

# RESEARCH *News*

OFFICE of RESEARCH and SPONSORED PROGRAMS

## WORKS WELL WITH OTHERS

Collaborative proposals involve outside institutions, including Wake Forest University Health Sciences, which is a wholly owned subsidiary of the university and, legally, a separate corporation. The Office of Research and Sponsored Programs does not have proposal signature authority for WFUHS nor vice-versa. Collaborations with the medical school or other institutions must be approved by their authority as well as ours.

WFU can participate in collaborative projects as the lead institution (grantee) or the collaborating institution (subgrantee). In either case, ORSP should prepare or review the budgets, and a routing sheet is required.

If WFU is the lead, ORSP needs such information from the partner as an approved budget and letter of intent, although letters of intent are usually not required for WFUHS. On the routing form, the total request includes funds for the subgrantee.

If WFU is the collaborating institution, the lead may ask for similar documents. On our routing sheet, the *total amount* should be our budget only, not the total grant budget, and for internal purposes, the PI is the director of research.

Administering collaborative proposals can take extra time, and PIs should plan accordingly. Please turn in your routing sheet *before* ORSP must supply documents to the lead institution. We want to allow sufficient time for the partner's internal approval process before we request a budget and other necessary documents.

## WHY DOES THE UNIVERSITY REQUIRE A ROUTING SHEET?

The routing sheet required for all applications to external sponsors confirms, first, that university resources are not unknowingly committed and, second, that the project complies with federal and sponsor regulations. Since most awards are made to the university, it is liable for any violations.

When PIs sign the routing sheet, they certify that the information is accurate; the project meets sponsor and university requirements; and all committee approvals for compliance have been or will be obtained before it begins, including WFU's patent and conflict-of-interest policies and questions of debarment, suspension, lobbying, and delinquency on federal debt (e.g., student loans and taxes).

The signature of the departmental chair or dean indicates institutional support for the proposed activities and guarantees any matching funds from WFU sources. Their endorsement demonstrates the project's relationship to department or university goals and priorities.

The controller's signature assures that Financial and Accounting Services has reviewed the budget for mathematical accuracy; acceptable indirect cost recovery; institutional fiscal standards have been met; and funds are sufficient to meet matching requests.

ORSP tracks all proposals that go through the routing process. They are included in university and department totals in the annual report of sponsored research activity and, if awarded, featured in *Research News*.

WFU wants to support as many sponsored research projects as possible but must know where university resources are committed. Your cooperation is appreciated.



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## GETTING GRADUATE STUDENTS FUNDED

The National Science Foundation awards approximately 1,000 Graduate Research Fellowships annually to build the diversity and vitality of the science, math, engineering, and technology human resource base. They provide \$30K stipends plus \$10,500 cost-of-education allowances for 3 years, usable over a 5-year period, with additional funds available for international research or to the physically challenged. Eligible applicants are US citizens or permanent residents in the senior year of their undergraduate education or the first or early second year of graduate school.

This fall, several Wake Forest faculty served on the program's review panels, which are convened by discipline, and returned to discuss ways to encourage our students to compete. The first message was *hard to get*. Award levels varied from 10-11% of total applicants. Nonetheless, all believed that WFU students with stellar undergraduate records, including research participation, could compete, if they prepared early with guidance from informed faculty.

Criteria varied, but most panels valued excellent research design (the proposed project); previous publications and presentations; and recommendation letters, in that order, over GREs and GPA. Although Cs were a problem, some applicants with GRE scores in the 60<sup>th</sup> percentile were successful. Panelists seldom talked about numbers but jumped right to the project description. "Broader impacts", including active membership in student societies and public service, such as tutoring, working with K-12 students or the disadvantaged, or serving as role models for underrepresented groups, were equated in importance with research. How the research will benefit humanity or its intellectual significance was emphasized as well.

The review procedure is as follows: 2 panelists grade each proposal on a scale of 1 to 5, where 1 is excellent. They carefully examine the distribution, making sure that no excellent candidates are put in the wrong category. When scores differ wildly, a third reading is assigned and, rarely, a fourth, and those candidates are discussed by the whole panel. From the resulting rankings, the top 40% are recommended for funding; if possible, NSF makes further decisions based on the reviews.

Since the application's writing is so critical, some universities require students interested in research-based graduate careers to take a course in GRF proposal writing. UC-Berkeley and UCSF flooded proposals, and their broader impacts sections were very strong. While grant-writing courses are part of graduate student professional development in WFU's Biomedical Sciences Program, similar training is less available on the Reynolda campus.

For the panels on which our faculty served, biochemistry placed no undergraduates in the top pile; they comprised 17% of the psychology panel's picks. That psychology panel also looked seriously at master's students, but the natural-science panels did not. Gloria Muday of Biology remarked that our students could be competitive, but because they have to apply at the beginning of their senior year, they don't yet know where they're going or what they want to study. Others pointed out that the applicant is not tied to the proposed project; it just indicates potential for success as a scientist. In any case, prior research experience is essential, and encouraging WFU students to get involved as early as possible will not only enhance their chances for an NSF fellowship but their education generally. Natalie Holzwarth noted that the number of students pursuing research in Physics is not increasing. It is required for the BS degree but not for the more prevalent BA.

All agreed that students must be made more aware of their options. Program directors, departmental chairs, and faculty with active labs should talk to promising juniors as soon as they commit to graduate school and to first-year graduate students. Preliminary activities, particularly in the broader impact area, must already be achieved by the time of application. Even if the student is rejected, the process teaches the skills necessary for a scientific career. A large number of Honorable Mentions are awarded, adding prestige to the student's résumé.

