THE ACS REFORM OF INTRODUCTORY SCIENCE COURSES

FOR

NON-SCIENCE MAJORS PROGRAM (ACS)

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The Impact of Highway Traffic on Atmospheric Chemistry and Biological Processes:

A New "Lab" Science Course for Non-Science Majors at Washington & Lee University.

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Summary

Funds sought by this proposal will be used to develop a field course to study the impact of local highways on both atmospheric composition and plant health as a function of distance and elevation relative to a major highway (Interstate 81 or "I-81"). This course has been designed to involve both science majors and non-science majors and will have lecture, laboratory, and field components. This course will be offered for the first time in the Spring term of 2006, will initially involve 20-30 students, and will be a major addition to the science component of the environmental studies curriculum at W&L. Introduction of this course at Washington & Lee University is timely in that there is a proposed major expansion of I-81 and no known air quality or environmental impact study. In addition, and of particular relevance to this project, the authors know of no air quality monitoring in the Shenandoah Valley within 60 miles of W&L. For the field studies, the proposed class will be divided into groups of four students, each of which being responsible for collecting and analyzing data from chosen locations at different elevations and proximity to I-81. Ultimately, all groups will combine the data and arrive at a class summary of their observations. In addition to posting it on a Web page, the class will submit their final summary report and any additional comments to the appropriate state agencies that are considering the highway expansion. Students will also be encouraged to inform both state and local government officials regarding their results.

Hamilton and Tuchler have successfully team taught in the past, have discussed the proposed course in detail, and have research expertise that compliment the atmospheric and biosphere impacts to be studied by the students in the proposed course.

Project Description

Introduction

Atmospheric science and its interface with the biosphere has increasingly been the subject of research in fields as varied as chemistry, biology, geology, and medicine (IGAC). Beyond interest in the anthropogenic impacts on global climate, scientists are interested in local impacts of atmospheric composition on plant health and diversity and human health (IPCC-a, IPCC-b). In particular, micro-atmospheres are increasingly studied and modeled in both mega-cities and in smaller, rural communities. Much of this research is focused on the formation of, composition of, and diurnal variations of coarse aerosols (10-2.5 μm) and fine aerosols (2.5 μm or smaller), both of which are implicated in respiratory and cardiovascular effects in humans. In general, particulate matter (PM) is composed of liquid and solid particles that are suspended in the air and are subject to variation in transport as a function of wind, temperature, elevation and time of day. PM is both naturally occurring and a result of human activities. The major sources of PM are cars, trucks, wood burning, and coal-fired power plants. In Rockbridge County, however, the major source of PM is the car and truck activity on I-81, which cuts a path through the Shenandoah valley and lies 3 miles east of the campus of W&L. The geography of the surrounding Lexington is such that the aerosols that are created on I-81 get stuck in the valley and end up in our gardens, our streams, and our forested lands. This is relevant to the W&L students, many of whom regularly enjoy outdoor activities such as hiking, biking, climbing, canoeing, fishing, etc. Also, many of the students live off-campus, either near one of the two James River tributaries (Maury River and Buffalo Creek) that pass through Rockbridge County or in the wooded land upon which these PM created on

I-81 fall. Thus the impact of this PM is not isolated to the science majors of our community. Therefore exploring the impacts of these aerosols on the environment is ideal for a new course for non-scientists and scientists alike.

This proposal utilizes the expertise of an experimental atmospheric chemist (Tuchler) and an experimental environmental biologist (Hamilton) in a new course at W&L designed to improve the science literacy among non-science majors in an area of great societal importance. The course is also designed to allow science and non-science majors to exchange information and educate each-other in a way that is becoming more important as environmental policy decisions need to be addressed.

Goals

The three fundamental goals of this proposal are:

1) to provide non-science majors a science vocabulary and understanding of science methodology through both "active" (field research) and classroom learning as they address an important topic that is familiar to them and has significant implications for public policy;
2) to create a setting in which active, informed discussion can occur between scientists and non-scientists about a common, important issues affecting the community;
3) and to expose students to the inter-relationships among different disciplines of science and the importance of this relationship for addressing problems of societal importance.

Achieving these goals for the student will depend upon close student-student and student-faculty contact, both types of which will be regularly encouraged. Also, the visible collaboration between two traditional science fields, as represented by Hamilton and Tuchler and the materials to be used by the students, will inspire the students to think outside the box of the traditional disciplines. All of the stated goals are consistent with the Environmental Studies program at W&L, the Chemistry department and the Biology department. The proposed course will add a much needed science component to the environmental studies program and will provide a needed lab-based course for non-scientists.

