals of this proposal is to redesign the Bio 269 labs so that they closely follow the topics covered in the lecture. The acquisition of PowerLab will enable us to achieve this goal. For example, an important but challenging topic taught in Bio 269 is the cardiac cycle. Students find it difficult to understand the events occurring in the cycle, as evidenced by low exam scores (less than 20% correct responses on exam questions). In lab, students measure cardiac electrical activity (ECG), heart rate (HR) and pulse pressure separately from a paper tracing. There is no opportunity with our existing equipment to concurrently measure these parameters. With PowerLab, all three parameters can be recorded simultaneously, greatly enhancing the students' ability to identify the relationship between electrical and mechanical activity in the heart. Student familiarity with computers will stimulate their interest and enable them to concentrate on the results from their experiments, thus encouraging inquiry-based learning.

Goal #2: Design and incorporate laboratory activities to help students develop an understanding of the scientific approach.

Bio 468/469: Three news labs will be introduced. *The first lab* will discuss how scientists identify and solve problems using the scientific approach. Prior to lab, students will be required to read a scientific article, and asked to describe the authors' hypothesis, experimental design, method of data presentation, and to comment on data interpretation. During lab, the professor will lead a discussion guiding the students through the scientific approach of problem solving, using the areas listed above. Student input will be sought after and expected during the class.

Students will be taught that an integral part of science is the ability to communicate ideas to others. *A second lab* will be designed to show students how scientists communicate their ideas at meetings using oral and poster presentations. Examples of posters presented by the Biology faculty at scientific meetings will be displayed in class. Students will be walked though the process of designing a poster to present scientific information. Students will also be guided on how to prepare an oral presentation for a scientific meeting.

Students will integrate knowledge gained from these initial labs at the end of the semester in *a third lab*, where they will present the results of one of the physiology experiments they conducted during the semester to the class. Each student will talk for 7 minutes with an additional 3 minutes for questions. Students will have the option of using the poster or oral presentation formats. Students making oral presentations will use the interactive white board technology offered by SmartBoard™ (www.smarttech.com/smartboard/) that allows them to highlight and manipulate data during their presentation. This technology enables the students to develop creative ways to present their ideas.

Bio 269: To enhance student learning of the inquiry process and to help students learn the skills required to "think like a scientist", new lab activities will be developed. To incorporate inquiry into the labs, students will work cooperatively on "challenges". Challenge activities are modifications of problem-based learning methods applied to the lab setting (Knabb and Woodruff, 2003). For example, students will learn how to use PowerLab to measure electrical activity (EMG) from the muscles on the palm of the hand. A scenario will then be presented where a concert violinist has been invited to play at an outdoor concert in Chicago where the average temperature on that day is 2°C. The musician is worried about her ability to play under these conditions. Using the PowerLab EMG equipment, a thermometer, and a cold pack, student groups will design an experiment to test their hypothesis of the effects of temperature on the EMG. They will collect data and draw conclusions from their experimental results. Other types of challenge activities will be developed for labs throughout the semester.

Goal #3: Design and incorporate laboratory activities that will allow students to engage in creative and critical thinking.

We plan to achieve this goal by re-organizing the way we teach our physiology labs, implementing a student-centered approach to learning (Kolkhorst, et al., 2001; Dipasquale, et al., 2003).

Our existing teacher-centered model in all physiology labs

- **First 30 minutes**: The professor covers the physiological principles of the lab topic and how to use the equipment.
- **Next 90 minutes for Bio 269, and 150 minutes for Bio 468/469**: Each group of students performs all of the assigned experiments as outlined in the lab manual (each group of students repeats the same experiments).

Proposed student-centered model for Bio 468 (majors) and Bio 469 (non-majors)

- **Week prior to lab:** Student will be given a research article on the topic of physiology and asked to read it for content, the scientific approach and its conclusions.
- **First 30 minutes**: The professor covers the physiological principles of the lab and the students are asked to comment on the article read and place it in context to the lab topic. No discussion of how to use PowerLab is necessary , as this material will be covered in Week 2 (see appendix p. 6, 11).
- **Next 30 minutes**: The class discusses what parameters the *students think* they can measure and why. Each group (n = 4) of students will come up with their own set of hypotheses to test. The laboratory professor will act as *a guide to student-led initiatives*. We feel a group of 4 students is large enough to stimulate creative thinking, but not too large to inhibit conducting the experiments efficiently.
- **Next 90 minutes**: Students will perform the experiments they proposed. Typically, 2 parameters will be measured by each group. Experiments may be repeated to enhance statistical validity or modified, particularly if the results are different from those proposed by the initial hypothesis.
- **Final 30 minutes**: Students engage in a "show and tell" session where one or two students from each group will explain the results of their experiment and will interpret their data for the rest of the class. The students speaking will be rotated each week. Each group must share their data with all members of the lab; thus, all students will have data generated by each group.

An example of an action potential (AP) lab in Bio 468/469 using the student-centered approach

Students will be given the paper "The refractory period of fast conducting corticospinal tract axons in man and its implications for intraoperative monitoring of motor evoked potentials" by Novack etal. (2004) to read prior to lab. In the first 30 minutes of lab, the professor would go through factors affecting AP generation with input from the students based on the article they have read. In the next 30 minutes the students would come up with variables to test. Students will check their proposed variables with the professor before proceeding with their experiments. For example, one group might test the effect of threshold voltage, stimulus strength or frequency of stimulus on the rate of AP generation. A second group might test for the presence and duration of the absolute or relative refractory periods by varying the frequency or timing of stimulation. Each group would have to determine threshold voltage for their nerve. Since nerves vary in size, students will learn by discovery that threshold voltage will vary among the groups. This type of variation teaches the concept of experimental variability in physiological systems. In the following 90 minutes of lab, all groups would perform their experiments based on the designs *chosen by them* and would generate data. In the final 30 minutes, each group of students would designate one or two members to present and explain the results of their experiments to the rest of the class. Class data would be generated and each student would be required to electronically save class data using PowerLab. These electronic data would be shared with the class during Show and Tell sessions using SmartBoard™.

Students will be expected to analyze the data by accessing the DataPad, Chart and Scope programs (all part of the PowerLab package) outside of lab hours. DataPad, Chart and Scope allow the students to create graphs and tabular data for their experimental results from PowerLab and import this information into Microsoft Excel and Word to facilitate their report writing. Students will be able to access PowerLab and its associated programs remotely from a server outside of class hours. The ability to access the program online is a valuable feature as more students are relying on working online. Students would then be expected to print out and explain the results of each group's experiment in a lab notebook that will be handed in for grading.

Critical thinking skills learned in our physiology courses will help those students pursuing further studies in graduate school or careers in the pharmaceutical industry, or in pre-professional programs such as medicine.

Proposed student-centered model for Bio 269 (non-majors)

As students in Bio 269 are freshmen and sophomores, the student-centered model proposed for Bio 468/469 will be modified. The course coordinator will hold hour long weekly meetings with all lab instructors prior to the lab where a series of potential experiments will be outlined. Instructors will use this information to guide students to ask the appropriate investigative questions. Each lab group will test a different hypothesis.

- **First 30 minutes**: A discussion of different types of physiology experiments and their objectives, where students will be presented with a list of factors to measure experimentally using PowerLab.
- **Next 90 minutes**: Students would be presented with a case scenario/study and asked to come up with a novel experiment to test a hypothesis based on knowledge they have learned from the classical experiments. Typically each group (n = 4) of students will undertake one or two variables to test.

An example of two autonomic nervous system labs in Bio 269 using the student-centered approach

This exercise is modified from the generic outline above because it would take 2 lab sessions to complete.
<u>Lab 1</u>: With PowerLab, students will be able to measure the galvanic skin response (GSR), a change in skin conductivity associated with sweating and mediated by the sympathetic nervous system. A preliminary lab activity will be designed to introduce the students to PowerLab and the GSR (appendix p. 2, week 3). Following this lab, students will read portions of an article in which the investigators studied the effects of music on GSR in college students (VanderArk & Ely, 1992). <u>Lab 2</u>: Student groups will design their own experiment to investigate the relationship between music and the GSR. This lab meeting will be devoted to conducting the experiment and reporting the results (appendix p. 2, week 4). Through this activity, students will gain an appreciation of the physiological effects of the autonomic nervous system and develop the critical thinking skills necessary to plan and conduct a scientific investigation and to interpret the resulting data.

Engaging students in critical thinking is the goal that will have the greatest impact not only within the discipline of physiology, but also across the discipline of majors that Bio 269 serves as a prerequisite. Students in Sports Medicine will be able to use skills gained in Bio 269 in the course Pathology and Evaluation of Athletic Injury, Nursing majors in the course Pathophysiology, Kinesiology majors in the course Exercise Physiology, and Nutrition majors in the course Chronic and Communicable Diseases.

EXPERIENCE AND CAPABILITIES OF THE INVESTIGATORS

Giovanni Casotti is an Associate Professor and has been teaching physiology for 11 years. He teaches Comparative Vertebrate Physiology, Human Anatomy and Physiology (A & P I) and Microtechnique. He maintains an active research program in the area of renal anatomy and physiology. He is a regular attendee at national meetings, and is the Graduate Coordinator of the Department.

Maureen Knabb is a Professor and has been teaching physiology for 18 years. She teaches in the areas of Human A & P II, Cell Physiology, Human Physiology and Cell and Molecular Biology. She is a member of the Council of Undergraduate Research and presents papers at national meetings in the areas of creative pedagogy and undergraduate programs.

Judith Greenamyer is the Chair of Department and has been teaching courses in Human A & P II, Animal Physiology, Parasitology and Endocrinology, for 16 years. She is the Director of the Animal Care Facility, and is the University Veterinarian.

Loretta Rieser-Danner (LRD): is an Associate Professor of Psychology. She teaches a variety of courses in Developmental Psychology as well as statistical methods at the undergraduate and graduate levels. She has extensive experience in the assessment of student learning outcomes, including having served as the WCU University Assessment Coordinator for three years. She maintains an active research program in human infant social and emotional development.

EQUIPMENT AND INSTRUMENTATION

PowerLab is a computerized data acquisition system that has been used to enhance teaching of physiology in colleges throughout the world (www.adinstruments.com/teaching/users/). We will incorporate PowerLab into all of our physiology classes to enable us to implement our curricular reforms. The Biology faculty at WCU use Macintosh computers. We considered another software program called IWorx but it is not Macintosh compatible, and the IWorx physiology teaching bundle has fewer options (i.e., possible experiments) than that offered by PowerLab. Another advantage of PowerLab is that it allows teachers to share their experiments online (www.powerlab-teaching.com/experiments/), while IWorx does not. Experiments can be downloaded from the PowerLab web site in MS Word format, thus are easily configured for individual class use.

PowerLab will be set up by ADInstruments Inc. and a full day demonstration of how to use the system will be provided. The system comes with a complete 3 year warranty. Software updates are free for the life of the product. After 3 years updates required to the computer hardware will be paid for by the Biology department. All computer hardware purchased on grant monies on the WCU campus is maintained by our Information Technology department.

