New Courses Under Development for the 2006 HHMI Grant

1. <u>Introduction to Interdisciplinary Science (a "Freshman Seminar")</u>: A continuing challenge is the retention in science of students from under-represented groups and disadvantaged backgrounds. Many enter with weak science preparation and poor study methods, and then find large freshmen science courses particularly challenging. We will develop a small freshman course, "Introduction to Interdisciplinary Science", that will reinforce basic science concepts by addressing interdisciplinary topics in a small and highly interactive setting. The course will fit seamlessly into College requirements as a 'Freshman Seminar'(maximum enrollment 15 per section), given that one is required for all freshmen. Case-studies will address interdisciplinary topics (e.g., drug delivery, toxicity and remediation, global warming, evolution of disease, prosthetic devices, and atmospheric particulates). Each case will require review and comprehension of basic biology, chemistry, and physics with an interdisciplinary and applied, biomedical science focus. "Drug Delivery," for example, would review the different kinds of chemical bonds, the chemistry of water, diffusion and transport (to and into cells), basic polymer chemistry, gels and phase transitions, and the physics of slow-release materials. Students will be trained in effective, efficient science learning techniques, including concept mapping, metacognition for understanding, 'minute sketching' for recall, the folded-list diagram-word tool, and science problem analysis. Class time will focus on exercises for investigation and self-learning. Spots will be advertised and guaranteed for every student from a disadvantaged or underrepresented group or the PLUS and Gateway programs (W&M programs designed for students from disadvantaged backgrounds). Spaces will be available for other students as well; any interested student would certainly benefit from this class. Perhaps most importantly, enrollment in this course would guarantee that students from disadvantaged backgrounds have ready access to a caring faculty member during that first, difficult semester when attrition is steep; the instructor in this course will serve as their advocate, mentor, and advisor and be ready to assist the student with appropriate intervention—arranging tutoring, appointments at the study skills or writing center—when the window of opportunity for addressing the problem is still open. Our expected outcome is measurable and clear: retention of increased numbers of students from disadvantaged backgrounds who major in science and who ultimately pursue science careers. Assessment will involve tracking of students in this course compared to a control group in terms of performance in their freshman seminar, subsequent course selection, choice of major and career plans. Qualitative assessment from the participants will allow for continual improvement of the course.

2. <u>Interdisciplinary Introductory Laboratory Course</u>.. A considerable amount of well deserved attention has been focused on re-invigorating science courses and laboratories directed toward science majors. However, non-majors courses, and especially laboratories which are time- and resource intensive, are often neglected, a situation detrimental to society's need for a more scientifically literate populace. Even the better quality non-majors courses often address science too narrowly, making it difficult for non-majors to generalize from a biology class to other science fields. We propose a new cross-disciplinary laboratory course for non-science majors that would (1) provide scientific knowledge crossing disciplinary boundaries, (2) instill an appreciation for the nature of scientific investigation, and (3) teach basic tools needed to critically analyze scientifically-based issues. The envisioned topics are: (1) an evolution and paleontology exercise examining local fossils and linking the data to current phylogenies using bioinformatics tools, (2) a biophysics-kinesiology-exercise physiology laboratory investigating the mechanical and cellular parameters in different muscle tissues, (3) a biochemistry of “fat” laboratory investigating the content and effects of different types of lipids of various foods and (4) an environmental toxicology laboratory examining effects of a specific compound on the (local) Matoaka watershed. Each exercise will extend over three to four weeks and will stress critical thinking in posing the right questions, experimental design, data analysis, and formation of valid and warranted conclusions. Two sections of twenty students each are initially planned. This lab will fulfill the science laboratory requirement for non- majors and will be administered through Interdisciplinary Studies, which administers six other very successful interdisciplinary degree programs including Neuroscience. Our anticipated outcome is that students who take this new lab will be more engaged, knowledgeable, and analytical with respect to contemporary scientific issues, with an increased ability to locate and analyze information on a given topic. Assessment will include: standard course evaluation sheets; student self-assessment by analyzing a newspaper article on a contemporary scientific issue at the outset of the course and then revisiting their analysis at the conclusion of the course; tracking students’ subsequent coursework; and a student retrospective on the impact of the course submitted in their senior year.

3. Upper Level Undergraduate Course: Networks in Biological and Physical Sciences. This course will examine an important new area in contemporary science, namely network theory, in particular the principles that give rise to order and structure from interacting elements (e.g. metabolic networks in single cells, and the organization of brain circuits). This class will employ tools from applied mathematics to explore how the functional properties of biological and physical systems are explained by the structure of their underlying networks. Team-taught by four faculty members from different departments including mathematics, biology, applied science, and chemistry, each instructor would present topics from their respective disciplines that depend on network structure and function. The class will employ simulation and modeling tools freely available via the StarLogo software program (education.mit.edu/starlogo/) which can be used to model a vast array of chemical, biological, and physical systems. Class lectures would be devoted to learning field-specific information, background, and principles. Students would then construct model systems and simulate and analyze them in multi-media equipped classrooms. Topics will include: gene regulatory networks; neural networks; ecosystem population dynamics; and oscillatory chemical reactions. This course will provide students with critical training in systems and computational biology, which is at the vanguard of contemporary research in biomedicine.

4. Upper Level Undergraduate Course: Biomaterial Characterization. . The purpose of this course is to introduce advanced undergraduate students to the broad and very interdisciplinary question of how biomaterials could be analyzed and characterized at the molecular level. The focus will be on the Biological Applications of Nuclear Magnetic Resonance, providing students with hands-on experience with ultra high field instrumentation (ultra high field 17.6 tesla solid-state NMR spectrometer) that is newly available at the College of William and Mary. The course will cover: Basic NMR theory; spin relaxation and molecular motion; multidimensional NMR; case studies of protein conformation in solution and crystalline forms, molecular recognition and internal motion in nucleic acids, ion transport dynamics in cell membranes, substrate binding and active site dynamics in enzymes. Lectures would be supplemented by weekly three hour laboratory sessions in which students would obtain and interpret spectra relating to the case studies outlined above. The course will also include modules on X-ray diffraction and mass spectrometry.

5. <u>Upper Level Undergraduate Course: Medical Image Computing</u>.

The goal of this class is to address research problems in medical image analysis and modeling using physics based models. It will focus on mesh generation methods for deformable models in image guided therapy, specifically, becoming familiar with technologies and challenges for parallel mesh generation methods which are applicable to critical decision-making in the operating room. This will be a problem-driven class in which we will use neurosurgery as an example. Topics will include: software for medical image computing; approximation and least square method for discrete data; distance mapping and transformations and overview of algorithms; mesh generation for medical image computing; guided neurosurgery; parallel computing, and data decomposition. An integral aspect of the course will be student projects using actual data obtained from the instructor and his collaborators at Harvard Medical School and Eastern Virginia Medical School.

The expected outcomes from the implementation of the upper level courses are a willingness to take other interdisciplinary courses, to pursue independent lab projects in these areas, and ultimately to undertake post-graduate programs in cross-disciplinary areas. The success of these outcomes will be assessed by tracking participants' course selection, participation in undergraduate research, and post-graduation activities, as well as the overall effectiveness of the course laboratory experience.