Background and Significance

Over the past 50 years, interstate highways have replaced train tracks to provide the major artery of commerce and travel. In addition, these arteries deliver significant and concentrated pollutants such as lead, zinc, iron, chromium, cadmium, nickel, copper, hydrocarbons, carbon monoxide, nitrogen oxides, and sulfur oxides. When released to the atmosphere, these pollutants may remain as gases to be washed out, or they can "condense" to form small, suspended aerosols that are themselves transported into the surrounding environment. Of particular interest to the proposed course is the particulate matter (PM), i.e., aerosols, which are of significance to both human health and plant ecology in the region surrounding the highway via runoff or atmospheric transport followed by direct deposition.

As there is no current effort associated with W&L nor with any known organization in the south-central valley to measure, evaluate, or monitor the impact of

PM on the region, the proposed course will have an immediate impact on the University and the surrounding community. The proposed course is ideally suited to educate the non-scientist about how a scientist might approach the socially and societally important questions regarding human impact on the environment. Similarly, this course provides the opportunity for the science student to engage non-scientists on a common issue so that they can learn about how a non-scientist would approach the problem. Both the science and non-science majors will learn about the difference in emphasis and importance that arises from a different background – we claim that this is a significant and unique result of the proposed course.

Description of Student Course Experience:

This course will be offered as a full course load in the spring term at W&L, i.e., students in the class will take no other class that term. The course will fulfill a general education requirement and is designed with the non-science major in mind. Both Hamilton and Tuchler have taught non-major courses.

The proposed course will consist of classroom lectures by Hamilton and Tuchler, an occasional visiting speaker from the Economics Department at W&L or from the Law School at W&L, and both a laboratory component and a field component (described in the next section). The classroom lecture will occupy at least 4 hours per week and the laboratory and field parts will occupy at least 8 hours per week.

Tuchler's classroom lectures will cover an introduction to global atmospheric composition, atmospheric modeling, atmospheric transport, and particulate formation and composition. Hamilton's classroom lectures will include an introduction to

photosynthesis, nutrient uptake, soil microbial processes, stress responses of organisms, and ecosystem function.

An extension of the classroom component associated with the class will be a student run "Journal Club". This club will meet once a week for one hour. At each meeting several members of the class will be responsible for presenting an article or perspective in a leading research journal (e.g., Science, Nature) that they have identified and which is relevant to the course. Peer evaluation and teacher feedback will be provided to the student by the instructors. This club is seen as an opportunity for the non-science student to extend the knowledge that they have accumulated in the course, thus giving them a confidence and independence for addressing issues involving science in the future.

Description of Proposed Field and Laboratory Activities

The students will be divided into several groups to perform the field work and laboratory work. Following an introduction to the equipment and to various data analysis techniques, the groups of student will run all field measurements independently. They will be responsible for calibrating all of their measurements so that comparisons between the results of different groups may be made. Within each group responsibilities will be rotated so that all students gain experience with each technique. Field work will be conducted in two phases, which are briefly summarized below.

The first phase involves PM monitoring at sites whose location will be determined by instructors. This initial monitoring will involve pair-wise sampling and will serve as a survey. Monitoring sites will be located at the overpasses of the two local James River

tributaries along I-81, in rural locations on both sides of the highway, and at various elevations on the Blue Ridge Mountains. The amount of aerosols of different sizes in the atmosphere will be quantified in real time using the requested DUSTTRAK Aerosol Monitors (TSI, Shoreview, MN; Budget Item 3). These monitors will be calibrated to standards so that they may be compared with results from the SHENAIR project. Identification of the aerosol chemical composition will be determined by air-pump sampling/collecting all aerosols onto filters (SKC Inc., Eighty Four, PA; Budget Item 6). The filters will be combusted in an ashing furnace (Budget Items 1 and 2), extracted using standard techniques, and analyzed for metals by ICP spectrophotometry which is available at W&L in the geology department. During sampling at each site, wind speed and direction, temperature, solar radiation, and relative humidity will be monitored (Onset Computers, Bourne, MA; Budget Item 4). These variables are important for developing patterns of particulate deposition and creating a model of transport patterns.