Curricular reform is integral to the implementation of PowerLab. WCU offers full day annual summer pedagogy workshops in May and June. Pedagogical workshop on physiology teaching are also offered at the annual meetings of Experimental Biology (EB) and the Human Anatomy and Physiology Society (HAPS). All investigators will present at pedagogical physiology teaching workshops. In addition, Loretta Rieser-Danner (assessment coordinator) will assist the Biology faculty team in their course modifications, thus enhancing faculty professional development.

EVALUATION PLAN

Evaluation plans will be developed by LRD in conjunction with the biology faculty team. All investigators will meet once a month to discuss progress and modifications to the evaluation plan. In addition, investigators will meet separately with LRD to discuss details of an evaluation plan before and after their courses are taught. A summary of proposed evaluation plans and details of each evaluation strategy are found in the appendix beginning on p. 14.

Formative evaluation: (see Table of Assessment Strategies in Appendix p. 27). Bio269: Laboratory exams (multiple choice and open-ended questions), as well as performance on challenge activities will be used to assess progress in all three goals across the semester. Bio 468/9: Weekly hypothesis testing skills, show and tell presentations, and bi-semester lab reports will monitor progress towards each of the 3 goals in this proposal.

Summative evaluation: (see Table of Assessment Strategies in Appendix p. 27). Bio269: In weekly journal entries, students will be asked to address two questions: 1) What physiological processes do you understand better from this experiment?, and 2) What science process skill(s) did you practice this week in lab? These journals will be evaluated at the end of the semester, using rubrics, for attainment of all three goals. In addition, Pre and Post Course Surveys will be conducted to determine the effectiveness of goals 2 and 3 of this proposal. A Post Course Assessment

Survey with a set of scientific problems will be used to assess students' attainment of all three learning goals. Examples of rubrics and surveys for Bio 269 are shown in the appendix p.14-20. Bio468/9: The culmination of skills learned throughout the semester (goals 1, 2, and 3) will be assessed by student presentations (oral/poster) at the end of these courses, and by a lab notebook that summarizes all experiments conducted throughout the semester. In addition, as part of the final exam, a problem-based exercise will be used to assess the students' abilities to engage in scientific reasoning. Grading rubrics for hypothesis testing, show and tell presentations, lab reports, oral and poster presentations, and the lab notebook have been developed and are shown in the appendix p. 14-20. We will also develop assessment rubrics for each of these course components. Last, an end of course survey will measure student perceptions about their attainment of each of the goals in this proposal (appendix p. 14-20).

DISSEMINATION PLAN

We will publish the results of our physiology curriculum integration in the journal, *Advances in Physiology Education*. Our curriculum innovation will also be shared with other local users of PowerLab, including Dr. S.H. Burch (Swarthmore College), Dr. G. Hess (Messiah College), and Dr. A. Browe (Indiana University of Pennsylvania). Our experiences with the PowerLab curriculum integration will also be shared with other WCU faculty as the investigators in this grant will participate in an annual summer pedagogy workshop ('06, '07 and beyond) on the WCU campus. We will also present our pedagogical practices at the annual meetings of the EB/IUPS, HAPS and the National science Teachers Association (NSTA). Finally, experiments we design with PowerLab will be downloaded by Dr. J. O'Dell, Education Project Manager, on the ADInstruments website (www.powerlab-teaching.com/experiments/contributions.html) for other users worldwide.

RESULTS FROM PRIOR NSF SUPPORT

MK is currently the director of the NSF CCLI #0126634 project ($187,026, 1/01 - 6/05) titled "Connecting Research Experiences And Teacher Excellence (CREATE) in Introductory Biology Laboratories at West Chester University. The purpose of this grant is to enhance and coordinate our introductory biology curriculum by 1) developing new laboratories through use of technologies, 2) linking concepts between the sub-disciplines, 3) encouraging collaboration among students and faculty, and 4) providing a research-rich learning environment as a training ground for our future secondary school teachers. There have been three presentations of the results of this work at 1) the Annual Conference for the Advancement of College Teaching and Learning, in Spring 2003 titled "Inquiry-based challenges: A strategy to assess the inquiry process in the introductory laboratory." 2) the Spring 2004 NSTA meeting in Atlanta called "Strategies for enhancing inquiry in introductory biology lab" and 3) "Assessing inquiry skills in the lab using the case study method" at the Annual Conference on Case Study Teaching in Science in October 2004. A paper has been accepted to *The American Biology Teacher* titled "Assessing inquiry process skills in the lab using a fast, simple, inexpensive fermentation model system".

TIME LINE FOR THE PROJECT

PowerLab will be purchased in the summer of '05. MK will devote part of that summer to incorporating the technology into the Bio 469 curriculum for fall '05. MK will monitor student progress, and inform LRD and the rest of the Biology team of the results. Based on data gathered by MK in her progress evaluation, GC will modify the Bio 468 curriculum accordingly and incorporate PowerLab in the Bio 468 curriculum in spring '06. In spring '06, GC will carry out a progress evaluation. The data he collects will be shared with LRD and the rest of the Biology team. MK will attend the NSTA meeting in 2006, and LRD will attend the HAPS meeting in May '06 and the WCU Summer Pedagogical Workshop. MK will present the results of curricular modifications in Bio 469, and LRD will make a presentation on the grant, its objectives and a summary of progress to date.

JG will incorporate PowerLab into the Bio 269 curriculum in summer '06 and use PowerLab in fall '06. JG, in consultation with MK, will gather progress evaluation data during that semester (fall '06) and make changes to the BIO 269 curriculum as needed for spring '07. GC and JG will attend the EB/IUPS meeting in April '07, and the WCU Summer Pedagogical Workshop and present results of curricular reforms for Bio 468 and Bio 269 respectively. Throughout this 2 year grant, LRD will be collating formative and summation evaluation data for all courses, and based on data received, will be advising GC, MK and JG on how to modify their evaluations accordingly. She will summarize the data and present it to the Biology team at the end of the first and second year's implementation. We anticipate that 2 full years of assessment ('05/06 and '06/07) would be adequate to fully incorporate the system into our physiology courses.

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Michael, J.A., Wenderoth, M.P., Modell, H.I., Cliff, W., Horwitz, B., McHale, P., Richardson, D., Silverthorn, D., Williams, S. and Whitescarver, S. (2002). Undergraduates' understanding of cardiovascular phenomena. *Advances in Physiology Education 26 (2) 72-84.*

Myers, M.J. and Burgess, A.B. (2003). Inquiry-based laboratory course improves students' ability to design experiments and interpret data. *Advances in Physiology Education* 27 (1): 26-33.

National Research Council (1999). *How People Learn: Brain, Mind, Experience, and School.* Committee on developments in the Science of Learning. Commission on Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

National Research Council (2000). *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. Washington, DC: National Academy Press.

National Research Council (2002). *Learning and Understanding: Improving Advanced Study of Mathematics and Science in U.S. High Schools*. Committee on Programs for Advanced Study in mathematics and Science. Washington, DC: National Academy Press.

Novak K, de Camargo AB, Neuwirth M, Kothbauer K, Amassian VE, Deletis V. (2004). The refractory period of fast conducting corticospinal tract axons in man and its implications for intraoperative monitoring of motor evoked potentials. *Clinical Neurophysiology* 115(8): 1931-1941.

Springer, I., Stanne, M.F. and Donova, S.S. (1997). *Effects of Small -Group Learning on Undergraduates in Science, Mathematics, Engineering and Technology: A Meta-Analysis.* Research Monograph No. 11, Madison: National Institute for Science Education, University of Wisconsin-Madison.

Springer, I., Stanne, M.F. and Donova, S.S. (1999). *Effects of Small -Group Learning on Undergraduates in Science, Mathematics, Engineering and Technology: A Meta-Analysis.* Rev. Educ. Res. 69: 21-51.

VanderArk, S.D. and Ely, D. (1992). Biochemical and galvanic skin responses to music stimuli by college students in biology and music. Perceptual Motor Skills. 24 (3) 1079-1090.

F. BIOGRAPHICAL SKETCHES
GIOVANNI CASOTTI

(I) Professional preparation

Murdoch University, Western Australia	BSc. Biology	1987
Murdoch University, Western Australia	Hons. Biology	1998
Murdoch University, Western Australia	PhD.	1993
University of Arizona, Arizona	Postdoctoral Fellowship	1996

(II) Appointments

2001- present	Associate Professor of Biology, West Chester University
1996-2001	Assistant Professor of Biology, West Chester University
1993-96	Postdoctoral fellow, University of Arizona
1989-93	Graduate Research Assistant, Murdoch University
1988	Graduate Research Assistant, CSIRO
1986-87	Consultant, Alcoa of Australia

(IIIa) Five publications most closely related to project

Casotti, G. and Braun, E.J. (2004). Protein location and elemental composition of urine spheres in different avian species. *The Journal of Experimental Zoology*, *Part A- Comparative Experimental Biology* 301A:579-587.

Casotti, G. (2001). Seasonal effects on kidney morphology in house sparrows. *Journal of Experimental Biology* 204, 1201-1206.

Layton, H.E., Davies, J.M., Casotti, G., and Braun, E.J. (2000). Mathematical model of an avian urine concentrating mechanism. *American Journal of Physiology* 279, F1139-F1160.

Casotti, G. and Braun E.J. (2000). Functional morphology of the avian medullary cone. *American Journal of Physiology* 279, R1722-R1730.

Casotti, G. and Braun E.J. (2000). Renal anatomy in sparrows from different environments. *Journal of Morphology* 243, 283-291.

(IIIb) Five other significant publications

Casotti, G., Beuchat, C.A. and Braun, E.J. (1998). Morphology of the kidney in a nectarivorous bird, the Anna's hummingbird *Calypte anna*. *Journal of Zoology, London*. 244, 175-184.

Casotti, G. and Braun, E.J. (1997). The ionic composition of urate containing spheres in the urine of the domestic fowl. *Comparative Biochemistry and Physiology.* 118A, 585-588.

Casotti, G. and Braun, E.J. (1996). Functional morphology of the glomerular filtration barrier in *Gallus gallus*. *Journal of Morphology*, 228, 327-334.

Casotti, G. and Braun, E.J. (1994). Structure of the glomerular capillaries of the domestic chicken and desert quail. *Journal of Morphology*, 224, 57-63.

Casotti, G. and Richardson, K. C. (1993). A qualitative analysis of the kidney structure of meliphagid honeyeaters from wet and arid environments. *Journal of Anatomy* 182, 239-247.

(IV) Synergistic Activities

1. Development of a Laboratory and lecture manual to enhance student learning in the upper division Physiology classroom BIO 468.

Casotti, G. (2002). Experiments in Comparative Vertebrate Physiology. West Chester University, West Chester, PA. 105pp.

Casotti (2002). Multimedia notes in Vertebrate Physiology. West Chester University, West Chester, PA. 150pp.

2. Development of a lecture manual in Human Physiology to enhance learning of physiology in lecture.

Casotti (2001). Multimedia notes in Human Physiology. West Chester University, West Chester, PA. 140pp.

3. Casotti, G. (2002). Using Dreamweaver MX in Web Design. Resources for the Electronic Classroom Conference, West Chester University, PA.

4. Reviewer for the following journals, *Journal of Experimental Biology*, *Physiological and Biochemical Zoology* and *Scanning Microscopy International*.

(V) Collaborators and other affiliations

(a) Collaborators and Co-Editors.

Carol Beuchat (San Diego State University), Eldon Braun (University of Arizona), John Davies (Duke University), Harold Layton (Duke University), Geraldine Misquith (West Chester University), Leslie Slusher (West Chester University).

(b) Graduate and Postdoctoral Advisors.

Eldon Braun (University of Arizona), Kenneth Richardson (Murdoch University, Western Australia).

(c) Thesis advisor and Postgraduate-Scholar Sponsor

Undergraduate students: Rebecca Ackerman, Jaime Archer, Audrey Burns, Katrina Keller, Aarti Patel (all WCU).

Graduate students: Y. Ogunkoya (Murdoch University), Anthony Desmond (Murdoch University), Yoshi Valadez (University of Arizona), Limberly Lindberg (University of Arizona), Dana Angelo, Melanie Hartman, Dawn Keesey, Nicole Jones, Megan Carfioli, Jeffrey Anderson, Richard Rohe, Tara Flick (all WCU).

F. BIOGRAPHICAL SKETCHES
MAUREEN KNABB

(I) Professional preparation

St. Joseph's University, Philadelphia, PA.	BS. Biology	1979
University of Virginia, Charlottesville, Va.	PhD. Physiology	1983
Washington University, St. Louis	Postdoctoral, Cardiology	1983-85

(II) Appointments

1999- present	Professor of Biology, West Chester University
1994-1999	Associate Professor of Biology, West Chester University
1986-1994	Assistant Professor of Biology, West Chester University
1985-1986	St. Joseph's University, Philadelphia, Pa. Instructor in General Biology. Villanova University, Villanova, Pa. Instructor in Zoology.

(IIIa) Five publications most closely related to project

Knabb, M. T. and G. Misquith. Assessing inquiry process skills in the lab using a fast, simple, inexpensive fermentation model system. *The American Biology Teacher*. July 2004 (in review)

Bharathan, N. and M.T.Knabb (2004) Biotechnology in a box: a collaborative effort to address the content and strategies in the National and Pennsylvania Standards. Proceedings of the Teacher Preparation PI Conference NSF CETP, STEMTP, ATE Programs. http://k12s.phast.umass.edu/stemtec/piconf/Proceedings/Papers/Bhar.doc

Knabb, M.T. (2003) Rapping to review: a novel strategy to engage students and summarize course material. Advan. Physiol. Edu. 27: 157-159, 2003

Knabb, M.T. (2000) Discovering teamwork: A novel cooperative learning activity to encourage group interdependence. *American Biology Teacher*, 211-214.

Knabb, M.T. (1997) Creating a Research Environment in an undergraduate cell physiology course. *Journal of College Science Teaching.* 27 (3): 205-209.

(IIIb) Five other significant publications

Knabb, M.T. (2004) Assessing inquiry skills in the lab using the case study method. Annual Conference on Case Study Teaching in Science. University of Buffalo.

Knabb, M. (2004) Strategies for enhancing inquiry in introductory biology labs. National Science Teachers Association meeting. Atlanta GA

Knabb,M.T. and R.I.Woodruff (2003) Inquiry-based challenges: A strategy to assess the inquiry process in the introductory laboratory. Annual Conference for the Advancement of College Teaching and Learning, Harrisburg, PA

Knabb, M.T. (1998) Mutations, misconduct and moral behavior: Exploring ethical issues during the Merck Summer Research Program. CUR Quarterly 18(3): 124-126.

Knabb, M.T. (1997) Using Rate it! to enhance creativity in an introductory cell physiology course. BioQuest Notes 8 (1): 6-9.

(IV) Synergistic Activities

1. Knabb, M.T. 2004 Using a Personal Response System to enhance and assess student learning in a large lecture course. May 14 RECAP 2004, West Chester University.
2. Knabb, M.T., A. Faulds, R.I. Woodruff. Bio 110 Laboratory Manual. Spring 2003 (This manual replaced the text previously used for Bio 110 lab).
3. Knabb, M.T. Electricity: Biological Applications. Spring 2003 (This manual was developed for the new general education science course for elementary education students, SCI 102)
4. Offered biotechnology workshop for teachers, January 9-10, 2003.
5. Knabb, M.T. (2000) Combining Research Experience and Teacher Excellence at West Chester University: A plan to incorporate research-based labs. Research Link 2000, Ferris State University, Big Rapids, MI.
6. Husic, D. M.T. Knabb. L Controis (2000) Novel interdisciplinary programs at the interface of biology and chemistry. CUR 2000 Workshop, College of Wooster.

(V) Collaborators and other affiliations

(a) Collaborators and Co-Editors.

Marcy Corjay, previously with the Cardiovascular Division at DuPont Pharmaceutical Company; Diane Husic, Chemistry, East Stroudsburg University; Brian Jones, Theater, Indiana University of PA; Jim Falcone (Chemistry), Dr. Gustav Mbuy (Biology), Dr. Sherry Melton (Kinesiology), Dr. William Passwaters (Physics), Dr. Frank Smith (Physics), Dr. Richard Woodruff (Biology) at West Chester University.

(b) Graduate and Postdoctoral Advisors.

Robert M. Berne (deceased, University of Va), Rafael Rubio (currently in Mexico), Burton Sobel (University of Vermont).

(c) Thesis advisor and Postgraduate-Scholar Sponsor

Graduate Students: Dong Gangyi, Barbara Russell, Geraldine Misquith, Liquiong Chen Kirt Willis, Cheryl Laubach, Michael Marquette, Kerry McShane-Kay, Jen Monismith, Charla Dissinger, Annalisa Torrente, Sue McElhiney, Amir Beg, JoAnn Wylie, Shengli Wu, Ken Halford, Ken Singleton, Sue Murray, Manoj Samuels, Tony Piselli, ZuoFong Chen, Robert Barber, SherryAnn Carter, Medramet Rao, Russ Cole, Ted Robinson, Mary Launi, Paul Joyce, Shannon Firor, Amy Dicamillo, Thomas Bradley, Robert Herion, Rich Coulter, Jeff Overstreet, Sue Mrugal, Patrick Zoder

Undergraduate Students: Kirt Willis, Khalid Saeed, Mary Schultz, Al Guagnozzi, David Yurgowicz, Nahid Taheri, Nancy Robinson, Amy Hinze, Sonya Kolbe, Nick Marino, Jay Reinhardt, Jon Lippy, Georgina Russell, Thaddeus Foreman, Terramika Ford, Corin Litsinger, Mark Huffman, Nick Fischer, Mike Lanci, Jen Bevan, Yury Khelemsky, Mark Fereshteh, Kristin Butterfield, Justin Sprenkle, Kate Weinstein, Lindsay Pfeffer, Casey Danielsen., Aditi Patel, Blair DeFulvio, Rosanne Gichuru

F. BIOGRAPHICAL SKETCHES
JUDITH GREENAMYER

(I) Professional preparation

The Ohio State University, Columbus OH	DVM, College of Veterinary Medicine	1972
The University of California, Davis, CA	MS, Cell Physiology	1982

(II) Appointments

2001 - Present	Chair, Department of Biology, West Chester University
1988 - Present	University Animal Facility Manager, West Chester University
1988 - Present	Assistant Professor, Department of Biology, West Chester University
1975 - 88	US Air Force Veterinary Corps
1972-75	Small animal private practice, Bayview Veterinary Hospital
1971	US Department of Agriculture, Animal and Plant Health Investigation Service

(IIIa) Five publications most closely related to project

None

(IIIb) Five other significant publications

None

(IV) Synergistic Activities

1. Revised laboratories in BIO 269 in 1997 to increase use of computer simulations, increase student participation as experimental subjects, eliminate live animal use, and more closely align lecture and laboratory material.

2. Teaching experience outside of West Chester University

1987	Lecturer, Medical aspects of nuclear, biological, and chemical warfare, Flight nurse/flight technician course USAFSAM/EDN
1986-87	Lecturer, Chemical agents and chemical defense, Aerospace physiologist course USAFSAM/EDB
1985-87	Lecturer, Medical aspects of chemical warfare, Battlefield medicine course USAFSAM/EDK
1985	Lecturer, Medical aspects of chemical warfare, US Army Academy of Health Sciences
1982-88	Assistant Instructor, USAFSAM Education Courses
1981	Graduate teaching assistant, University of California Davis
1967-69	Undergraduate teaching assistant, Introductory Chemistry, Ohio State University

(V) Collaborators and other affiliations

(a) Collaborators and Co-Editors.

1989 - Present Small/Laboratory animal medicine consultant, Bryn Mawr Veterinary Hospital

LICENSED: Pennsylvania (active), Ohio (inactive), Washington (inactive), Texas (inactive)

MEMBER OF: American Veterinary Medical Association
American Association for the Advancement of Science
American Association for Laboratory Animal Science
Phi Zeta (Veterinary Scholastic Honorary Society)

(b) Thesis advisor and postgraduate-Scholar Sponsor

Co-advisor for thesis of Dong Gangyi, MA (May 1990)
Advisor for Kenneth Halford—left program after 2 years
Advisor for Donald Schroeder--left program after one year
On thesis committee for Patricia Mirakovits (withdrew), Barbara Russell (MA 1994), and Dawn Zimmerman (MS 1998)
On non-thesis committee for Sherry Bensinger (MS 1999) and Rosemary Page, (MS 2001)
Non-thesis advisor for Dawn Keesey.

F. BIOGRAPHICAL SKETCHES
LORETTA RIESER-DANNER

(I) Professional preparation

The Pennsylvania State University	BS, Individual & Family Studies	1981
The University of Texas at Austin	PhD, Developmental Psychology	1989

(II) Appointments

2000 – 2003	University Assessment Coordinator, West Chester University
2004- present	Associate Professor of Psychology, West Chester University
1997- 2004	Assistant Professor of Psychology , West Chester University
1991 - 1997	Assistant Professor of Psychology, The Pennsylvania State University
1989 - 1991	Assistant Professor of Psychology, Villanova University
1987 - 1989	Instructor of Psychology, Villanova University
1981 - 1987	Graduate Research Assistant, The University of Texas at Austin

(IIIa) Five publications/presentations most closely related to project

Rieser-Danner, L.A. (2003). Assessing general education goals in introductory psychology classes. Poster presented at the annual meeting of the Society for Teaching in Psychology, Best Practices in Teaching Introductory Psychology, Atlanta, GA.

Rieser-Danner, L.A. (2003). Teaching undergraduate statistics: How do we promote long term gains in critical thinking? Discussion section presented at the annual meeting of the National Institute on the Teaching of Psychology, January 2-5, 2003.

Rieser-Danner, L.A. (2003). Debating children's lives: A psychology major capstone course. Poster presented at the annual meeting of the National Institute on the Teaching of Psychology, January 2-5, 2003.