The sites for the second phase of sampling will be determined by the students and will be based on the results of the first phase of monitoring. Extensive sampling will be performed at these second phase sites, with the addition of quantifying daily cycles of aerosols. Furthermore, the gaseous components at these sites will be quantified using diffusion tubes that quantify nitrogen oxides, sulfur oxides, and carbon monoxide (SKC Inc., Eighty Four, PA; Budget Item 6). Leaf and soil samples will be collected and analyzed for metal content using the same methods as the air sampling filters.

Any additional equipment or supplies that may be required for the proposed course are standard in the stockrooms of the biology or chemistry departments and are thus readily available.

Requested Budget

	Item	Price	Quantity	Total
1	Ashing Furnace	$2,500.00	1	$2,500.00
2	Crucibles for Ashing	$15.00	20	$300.00
3	TSI DUSTTRAK Aerosol Monitor Model 8520	$4,500.00	3	$13,500.00
4	Portable Weather Stations	$1,200.00	2	$2,400.00
5	Diffusion Tubes (NOx, SOx)	$9.00	130	$1,170.00
6	Filter Cassettes for Particulate Analysis	$60.00	2	$120.00
				$19,990.00

The requested budget will provide the funds necessary to provide equipment materials that are required for the course. The specifics pertaining their application are contained in the "Description of Proposed Field and Laboratory Activities" section above.

Timeline

The proposed course will be offered in the spring term of the 2005-2006 academic year. Purchasing a testing of all proposed equipment will begin immediately upon receipt of the grant. This testing will involve students in a way that will allow the course instructors to identify challenges in uses. The testing will begin in the winter term, 2006, allowing the instructors plenty of time to evaluate the field guides and usage instructions that will be provided the various groups in the spring term. Following the Spring term, evaluation by the students of the various aspects of the course will be collected and modifications, if necessary, will be made. These modification will be made by the instructors during the summer of 2006. Any modifications to equipment operation will be tested with students during either the summer or the fall term of the 2006-2007 academic year.

Impact on Washington & Lee University

The proposed course is ideal for W&L as its seeks to broaden the local reach and impact of environmental studies program by including field science courses in the Shenandoah valley. The proposed course would also serve to fill a general education requirement in laboratory science. In order to optimize the impact on W&L, additional development of the labs will be pursued over the summer of 2006, as will a review of all course material.

Evidence of Institutional support

The support of both the Biology and Chemistry departments for developing this interdisciplinary course and their willingness to commit significant faculty and material resources to this course indicates the seriousness of the institution to developing science courses for non-scientists and increasing science literacy on our campus.

Evaluation and Dissemination:

The course will have a website associated with and available to the public. On the website will be a complete description of the course, a lecture syllabus, and a description of the field study. Finally, the data collected and the students conclusions based on that data will be published on a separate page, hyperlinked to the main page. This data will be presented as a summary of all the groups data. Together, the students will arrive at a summary of their observations and a statement of any conclusions or recommendations.

The class will submit their final report and any additional comments to the appropriate state agencies that are considering the highway expansion. Students will also be encouraged to inform both state and local government officials regarding their results.

Literature Cited

Associated Colleges of the South (ACS) Phase II Proposal for the W.M. Keck Foundation. Focusing on the Reform of Science Education for Non-Science Majors. March, 2003.

International Global Atmospheric Chemistry Project of the International Geosphere-Biosphere Programme (IGAC); Atmospheric Chemistry in a Changing World: An Integration and Synthesis of a Decade of Tropospheric Chemistry Ressearch (Springer, Berlin) 2003.

IPCC Third Assessment Report: Climate Change (IPCC-a), "Climate Change 2001: Impacts, Adaptation, and Vulnerability" (Cambridge University Press, Cambridge), 2001.

IPCC Third Assessment Report: Climate Change (IPCC-b), "Climate Change 2001: Synthesis Report" (Cambridge University Press, Cambridge), 2001.

Disclosure Statement

Hamilton:

Feb2004 –Feb 2006 NSF- "Collaborative RUI: CO2 - Induced Changes in Heat-Shock Proteins and Photosynthetic Tolerance to Acute Heat Stress" Ecological and Evolutionary Physiology ($131,000)

Tuchler:

"Direct Determination of Equilibrium Constants of Oxsides of Nitrogen With Cavity Ringdown Absorption Spectroscopy" (Thomas F. and Kate Miller Jeffress Memorial Trust, June ,2005).