Rieser-Danner, L.A., Leach, E., & Larsen, E. (2002). General education assessment: What we can learn from students. Paper presented at the National Conference on Higher Education, Chicago, IL.

Rieser-Danner, L.A., & Renner, CH. (2001). Assessment as faculty development. Paper presented at the 13th Annual International Conference on Assessing Quality in Higher Education, Glasgow, Scotland, UK.

(IIIb) Five other significant publications/presentations

McConatha, J.T., Rieser-Danner, L., Harmer, K., Hayta, V., & Polat, T.S. (2004). Life satisfactionin three countries. Psychological Reports, 94, 795-806.

McConatha, J.T., Hayta, V., Rieser-Danner, L.A., McConatha, D., & Polat, T.S. (2004). Turkish and US attitudes toward aging. Educational Gerontology, 30, 1-16.

Rieser-Danner, L.A. (2003). Individual differences in infant fearfulness and cognitive performance: A testing, performance, or competence effect? Genetic, Social, and General Psychology Monographs, 129(1), 41-71.

Rieser-Danner, L.A., DeShields, T., Grossman, J., Corby, A.M., & Bordner, S. (2004). Mothers at play: Individual differences in maternal free play behavior are predicted by infant temperament. Poster presented at the biennial meeting of the International Conference on Infant Studies, May 5-8, 2004, Chicago, IL.

McConatha, J.T. Rieser-Danner, L., & Hayta, Va. (2003). A cross-cultural analysis of factors influencing life satisfaction. Poster presented at the annual meeting of the American Psychological Association, Toronto, Canada.

(IV) Synergistic Activities

1. Invited External Reviewer for 3rd Annual Learning Outcomes Assessment Poster Symposium, Lock Haven University, Lock Haven, PA, October, 2003
2. Rieser-Danner, L.A. (2002). Statistics for the Behavioral Sciences: Manuals and Workbooks I - IV. West Chester University, West Chester, PA.
3. Development of an application problem set for use in teaching Developmental Psychology classes (PSY 382 and PSY 210).
4. Rieser-Danner (2002). Developmental Psychology: A Problem-Based Learning Approach. West Chester University, West Chester, PA.
5. Rieser-Danner, L. & Gedge, K. (2002). Student Learning Outcomes Assessment: A Manual for Faculty and Staff of West Chester University.
6. Invited participant and Group synthesizer, 2002 AAHE National Conference Research Forum: Learning in Context: Who Are our Students?"
7. Program planning and local arrangements coordinator, 2000 PA State System of Higher Education Assessment Conference: Developing Creative & Collaborative Assessment Models.
8. Offered Assessment of Student Learning Outcomes workshops, West Chester University, 2000 – 2003 (including development of assessment plans, development of assessment materials and rubrics, development of assessment reports, and using new assessment software for planning, implementing, and reporting assessment results).
9. Reviewer for the following journals, *Child Development and Journal of General Education.*

(V) Collaborators and other affiliations

(a) Collaborators and Co-Editors.

Karin Gedge (History, West Chester University), Laura Hubbs-Tait (Kansas State University), Judith Langlois (Psychology, University of Texas at Austin), Elizabeth Larsen (English, West Chester University), Evan Leach (Management, West Chester University), Jasmin T. McConatha (Psychology, West Chester University), Catherine H. Renner (Psychology, West Chester University), Laura Travea (former graduate student, West Chester University)

(b) Graduate and Postdoctoral Advisors.

Judith H. Langlois (Psychology, University of Texas at Austin), H. Hill Goldsmith (Psychology, University of Wisconsin-Madison)

(c) Thesis advisor and Postgraduate-Scholar Sponsor

Graduate students: C. Bohn (Villanova University), J. Baran (Villanova University), G. Kidorf (Villanova University), A. Mace (West Chester University), R. Kalfon (West Chester University),
D. Radl (Drexel University).

G. BUDGET AND BUDGET JUSTIFICATION

Monies for the equipment requested for the grant will be matched by West Chester University. The equipment budget on the NSF budget sheet represents 50% of the total equipment budget.

PowerLab equipment: This bundle allows for a wide variety of physiology experiments to be performed including, spirometry, degree of chest expansion, nerve and muscle studies, measurement of ECG (electrocardiography), EEG (Electroencephalography) and EMG (electromyography), measurement of blood pressure, muscle contractile force and an evoked auditory response. All PowerLab systems are approved for use on human subjects. The bundle comes with a 3 year warranty. The per unit cost of the teaching bundles is $5,490 . We are requesting 6 units so that each 6 groups of 4 students can use the system simultaneously. The total list price of 6 units is $32,940. The University discount price is $30,720 (a saving of $2,220). **NSF request is $15,360.**

The transducers needed for the GSR experiment is separate to the teaching bundle and has a list price of $999 per unit. The University discount price is $950. We require 6 units at a total purchase price of $5,700 (a saving of $294). **NSF request is $2,850.**

Miscellaneous PowerLab components: To enable our students to use PowerLab outside of lab hours to analyze their collected data, we request funds for a Macintosh OsX Server. Students will be able to logon to the Server to complete their assignments using DataPad, Chart and Scope analysis programs (all of which come with PowerLab). The list price of the server and a monitor is $4,298. The University discount price is $3,698 (a saving of $600). **NSF request is $1,849.**

Installation and software training: Shipping and installation of PowerLab by ADInstruments and a day's training session for the faculty involved is $2,300. **NSF request is $1,150**.

Disposable supplies: Disposable supplies for PowerLab system include ECG electrodes and electrode paste. We are requesting that 12 packets of electrodes costing $50 each be purchased with the system. The total price is $600. **No money is request from NSF.**

We are requesting that 12 packets of electrode paste costing $11 each be purchased with the system. The total cost is $132. **No money is request from NSF.**

Computer technology: We request 6 desktop G5 Macintosh computers and monitors to allow us to run the PowerLab software in the laboratory. The physiology classroom has only one LAN connection, thus to perform software updates via the internet and for students to print out graphs efficiently (purchase 1 printer instead of 6) we need the ability to go wireless. For this, each CPU has to have a wireless card inside it, and we must purchase a base station and wireless laser printer. The list price of the CPU with wireless capabilities (G5, 1.8 GHz, 512 RAM, CD-RW) and monitor combined is $2,952 per unit. The University discount price is $2,585. We request 6 units at a total cost of $15,510 (a saving of $2,202). **NSF request is $7,755**. The cost of the wireless base station is $200. **NSF request is $100**.

We are requesting the ability for the students to have a paper copy of their text and graphical data before they leave the lab. Our physiology lab has only one LAN connection (for the base station), therefore we request funds for a wireless Hewlett Packard laser printer at a list price of $1,200. The University discount price is $1,000 (a saving of $200). **NSF request is $500.**

We are requesting the ability for our students to use SmartBoard™ technology to present their data in Show and Tell sessions and for their oral presentations to the class at the end of semester. The list price of a SmartBoard is $2,999. The University discount price is $1,900 (a saving of $1,099). **NSF request is $950**.

In order to project a presentation on the board we need a portable projector (NEC NT2600). The list price of the projector is $7,995. The University discount price is $3,800 (a saving of $4,195). **NSF request is $1,900.**

We also require a Macintosh computer to run the presentation. We need to be able to lock the computer in a draw when it is not being used (since we do not have a storage room), thus we require the portability of a laptop computer. The list price of a Macintosh laptop computer is $2,078. The University discount price is $1,890 (a saving of $210). **NSF request is $945.**

Conference (workshop attendance): We are requesting funds for LRD to present at the HAPS meeting in May 2006 and MK to present at the NSTA (venues yet to be determined), and GC and JG to present at the Experimental Biology (IUPS/EB) meeting in Washington D.C. in April 2007. Economy round trip airfare from Philadelphia to the HAPS and to the NSTA meeting is anticipated to be $500 (total $1,000). Train travel to Washington D.C. for the IUPS/EB meeting will be $400, and will be **paid for by WCU** (total $1,400). Conference registration for all meetings is likely to total $1,000. Accommodation for 4 nights at $130 per night LRD ($520), MK ($520), GC and JG (separate rooms) (total $1,040), and meals ($30 per day) (total $480). Total is $3,560. **NSF request is $3,560.**

Personnel: The Dean of the College of Arts and Sciences will provide 3-credit course hours of release time (with benefits) in spring '06 and '07 to GC, to administer the implementation of the PowerLab system ($24,611)**.** This administration will involve: A. coordinating the setup and implementation of PowerLab, B. rewriting the laboratory manual for Bio 468 to incorporate PowerLab into the curriculum, C. complying evaluation data for Bio 468, and D. overseeing all aspects of administration of the PowerLab acquisition.

The equivalent of 2 months of summer salary (with benefits) is requested for MK in summer '05 to rewrite the Bio 469 Lab Manual to incorporate PowerLab into the curriculum. **NSF request is $22,794.**

The equivalent of 2 months of summer salary (with benefits) is requested for JG in summer '06 to rewrite the Bio 269 Lab Manual to incorporate PowerLab into the curriculum. **NSF request is $17,102.**

The equivalent of 2 months of salary (with benefits) is requested for LRD in summer '06 and summer '07 to coordinate assessment for this proposal. **NSF request is $38,750.**

West Chester University has committed at total of $59,798 to this project.

SUMMARY TABLE

Items to be supported	List price	Education price	NSF contribution	Matching funds
PowerLab equipment	38,934	36,420	18,210	18,210
Misc. PowerLab components	6,598	5,998	2,999	2,999
Disposable supplies	732	732	0	732
Computer technology	32,205	24,300	11,846	11,846
Conference- workshop travel	1,400	1,400	0	1,400
Conference- workshop expenses	3,560	3,560	3,560	0
Personnel – GC	N/A	N/A	0	24,611
Personnel – MK	N/A	N/A	22,794	0
Personnel – JG	N/A	N/A	17,102	0
Personnel – LRD	N/A	N/A	38,750	0

H. CURRENT AND PENDING SUPPORT

Current

NSF CCLI #0126634 project ($187,026, 1/01 - 6/05) titled "Connecting Research Experiences And Teacher Excellence (CREATE) in Introductory Biology Laboratories at West Chester University.

Pending

The current proposal: "Inquiry-based curricular integration in physiology at West Chester University", NSF CCLI (requested funding $151,438).

I. FACILITIES, EQUIPMENT AND OTHER RESOURCES

The Biology Department occupies two buildings: Boucher Hall (built in 1995) and the newly renovated (November 2003) adjoining Schmucker North Science Complex. Both buildings are state-of-the-art and total square footage is approximately 80,000 sq.ft. The newly renovated building has three new multimedia lecture theatres seating 25, 50 and 75 students respectively, and a computer room with seating for 24 students. Students taking our physiology classes will be free to use the computer room throughout the semester to allow them to log onto the server to complete their lab reports.

The Biology department also has a permanent, full time laboratory coordinator to assist in laboratory preparation, conducting routine maintenance and ensuring that all our equipment is maintained under service contract.

The Information Technology (IT) department at WCU is comprised of 20 personnel. Our IT department supports both Macintosh and PC platforms, and has a dedicated Macintosh Information Specialist on staff.

The physiology laboratories are taught in a laboratory occupying 1,200 sq.ft. of space in Boucher Hall. The classroom is currently equipped with 6 Narco MK-III-S physiographs and recording equipment (purchased in 1987) to conduct labs involving the measurement of muscle tension, pulse pressure, chest expansion and ECG. Other equipment includes 6 pulse transducers, 6 Collins Survey II spirometers, a

Triac centrifuge for spinning blood, 10 Nikon microscopes, a 14” drill press, a Precision water bath and assorted glassware and dissection equipment.

The Dean of the College of Arts and Sciences, Dr. Charles Hurt has agreed to support the project in the form of 0.25 release time for GC for each year of this 2 year proposal.

J. SPECIAL INFORMATION AND SUPPLIMENTARY DOCUMENTATION

Dean’s letter placed here

10 November 2004

TO: Dr. Pimmell, Program Director

RE: Financial commitment by the Department of Biology

This letter is to confirm that the Department of Biology is committing to the future support of this proposal by agreeing to provide hardware updates as needed after the first three years of the grant (2008 onward). Our department has a strong history of support for computer assisted teaching in a variety of courses. We understand that computer hardware has a finite life span, and would expect to replace the computers on a rotating basis of 20-25% each year. That would presume a life expectancy of 4-5 years for each machine, and would be well within the capability of our annual department budget. Alternatively, we could "bank" the money for replacement of all the computers, at once. Add ons and plug ins will be bought as they become available, as faculty show that they have a need for them.

The replacement of our outdated physiographs with computers that record data in a format that the students can readily store and access for study and reporting purposes, fits well with our mission of training undergraduates in scientific methodology and the application of technology. In addition, the use of computer assisted data collection will prepare our majors for the real laboratory environment of industry and research. Our students are coming to us with ever improving computer skills, and should be able to make optimum use of this new technology. This is definitely a way to deliver a better, more student-directed, laboratory component to our courses.

Judith J. Greenamyer, DVM
Chair, Department of Biology

K. APPENDIX

CURRENT Bio 269 LECTURE AND LAB SCHEDULE

Week	Lecture topic	Lab Topic	Lab Content
1	Autonomic nervous system, Endocrinology	Scientific notation and metrics	
2	Endocrinology	Senses	Patella, Achilles and plantar reflexes general sensation - two point threshold, tactile localization, Taste bud and olfactory stimulation
3*	Hematology, Immunology	Senses (computers)	Tests for blind spot, near point accommodation, visual acuity, astigmatism, color blindness, hearing acuity, conduction deafness, Rinne test, Simulation lab
4	Immunology	Blood/hematology	Hematocrit Hemoglobin determination Blood typing, RBC counts
5	Lymphatic tissue, Cardiovascular physiology	Lab exam 1	
6*	Cardiovascular physiology	Membrane physiology (computers)	Diffusion, osmosis, tonicity, Simulation lab
7	Blood vessels, Hemodynamics	Cardiovascular physiology	ECG, heart sounds, pulse, blood pressure
8*	Lymphatic flow	Muscle contraction (computers)	Twitch, treppe, tetanus, fatigue, Simulation lab
9	Pulmonary physiology	Lab exam 2	
10	Gas exchange, Renal physiology	Respiration	Respirometry, TV, IRV, ERV, IC, VC,
11*	Renal physiology, Fluid balance	Renal (computers)	Urinalysis tests Simulation lab
12	Electrolytes, Acid/base balance	Digestion	Digestive system anatomy
13*	Digestive physiology	Digestion (computers)	Simulation lab
14	Finals week	Lab exam 3	

* Denotes labs using computer simulations

PROPOSED Bio 269 LECTURE AND LAB SCHEDULE

Week	Lecture topic	Lab Topic
1*	Endocrinology	Introduction to inquiry and PowerLab
2	Endocrinology	Endocrine system experiment with PhysioEx
3*	Autonomic nervous system	ANS and GSR with PowerLab
4*	Muscle physiology	GSR and music investigation with PowerLab
5*	Cardiovascular physiology	EMG with PowerLab plus challenge activity
6*	Blood vessels, Hemodynamics	ECG with PowerLab plus challenge activity
7	Hematology	Lab exam
8	Immunology	Hematology lab
9*	Pulmonary physiology	Respiratory I with PowerLab plus challenge activity
10*	Gas exchange, Renal physiology	Respiratory II with PowerLab plus challenge activity
11	Renal physiology, Fluid balance	Renal lab
12*	Electrolytes, Acid/base balance	Integrative exercise lab with PowerLab plus challenge activity
13	Digestive physiology	Digestion lab
14	Finals week	Final exam

* denotes weeks using PowerLab

Lab assessment

Lab is worth 150 points. 50 points for each lab exam and 50 points for investigative activities (10 x 5).

CURRENT Bio 468/9 LECTURE SCHEDULE

Week	Lecture topic	Assessment
1	Homeostasis, Membrane physiology I, II	
2	Nervous system I, II, III	
3	Nervous system IV, V	
4	Muscle physiology I, II, III	Exam #1
5	Muscle physiology IV, Circulation I	
6	Circulation I, II, III	
7	Circulation IV, Respiration I, II	
8	Respiration III, IV	Exam #2
9	Buoyancy, Osmoregulation I, II	
10	Osmoregulation III, IV	
11	Thermoregulation I, II, Metabolism	
12	Digestion I, II	Exam #3
13	Digestion II, Reproduction I, II	
14	Reproduction II, IV	
15	Final’s week	Final exam

CURRENT Bio 468 LABORATORY SYLLABUS

Week	Topic	Content	Assessment
1	Membrane Physiology	Diffusion, osmosis, tonicity, cell permeability,	
2	Axons (computer simulation)	Absolute refractory period Relative refractory period Chronaxie and rheobase Threshold stimulus/All or None Law	
3	Neuromuscular blockade (frogs)	Effects of curare on the neuromuscular junction	
4	Nerve-Muscle (frogs)	Independent nerve muscle irritability Threshold voltage Effect of stimulus strength, frequency Length-tension relationship Neuromuscular fatigue	
5	Blood (sheep)	Hematocrit Hemoglobin determination RBC, WBC and differential counts WBC identification	
6	Cardiovascular physiology (human)	Heart sounds Systolic and diastolic blood pressure Effect of cold on blood pressure Peripheral pulse Effect of increase in abdominal pressure on pulse pressure Electrical axis of the heart	Formal lab write up
7	Mid-term Exam		Exam
8	Cardiac function (frogs)	Normal heart beat Refractory period, tetanus of the heart Starlings law Effect of temperature, drugs on heart rate First, second and third degree heart block All or none law of the heart	
9	Respiration (human)	Normal respiration on chest expansion Effect of hyperventilation in an open and closed system Effect of rebreathing, mental concentration, speech, respiratory pathway blockage, exercise Respiration volume measures TV, IRV, ERV, IC, VC, MVV	

10	Osmoregulation (human)	Effect of drinking hypotonic, isotonic and hypertonic solutions on volume, specific gravity, chloride concentration, glucose, blood, pH and protein in urine	
11	Metabolism (mice and snakes)	Oxygen consumption in an ectotherm and endotherm	
12	Digestion (rats)	Effect of insulin and glucagon on blood glucose concentration Effect of hormone concentration on blood glucose concentration	Formal lab write up
13	Reproduction (rats)	Effects of PMSG on A. weight of uterus, B. weight of ovaries, C. presence of corpora hemorrhagica. Examination of ovaries for stages of follicular development	
14	Final exam		Exam, lab notebook

Lab assessment	**%**
Two formal lab reports	30
Laboratory notebook	20
Mid-term exam	25
Final exam	25

Lab assessment notes

Laboratory reports: Each week you will perform a different experiment incorporating (from a practical perspective) information that was covered in the lectures. Students will be expected to hand in the results of each experiment as part of a lab note book (see next section). In addition, students will only be required to write up 2 of these experiments in proper scientific format (Abstract, Introduction, Methods etc.).

Laboratory notebook: Good note taking is an essential component of any experiment. You should bring a laboratory notebook to class each week and write in any relevant notes from the experiments or from the prelab discussion. Examples of items to be included in these notebooks are the times and dates of experiments, problems encountered during the experiments, any data pertinent to or obtained from the experiment - good and bad, etc.

PROPOSED Bio 468 LABORATORY SYLLABUS

Week	Topic	Content	Assessment
1	The scientific process	Students will review a scientific paper and familiarize themselves with the scientific process of hypothesis testing, experimental design, data collection and interpretation	
2*	PowerLab	An introduction into using PowerLab	
3*	Axons (frogs)	Absolute refractory period Relative refractory period Chronaxie and rheobase Threshold stimulus/All or None Law	Show and tell
4*	Nerve-Muscle (frogs)	Independent nerve muscle irritability Threshold voltage Effect of stimulus strength, frequency Length-tension relationship Neuromuscular fatigue, blockade	Formal write up, Show and tell
5	Blood (sheep)	Hematocrit Hemoglobin determination RBC, WBC and differential counts WBC identification	Show and tell
6*	Cardiovascular physiology (human)	Heart sounds *(electric stethoscope)* Systolic and diastolic blood pressure Effect of cold/hot on blood pressure Peripheral pulse *(finger pulse transducer)* Effect of increase in abdominal pressure on pulse pressure Electrical axis of the heart	Show and tell
7	Presenting data	How to construct a poster and oral presentation for a scientific meeting	
8*	Cardiac function (frogs)	Normal heart beat *(force transducer)* Refractory period, tetanus of the heart, treppe Starlings law Effect of temperature, drugs on heart rate First, second and third degree heart block All or none law of the heart	Show and tell
9*	Respiration (human)	Normal respiration on chest expansion Effect of hyperventilation in an open and closed system Effect of rebreathing, mental concentration, speech, respiratory pathway blockage, exercise Respiration volume measures TV, IRV, ERV, IC, VC, MVV	Show and tell

10	Osmoregulation (human)	Effect of drinking hypotonic, isotonic and hypertonic solutions on volume, specific gravity, chloride concentration, glucose, blood, pH and protein in urine	Formal write up
11	Metabolism (mice and snakes)	Oxygen consumption in an ectotherm and endotherm Effects of cold and heat on metabolism Concept of the thermoneutral zone	Show and tell
12	Digestion (rats)	Effect of insulin and glucagon on blood glucose concentration Effect of hormone concentration on blood glucose concentration	Show and tell
13	Reproduction (rats)	Effects of PMSG on A. weight of uterus, B. weight of ovaries, C. presence of corpora hemorrhagica. Examination of ovaries for stages of follicular development	Show and tell
14	Student presentations	PowerPoint presentations	Presentations, lab notebook

* Denotes labs using the PowerLab system

Lab assessment	**%**
Hypothesis testing	5
Show and tell presentations	5
Two formal lab reports	40
Laboratory notebook	20
Oral/poster presentation	30

Lab assessment notes

Hypothesis testing: points will be awarded to each student for their performance and participation in hypothesis testing during the first hour of the laboratory discussion. This will count for 5% of the final lab grade.

Show and tell presentations: points will be awarded to each student for their participation and performance in the final 30 minutes of each laboratory. This will count for 5% of the final lab grade.

Formal lab reports: *Two* of the labs will to be written up in proper scientific format (abstract, introduction, materials and methods, results, discussion, references), by each student independently. Each report will count for 20% of the final lab grade (total 40%).

Lab note book: Students will be expected to share all of the experimental data gathered among groups and write a half page summary for each experiment as part of their lab note book. This will be handed into the professor for grading at the end of the semester and will count for 20% of the final lab grade.

Oral/poster presentation: Each group of students will be required to pick one laboratory topic and the group must give either an oral or poster presentation to the rest of class in the final lab of the semester. Each student within the group must speak. If the group chooses to put together a poster presentation, they must still present their poster to the class and discuss their data to the rest of the class. All presentations must include the following information: the purpose of the experiment, hypothesis, details of the methodology (sufficient that another person could repeat the experiment), the results of the experiment in either tabular or graphical format, the interpretation and the significance of the data. This presentation will count for 30% of the final lab grade. All members of the group will receive the same grade.

CURRENT Bio 469 LABORATORY SYLLABUS

Week	Topic	Content	Assessment
1	Membrane Physiology	Diffusion, osmosis, tonicity, cell permeability,	
2	Axons (computer simulation)	Absolute refractory period Relative refractory period Chronaxie and rheobase Threshold stimulus/All or None Law	
3	Neuromuscular blockade (frogs)	Effects of curare on the neuromuscular junction	
4	Nerve-Muscle (frogs)	Independent nerve muscle irritability Threshold voltage Effect of stimulus strength, frequency Length-tension relationship Neuromuscular fatigue	
5	Blood (sheep)	Hematocrit Hemoglobin determination RBC, WBC and differential counts WBC identification	
6	Cardiovascular physiology (human)	Heart sounds Systolic and diastolic blood pressure Effect of cold on blood pressure Peripheral pulse Effect of increase in abdominal pressure on pulse pressure Electrical axis of the heart	Formal lab write up
7	Mid-term Exam		Exam
8	Cardiac function (frogs)	Normal heart beat Refractory period, tetanus of the heart Starlings law Effect of temperature, drugs on heart rate First, second and third degree heart block All or none law of the heart	
9	Respiration (human)	Normal respiration on chest expansion Effect of hyperventilation in an open and closed system Effect of rebreathing, mental concentration, speech, respiratory pathway blockage, exercise Respiration volume measures TV, IRV, ERV, IC, VC, MVV	
10	Osmoregulation (human)	Effect of drinking hypotonic, isotonic and hypertonic solutions on volume, specific gravity, chloride concentration, glucose, blood, pH and protein in urine	

11	Metabolism (mice and snakes)	Oxygen consumption in an ectotherm and endotherm	
12	Digestion (rats)	Effect of insulin and glucagon on blood glucose concentration Effect of hormone concentration on blood glucose concentration	Formal lab write up
13	Reproduction (rats)	Effects of PMSG on A. weight of uterus, B. weight of ovaries, C. presence of corpora hemorrhagica. Examination of ovaries for stages of follicular development	
14	Final exam	Exam	lab notebook

Lab assessment	**%**
Two formal lab reports	30
Laboratory notebook	20
Mid-term exam	25
Final exam	25

Lab assessment notes

Laboratory reports: Each week you will perform a different experiment incorporating (from a practical perspective) information that was covered in the lectures. Students will be expected to hand in the results of each experiment as part of a lab note book (see next section). In addition, students will only be required to write up 2 of these experiments in proper scientific format (Abstract, Introduction, Methods etc.).

Laboratory notebook: Good note taking is an essential component of any experiment. You should bring a laboratory notebook to class each week and write in any relevant notes from the experiments or from the prelab discussion. Examples of items to be included in these notebooks are the times and dates of experiments, problems encountered during the experiments, any data pertinent to or obtained from the experiment - good and bad, etc.

PROPOSED Bio 469 LABORATORY SYLLABUS

Week	Topic	Content	Assessment
1	The scientific process	Students will review a scientific paper and familiarize themselves with the scientific process of hypothesis testing, experimental design, data collection and interpretation	
2*	PowerLab	An introduction into using PowerLab	
3*	Nerve conduction (human)	Tendon reflex Blink reflex Sympathetic skin response Human motor-nerve experiment *(abrasive pads, EMG electrodes, electrode cream)*	Show and tell
4*	Nerve-Muscle (human)	Electromyography, measurement of single motor units and recruitment, the stretch reflex and conduction velocity Independent nerve muscle irritability Threshold voltage Effect of strength *(hand dynamometer)* Effect of frequency *(hand dynamometer)* Neuromuscular fatigue *(hand dynamometer)*	Formal write up, Show and tell
5	Blood (sheep)	Hematocrit Hemoglobin determination RBC, WBC and differential counts WBC identification	Show and tell
6*	Cardiovascular physiology (human)	Heart sounds *(electric stethoscope)* Systolic and diastolic blood pressure Effect of cold/hot on blood pressure Peripheral pulse *(finger pulse transducer)* Effect of increase in abdominal pressure on pulse pressure Electrical axis of the heart	Show and tell
7	Presenting data	How to construct a poster and oral presentation for a scientific meeting	
8*	Cardiac function (frogs)	Normal heart beat *(force transducer)* Refractory period, tetanus of the heart, treppe Starlings law Effect of temperature, drugs on heart rate First, second and third degree heart block All or none law of the heart	Show and tell

9*	Respiration (human)	Normal respiration on chest expansion Effect of hyperventilation in an open and closed system Effect of rebreathing, mental concentration, speech, respiratory pathway blockage, exercise Respiration volume measures TV, IRV, ERV, IC, VC, MVV	Show and tell
10	Osmoregulation (human)	Effect of drinking hypotonic, isotonic and hypertonic solutions on volume, specific gravity, chloride concentration, glucose, blood, pH and protein in urine	Show and tell
11	Metabolism (mice and snakes)	Oxygen consumption in an ectotherm and endotherm Effects of cold and heat on metabolism Concept of the thermoneutral zone	Show and tell
12	Digestion (rats)	Effect of insulin and glucagon on blood glucose concentration Effect of hormone concentration on blood glucose concentration	Show and tell
13	Reproduction (rats)	Effects of PMSG on A. weight of uterus, B. weight of ovaries, C. presence of corpora hemorrhagica. Examination of ovaries for stages of follicular development	Show and tell
14	Student presentations	PowerPoint presentations	Presentations

* Denotes labs using the PowerLab system

Lab assessment	**%**
Hypothesis testing	5
Show and tell presentation	5
Two formal lab reports	40
Laboratory notebook	20
Oral/poster presentation	30

Lab assessment notes

Hypothesis testing: points will be awarded to each student for their performance and participation in hypothesis testing during the first hour of the laboratory discussion. This will count for 5% of the final lab grade.

Show and tell presentations: points will be awarded to each student for their participation and performance in the final 30 minutes of each laboratory. This will count for 5% of the final lab grade.

Formal lab reports: *Two* of the labs will to be written up in proper scientific format (abstract, introduction, materials and methods, results, discussion, references), by each student independently. Each report will count for 20% of the final lab grade (total 40%).

Lab notebook: Students will be expected to share all of the experimental data gathered among groups and write a half page summary for each experiment as part of their lab note book. This will be handed into the professor for grading at the end of the semester and will count for 20% of the final lab grade.

Oral/poster presentation: Each group of students will be required to pick one laboratory topic and the group must give either an oral or poster presentation to the rest of class in the final lab of the semester. Each student within the group must speak. If the group chooses to put together a poster presentation, they must still present their poster to the class and discuss their data to the rest of the class. All presentations must include the following information: the purpose of the experiment, hypothesis, details of the methodology (sufficient that another person could repeat the experiment), the results of the experiment in either tabular or graphical format, the interpretation and the significance of the data. This presentation will count for 30% of the final lab grade. All members of the group will receive the same grade.

FORMATIVE AND SUMMATIVE ASSESSMENT STRATEGIES
BY COURSE AND STUDENT LEARNING OUTCOME

Bio269

OUTCOME #1: Students will learn physiological concepts

FORMATIVE EVALUATIONS

A. Multiple Choice Lab Exam Items

Two laboratory exams, consisting of both multiple-choice and open-ended questions, will be given during each semester. For each exam, we will determine for each student the percentage of items that link laboratory results to physiological concepts that are answered correctly. The average student percentage of correctly answered items will be calculated and compared to the same average percentage obtained during the 2004-05 academic year. We expect to see an increase in the percentage of correctly answered items following implementation of the new laboratory curriculum. We expect that students will correctly answer, on average, 80% of these items.

B. Open-Ended Lab Exam Items

Laboratory exams will also include open-ended questions. One Example Question: Give an example of a type of experiment that you could perform to test the effects of temperature on muscle contraction. For each open-ended question, a scoring rubric will be designed to measure the degree to which each student expresses an understanding of the physiological concept in question. This scoring rubric will be similar to the one described below for Challenge Activities (Outcome #2, Evaluation A). Our goal will be to have 80% of students receiving Acceptable or Proficient ratings on all rubric items by the termination of the project. As evaluations are completed each semester, modifications to laboratory procedures/projects will be considered if this goal is not attained.

SUMMATIVE EVALUATIONS

C. Laboratory Journals

Students will be required to keep laboratory journals that will be collected and evaluated at the end of each semester. Journals will be evaluated using a rubric similar to the following:

Laboratory Journals – grading rubrics

1. Well organized and neat (5 points) ______
2. All experiments are present and scientific interpretation of the results are correct (10 points) ______
3. Questions at the end of each experiment are answered correctly (5 points) ______

Total Points possible: 20 Your score: ______

Points obtained for items #2 and 3 will be used to demonstrate understanding of physiological concepts covered in laboratory exercises.

D. Post Course Assessment Survey I

All students will complete a 17-item survey at the end of each semester to determine the degree to which the course has helped them to achieve each of the three student learning outcomes. Items 1-4 of this survey address learning outcome #1 (knowledge of physiological concepts):

Survey questions (Administered at the end of course)
Please evaluate the course by answering the following questions. This physiology course has taught me how to:

1) better understand physiological systems.

Strongly agree	Agree	Disagree	Strongly disagree

2) interpret how organ systems interact with one another.

Strongly agree	Agree	Disagree	Strongly disagree

3) read and understand scientific literature.

Strongly agree	Agree	Disagree	Strongly disagree

4) know if an organ system is functioning correctly

Strongly agree	Agree	Disagree	Strongly disagree

The overall average number of students who respond with "Strongly Agree" or "Agree" for each of these items will be calculated and will be compared to the average number of "Strongly Agree" or "Agree" responses obtained for the same survey items during the 2004-05 academic year.

OUTCOME #2: Students will develop an understanding of the scientific approach

FORMATIVE EVALUATIONS

A. Inquiry-Based Challenge Activities

As part of each challenge activity (as described in the Detailed Project Plan), students will be presented with a set of questions. Responses to these questions will be evaluated using a standard scoring rubric. Below is a set of instructions for an example challenge activity, along with the questions to be addressed by student groups and the scoring rubric to be used for evaluation purposes.

Effects of temperature on muscle activity: MaMa Yo's dilemma

Introduction: MaMa Yo, the world famous concert violinist, has been invited to play at an outdoor concert in Chicago where the average temperature on that date is 2°C. She is worried about her ability to play under these conditions. Specifically, she is concerned that she will not be able to sustain her hold on the bow. Fortunately, her performance is limited to a portion of a concerto that only lasts for 10 min. Does she have any need to be concerned about playing at this temperature for this short time?

Using the PowerLab EMG equipment, a thermometer, a cold pack, and a stop watch, design an experiment to test the effects of temperature on sustained muscle contraction.

Questions

1) What is your hypothesis? Do you think the low temperature will increase, decrease, or have no effect on the sustained muscle contraction? Why? (2 points)
2) What procedure will you use to test your hypothesis (2 points)?
3) What are your results (2 points)?
4) What conclusions can you draw from your results? (2 points)
5) Was your hypothesis correct? Why or why not? (2 points)

Scoring rubric

Proficient (2) Acceptable (1) Not Acceptable (0)

1) Formulates a testable hypothesis and states a rationale for that hypothesis Score: ________
2) Experiment is well designed and has appropriate controls Score: ________
3) Data is summarized and well-organized Score: ________
4) Data interpretation is consistent with results Score: ________
5) Connects original hypothesis with experimental results Score: ________

Overall scores will be calculated for each student for each challenge. Our goal is to have at least 80% of all challenge activities submitted by students achieve a minimum overall score of 5.

B. Open-Ended Lab Exam Items

For each open-ended exam question (as described above, Outcome 1, Evaluation B), a scoring rubric will be designed to measure the degree to which each student expresses an understanding of the scientific approach. This scoring rubric will be similar to the one described above for Challenge Activities (Outcome #2, Evaluation A). Our goal will be to have 80% of students receiving Acceptable or Proficient ratings on all rubric items by the termination of the project. As evaluations are completed each semester, modifications to laboratory procedures/projects will be considered if this goal is not attained.

SUMMATIVE EVALUATIONS

C. Laboratory Journals

See Outcome 1, Evaluation C for description. Points obtained for item #2 of the scoring rubric will be used to demonstrate understanding of the scientific approach.

D. Post Course Assessment Survey I

Items 5-13 of this 17-item survey address learning outcome #2 (understanding of the scientific approach):

Survey questions (Administered at the end of course)
Please evaluate the course by answering the following questions. This physiology course has taught me how to:

5) design an experiment and make predictions.
Strongly agree Agree Disagree Strongly disagree

6) summarize scientific findings.
Strongly agree Agree Disagree Strongly disagree

7) outline scientific problems.
Strongly agree Agree Disagree Strongly disagree

8) summarize scientific findings.
Strongly agree Agree Disagree Strongly disagree

9) graph and tabulate the results of scientific experiments
Strongly agree Agree Disagree Strongly disagree

10) explain and interpret scientific findings.

Strongly agree | Agree | Disagree | Strongly disagree

11) make predictions about what future experiments should be entail based upon data obtained from completed experiments

Strongly agree | Agree | Disagree | Strongly disagree

12) work cooperatively in teams.

Strongly agree | Agree | Disagree | Strongly disagree

13) use computers to acquire and analyze data from experiments.

Strongly agree | Agree | Disagree | Strongly disagree

The overall average number of students who respond with “Strongly Agree” or “Agree” for each of these items will be calculated and will be compared to the average number of “Strongly Agree” or “Agree” responses obtained for the same survey items during the 2004-05 academic year.

E. Pre and Post Course Survey

A 10-item survey will be administered to all students at the beginning and end of the course to assess students’ perceived familiarity with the scientific approach and perceptions of the degree to which they are confident of their ability to apply the scientific approach to real-life issues and problems. Items 1-9 of this survey address learning outcome #2 (understanding of the scientific process):

Survey Questions

Please evaluate your familiarity with the following **scientific processes**:

1) understanding science as a process through which scientists learn new information.

Strongly confident | Somewhat confident | Neutral | Somewhat unfamiliar | Completely unfamiliar

2) how to formulate questions and hypotheses.

Strongly confident | Somewhat confident | Neutral | Somewhat unfamiliar | Completely unfamiliar

3) how to design an experiment and make predictions.

Strongly confident | Somewhat confident | Neutral | Somewhat unfamiliar | Completely unfamiliar

4) how to analyze data collected from an experiment.

Strongly confident | Somewhat confident | Neutral | Somewhat unfamiliar | Completely unfamiliar

5) how to communicate your observations orally.

Strongly confident | Somewhat confident | Neutral | Somewhat unfamiliar | Completely unfamiliar

6) how to communicate your observations in writing.

Strongly confident | Somewhat confident | Neutral | Somewhat unfamiliar | Completely unfamiliar

7) how to work cooperatively in teams.

Strongly confident | Somewhat confident | Neutral | Somewhat unfamiliar | Completely unfamiliar

8) how to read and understand scientific literature.

Strongly | Somewhat | Neutral | Somewhat | Completely confident confident unfamiliar unfamiliar

9) how to use computers to acquire and analyze data from experiments.

Strongly confident | Somewhat confident | Neutral | Somewhat unfamiliar | Completely unfamiliar

The number of students responding with "Strongly Confident" or "Somewhat Confident" to each item will be calculated at the beginning and at the end of the course. We expect to find a significant increase in the number of Confident responses to each item. In addition, overall Confidence scores will be calculated for each student at each time point (with all "Strongly Confident" ratings receiving a score of 5 and all "Completely Unfamiliar" ratings receiving a score of 0). Difference scores will be then be calculated for each student. We expect that difference scores, overall, will be positive (suggesting greater levels of confidence among students).

F. Post Course Assessment Survey with Exercises

An additional survey will be administered to students at the end of each semester. This survey consists of 5 likert-scale items designed to obtain information about students' perceptions of the degree to which the course emphasized critical and creative thinking (Outcome #3) and a set of exercises designed to test the students' ability to reason scientifically by presenting them graphical and tabular data. With regard to Student Learning Outcome #2 (understanding of the scientific process), only the exercises will be used for assessment purposes.

Example Exercise:

Problem in respiratory physiology

In a study performed in 1947, Dripps and Comroe (AJP 149:277) investigated the effects of brief periods of hypoxemia on pulmonary ventilation. The purpose of the study was to explore the stimulatory effect of oxygen deprivation on respiratory rate and depth. The table below summarizes some of the results of the study.

Concentration of oxygen in inspired air (%)	Tidal volume (ml)	Frequency (Breaths/min)
20.93	500	14
18.0	500	14
16.0	536	14
12.0	536	14
10.0	593	14
8.0	812	16
4.2	933	30

1. Based on the results for this study the investigators would conclude that
   a. Decreasing the % oxygen from 21% to 18% in inspired air has a profound effect on respiratory depth.
   b. Decreasing the % oxygen from 21% to 10% in inspired air has a profound effect on respiratory rate.
   c. Decreasing the % oxygen from 10% to 4.2% in inspired air has a profound effect on respiratory rate.
   d. All of the above are true

2. A major conclusion from this experiment would be that
   a. Oxygen is a powerful stimulant for respiratory rate and depth.
   b. Oxygen is not a powerful stimulant for respiratory rate and depth.

Responses to the first multiple choice question listed above will be used to assess understanding of the scientific process.

OUTCOME #3: Students will engage in creative and critical thinking

FORMATIVE EVALUATIONS

A. Open-Ended Lab Exam Items

For each open-ended exam question (as described above, Outcome 1, Evaluation B), a scoring rubric will be designed to measure the degree to which each student exhibits creative and/or critical thinking. This scoring rubric will be similar to the one described above for Challenge Activities (Outcome #2, Evaluation A). Our goal will be to have 80% of students receiving Acceptable or Proficient ratings on all rubric items by the termination of the project. As evaluations are completed each semester, modifications to laboratory procedures/projects will be considered if this goal is not attained.

SUMMATIVE EVALUATIONS

B. Laboratory Journals

See Outcome 1, Evaluation C for description. Additional items will be developed for the scoring rubric and points obtained for those items will be used to determine if students exhibit creative and/or critical thinking.

D. Post Course Assessment Survey I

Items 14-17 of this 17-item survey address learning outcome #3 (creative and critical thinking):

Survey questions (Administered at the end of course)
Please evaluate the course by answering the following questions. This physiology course has taught me how to:

14) analyze scientific data.

Strongly agree	Agree	Disagree	Strongly disagree

15) communicate my scientific ideas to others orally.

Strongly agree	Agree	Disagree	Strongly disagree

16) communicate my scientific ideas to others in writing.

Strongly agree	Agree	Disagree	Strongly disagree

17) formulate a hypothesis.

Strongly agree	Agree	Disagree	Strongly disagree

The overall average number of students who respond with “Strongly Agree” or “Agree” for each of these items will be calculated and will be compared to the average number of “Strongly Agree” or “Agree” responses obtained for the same survey items during the 2004-05 academic year.

E. Pre and Post Course Survey

Item 10 of this survey (described above in Outcome 2, Evaluation E) addresses learning outcome #3 (creative and critical thinking):

Survey Questions

Please evaluate your familiarity with the following **scientific processes**:

10) understanding science as a process through which scientists learn new information.

Strongly confident	Somewhat confident	Neutral	Somewhat unfamiliar	Completely unfamiliar

The number of students responding with "Strongly Confident" or "Somewhat Confident" to this item will be calculated at the beginning and at the end of the course. We expect to find a significant increase in the number of Confident responses to this item. In addition, overall Confidence scores will be calculated for each student at each time point (with all "Strongly Confident" ratings receiving a score of 5 and all "Completely Unfamiliar" ratings receiving a score of 0. Difference scores will be then be calculated for each student. We expect that difference scores, overall, will be positive (suggesting greater levels of confidence among students).

F. Post Course Assessment Survey with Exercises

This additional survey consists of 5 likert-scale items designed to obtain information about students' perceptions of the degree to which the course emphasized critical and creative thinking (Outcome #3) and a set of exercises designed to test the students' ability to reason scientifically by presenting them with graphical and tabular data. An example exercise is described above (Outcome 2, Evaluation F). Likert-items are listed below.

To what extent has this course emphasized the following **mental activities**?

1) Memorizing facts, ideas, or methods so that you can repeat them in pretty much the same form
   Very much — quite a bit — some — very little
2) Formulating hypotheses to find answers to problems.
   Very much — quite a bit — some — very little
3) Synthesizing and organizing ideas, information, or experiences into new, more complex interpretations and relationships.
   Very much — quite a bit — some — very little
4) Making judgments about the value of information or methods and assessing the soundness of conclusions.
   Very much — quite a bit — some — very little
5) Applying theories or concepts to practical problems or in new situations.
   Very much — quite a bit — some — very little

The number of students responding with "Very Much" or "Quite a Bit" to each of these items will be calculated to determine students' perceptions of the degree to which the course emphasized creative and critical thinking (with "Very Much" ratings receiving a score of 4 and "Very Little" responses receiving a score of 1; responses to item 1 will be reverse coded). An overall score will also be calculated for each student, with possible scores ranging from 5 to 20. We expect that at least 75% of all students will have an overall score of 15 or higher.

With regard to the Exercises included with this survey, responses to the second multiple choice question listed above (Outcome 2, Evaluation F) will be used to assess creative and/or critical thinking.

Bio 468 and Bio 469

Outcome #1: Students will learn physiological concepts

FORMATIVE EVALUATIONS

A. Show and Tell Presentations

In the new laboratory curriculum, students will spend the final 30 minutes of each laboratory session engaged in a "show and tell" session where one or two students from each group will explain the results of their experiment and will interpret their data for the rest of the class. Each show and tell presentation will be evaluated using the following scoring rubric:

Each category is worth 1 point each.

1. Style: Clear voice, understandable dialog ______
2. Introduction: Background material is sufficient to understand why the experiment was undertaken. There was a logical progression of scientific facts and hypothesis ______
3. Methods: Clear, concise and repeatable experiments. The sample size is adequate ______
4. Results: Graphs were fully labeled and trends in the data were evident ______
5. Discussion: The experiment(s) addressed the question(s) posed ______

Total Points possible: 5 Your score: ______

Scores for Categories #2 and #5 will be used to determine if students understand the physiological concepts under investigation.

B. Lab Reports

Regular laboratory reports will be required of all students. Each lab report will be graded using the following scoring rubric:

1. Abstract (4 points)
- A statement on what was done ______
- A statement or two on what methodology was used ______
- Main results were outlined ______
- The significance of the data were mentioned ______

2. Introduction (4 points)
- Adequate background information to introduce each experiment was provided ______
- A statement of purpose was included ______

3. Materials and Methods (4 points)
- This section was written clearly and concisely ______
- There was enough detail for others to repeat the experiment ______
- No unnecessary information was provided ______

4. Results (4 points)
- Tables and figures were legible ______
- Tables and figures were used appropriately ______
- Text accompanied and summarized data in table or figures ______

5. Discussion (4 points)
- A brief summary of key results was presented ______
- Experiments were discussed in the order they appeared in the results ______
- Results of each experiment were related back to information provided in the introduction ______
- The success of your experimental design and directions of future studies were discussed ______

Total Points possible: 20 Your score: ______

Points awarded for pieces of Sections 1, 2, and 5 will be used to determine the degree to which students understand the physiological concepts addressed in each laboratory assignment.

SUMMATIVE EVALUATIONS

C. Oral/Poster Presentations

At the end of the semester, each student will present to the class the results of one of the physiology experiments they conducted during the semester. Each student will talk for 7 minutes with an additional 3 minutes for questions. Students will the have the option of using the poster or oral presentation formats. Each presentation will be evaluated using the following scoring rubric:

1. Style (3 points)
- Clear and audible voice ______
- Grammar and spelling are correct ______
- Slide/poster presentation well organized ______

2. Abstract (4 points)
- A statement on what was done ______
- A statement or two on what methodology was used ______
- Main results were outlined ______
- The significance of the data were mentioned ______

3. Introduction (4 points)
- Adequate background information to introduce each experiment was provided ______
- A statement of purpose was included ______

4. Materials and Methods (4 points)
- There was enough detail for others to repeat the experiment ______
- No unnecessary information was provided ______

5. Results (4 points)
- Tables and figures were legible ______
- Tables and figures were used appropriately ______
- Text accompanied and summarized data in table or figures ______

6. Discussion (4 points)
- A brief summary of key results was presented ______

- Experiments were discussed in the order they appeared in the results ______
- Results of each experiment were related back to information provided in the introduction ______
- The success of your experimental design and directions of future studies were discussed ______

Total Points possible: 23 Your score: ______

Points awarded for pieces of Sections 2, 3, and 6 will be used to determine the degree to which students understand the physiological concepts addressed in each laboratory assignment.

D. Lab Notebook

At the end of the semester, all students will submit their laboratory notebooks, which should contain all laboratory and experimental notes as well as answers to specific questions posed at the end of each experiment. All notebooks will be evaluated using the following scoring rubric:

1. Well organized and neat (5 points) ______
2. All experiments are present and scientific interpretation of the results are correct (10 points) ______
3. Questions at the end of each experiment are answered correctly (5 points) ______

Total Points possible: 20 Your score: ______

Points awarded for items 2 and 3 will be used to determine the degree to which students understand the physiological concepts addressed during the semester.

E. Problem-Based Exercise

At the end of the semester, students will be asked to complete a problem-based exercise, similar to the one described below. This exercise is designed to test the student's ability to reason scientifically and tests attainment of each of the three student learning outcomes outlined in this proposal. Outcome #1 is addressed by question #2 below.

Investigation into the effects of a neuromuscular poison.

Introduction

A group of students were asked to investigate the effects of the neuromuscular poison tubocurare on the isolated gastrocnemius muscle of a frog. Students were told that the poison is a neuromuscular blocker. The students hypothesized that if they artificially stimulated the muscle with electricity the muscle would not react after a short while. They further hypothesized that drug would need time to take effect but did not know how long that time period would be.

To investigate how long it took the drug to take effect, the following experimental protocol was designed.

Methods

A gastrocnemius muscle, the Achilles tendon, femur bone and the sciatic nerve were dissected from a frog and arranged such that the force of muscle contraction could be recorded by the physiograph. An electrical stimulator was placed on the sciatic nerve. 0.1 ml of the drug was injected into the belly of the muscle at time 0. An electrical current of varying intensity was given to the muscle at regular intervals (every 30 sec.) and the force of contraction recorded. The table below shows the amount of force generated by a given amount of current.

Results

Time (30 second intervals)	Stimulus given every 30 sec. (volts)	Force of contraction (mm deflection)
1	1	10
2	1	10
3	1	8
4	1	3
5	1	0
6	5	15
7	5	5
8	10	1
9	20	1
10	50	0
11	100	0

Questions

1. Draw a graph showing the effects on muscle contraction as a function of stimulus voltage.
2. From the graph you have drawn: How long did it take for the drug to begin to take effect? At what time period did the most noticeable change in the effect of the drug take place? Was anesthesia effectively achieved?
3. What factors/experiments might you undertake if you wish to see that the drug could be used and approved for human trials from the FDA?

The number of correct answers to the three issues posed by question #2 will be used to determine if students have learned the physiological concepts necessary for this exercise.

F. Post Course Assessment Survey I

All students will complete a 17-item survey at the end of each semester to determine the degree to which the course has helped them to achieve each of the three student learning outcomes. As described above (Bio 269, Outcome 1, Evaluation D), items 1-4 of this survey address learning outcome #1 (knowledge of physiological concepts).

The overall average number of students who respond with "Strongly Agree" or "Agree" for each of these items will be calculated and will be compared to the average number of "Strongly Agree" or "Agree" responses obtained for the same survey items during the 2004-05 academic year.

<u>OUTCOME #2: Students will develop an understanding of the scientific approach</u>

FORMATIVE EVALUATIONS

A. Hypothesis Testing

Various laboratory materials (lab reports, lab notebooks, etc.) will be evaluated for students' ability to engage in the hypothesis testing process. Each student item will be evaluated using the following scoring rubric:

There is evidence that a question has been asked (2 points)	______
The hypothesis can be tested with the equipment provided (1 point)	______
The hypothesis can be tested within the time provided (1 point)	______
There is a null hypothesis (1 point)	______
Total Points possible: 5 Your score:	______

Expectations regarding the scores of students on this evaluation are yet to be developed.

B. Show and Tell Presentations

Each show and tell presentation will be evaluated using a standard scoring rubric (presentation and rubric are both described above in Outcome 1, Evaluation A). Scores for Categories 2, 3, 4, and 5 will be used to determine the degree to which students understand the scientific approach.

B. Lab Reports

All lab reports will be evaluated using a standard scoring rubric (described above in Outcome 1, Evaluation B). Points awarded for pieces of all 5 sections will be used to determine the degree to which students understand the scientific process.

SUMMATIVE EVALUATIONS

D. Oral/Poster Presentations

End of the semester student presentations will be evaluated using a standard scoring rubric (described above in Outcome 1, Evaluation C). Points awarded for pieces of all 6 sections will be used to determine the degree to which students understand the scientific process.

E. Problem-Based Exercise

Outcome #2 is addressed by questions #1 and #2 of the Problem-based Exercise (described above, Outcome 1, Evaluation E). A new scoring rubric will be developed to evaluate responses to question #1. The number of correct answers to the three issues posed by question #2 will be used to determine if students have developed an understanding of the scientific process.

F. Post Course Assessment Survey I

All students will complete a 17-item survey at the end of each semester to determine the degree to which the course has helped them to achieve each of the three student learning outcomes. As described above (Bio 269, Outcome 1, Evaluation D), items 5-13 of this survey address learning outcome #2 (understanding the scientific approach).

The overall average number of students who respond with “Strongly Agree” or “Agree” for each of these items will be calculated and will be compared to the average number of “Strongly Agree” or “Agree” responses obtained for the same survey items during the 2004-05 academic year.

OUTCOME #3: Students will engage in creative and critical thinking

FORMATIVE EVALUATIONS

A. Show and Tell Presentations

Each show and tell presentation will be evaluated using a standard scoring rubric (presentation and rubric are both described above in Outcome 1, Evaluation A). Scores for Categories 2 and 5 will be used to determine the degree to which students engage in creative and/or critical thinking.

B. Lab Reports

All lab reports will be evaluated using a standard scoring rubric (described above in Outcome 1, Evaluation B). Points awarded for pieces of sections 1, 2, and 5 will be used to determine the degree to which students engage in creative and/or critical thinking.

SUMMATIVE EVALUATIONS

C. Oral/Poster Presentations

End of the semester student presentations will be evaluated using a standard scoring rubric (described above in Outcome 1, Evaluation C). Points awarded for pieces of sections 2, 3, and 6 will be used to determine the degree to which students engage in creative and/or critical thinking.

D. Lab Notebook

At the end of the semester, all students will submit their laboratory notebooks, which should contain all laboratory and experimental notes as well as answers to specific questions posed at the end of each experiment. All notebooks will be evaluated using a standard scoring rubric (described above in Outcome 1, Evaluation D). Points awarded for item 2 will be used to determine the degree to which students engage in creative and/or critical thinking.

E. Problem-Based Exercise

Outcome #3 is addressed by question #3 of the Problem-based Exercise (described above, Outcome 1, Evaluation E). A new scoring rubric will be developed to evaluate responses to this question with regard to students' use of creative and/or critical thinking.

F. Post Course Assessment Survey I

All students will complete a 17-item survey at the end of each semester to determine the degree to which the course has helped them to achieve each of the three student learning outcomes. As described above (Bio 269, Outcome 1, Evaluation D), items 14-17 of this survey address learning outcome #3 (creative and critical thinking).

The overall average number of students who respond with "Strongly Agree" or "Agree" for each of these items will be calculated and will be compared to the average number of "Strongly Agree" or "Agree" responses obtained for the same survey items during the 2004-05 academic year.