Because these were scientists, they proposed mechanisms to spark application. Two workshops will be held, starting in September. The first will convene faculty who have served on review panels to advise colleagues, administrators, first-year graduate students, and juniors and seniors in NSF-supported fields about the Graduate Research Fellowship Program. The second will be a proposal-writing laboratory focusing on these applications. Watch your email in August for details!

# OUTSTANDING PROJECT PROFILES

**Dany Kim-Shapiro**, Associate Professor of Physics, has earned a prestigious Independent Scientist Career Development Award from the National Heart, Lung, and Blood Institute. It allows him to reduce his teaching and service load so that he can spend more than 75% of his time on research.

Dr. Kim-Shapiro has studied sickling for over 10 years. His project, *Nitrite and Nitric Oxide in Sickle Cell Blood*, recently revealed that nitrite, a salt naturally found in the body and thought to play no major role, can be converted into nitric oxide (NO). NO expands blood vessels normally and can be used therapeutically for people with sickle cell anemia, whose blocked blood vessels cause painful crises. Dr. Kim-Shapiro is also a primary collaborator, with Chemistry's **Bruce King** on a study of the NO-donating properties of hydroxyurea to improve the FDA-approved drug's application to sickle cell disease. Finally, Dr. Kim-Shapiro plans to develop noninvasive imaging tools to study microcirculation pathology. Four undergraduate and two graduate students work in his lab.

Physics Professor **Keith Bonin** won a Research Corporation award to study *Optical Torquing and Nanofluidics*. The project uses laser light to trap tiny cylindrical rods or tubes and examine how their charge and rotation change as they move close to a surface or through different media. It will aid the development of novel nanodevices that may lead to faster and more powerful computers, more sensitive and accurate environmental and biological sensors, less invasive medical instruments, and more effective medicines. In greatly improving departmental capabilities in single-molecule research, it will encourage collaborations among researchers in different physics areas and at the Medical School. Two undergraduates will participate in this cutting-edge research.

The Arthritis Foundation has chosen the publication of findings by Professor of Health and Exercise Science **Steve Messier** and colleagues one of the Top Ten Advances of 2004. "Exercise and dietary weight loss in overweight and obese older adults with knee osteoarthritis: the Arthritis, Diet, and Activity Promotion Trial" (*Arthritis and Rheumatism* 50, 5 [May 2004]:1501-10) describes an 18-month randomized, single-blind clinical trial designed to determine whether long-term exercise and dietary weight loss are more effective, either separately or in combination, than conventional care. The study found

that the combination of 5% weight loss and moderate exercise provides better overall improvements in self-reported function and pain measures and performance measures of mobility than either intervention alone. The results are especially timely as problematic side-effects cause drugs widely prescribed for arthritis pain to be removed from the market.

In the Humanities, Associate Professor of Romance Languages **Sol Miguel-Prendes** won the John K. Walsh Award for her essay, "Reimagining Diego de San Pedro's Readers at Work: *Cárcel de Amor*." The annual award recognizes the outstanding article published in *La corónica*, as judged by the Executive Committee of the Modern Language Association's Division on Medieval Spanish Language and Literature, and is celebrated at the MLA Convention.

## ORSP HONORS FACULTY

The Associate Provost for Research and ORSP will host two receptions honoring WFU authors/editors and researchers. Authors will be recognized at a reception in the Rhoda Channing Reading Room, Z Smith Reynolds Library, on Friday, 15 April. Researchers will be recognized at a reception on Monday, 25 April, in the Green Room, Reynolda Hall. Invitations will be sent in early April.

## NIH RESOURCES FOR NEW INVESTIGATORS

The primary sponsor of biomedical and behavioral research, the National Institutes of Health, has posted resources for new investigators at [grants1.nih.gov/grants/new\\_investigators/index.htm](http://grants1.nih.gov/grants/new_investigators/index.htm)

Acknowledging that "new investigators...pioneer new areas," the agency admits that its "special programs to assist them in obtaining independent research funding" did not work. On the contrary, "the average age at which an investigator first obtains R01 funding has increased by 5-6 years (to 42 for PhDs and 44 for MDs and MD/PhDs)," and although the absolute number of new R01 investigators has increased, they remain approximately 6% of total R01s awarded during the doubling of the NIH budget.

New investigators are encouraged to check a box on the R01 face page for special consideration, and reviewers are instructed to prioritize research methods over track record and preliminary data. Many institutes and centers will also award them 5 years' support, rather than the usual 4.

## PERKS ALL AROUND

Members of Wake Forest's Institutional Review Board are responsible for protecting human research participants. They generally meet every third Monday of the month during the academic year to review proposed research, to discuss federal regulations affecting WFU researchers, and to monitor activity in ongoing studies. In 2003-2004, 151 applications were submitted: 20 were reviewed by the full board over 8 meetings; 13 were exempted; and 118 were expedited.

To assure their mastery of compliance regulations and WFU policies and procedures, members and alternates must complete a training program. As Dale Dagenbach, Psychology, reflected, "Serving on the IRB makes one more fully appreciate the dynamic nature of human subjects protection. The laws and regulations change with some frequency, and one becomes sensitive to the need to stay current...One also gets a sense of what are red flags for the board, and how to present information so that it receives a fair hearing..."

Why serve? Current IRB chair Steve Folmar, Anthropology, remarked, "One advantage to me is that I have been introduced to a wide array of methodologies I have not myself used. Some of the applications have gotten me to think about approaching my own research from new angles. I am now in the process of designing methods suggested by other faculty and student research."

"Faculty support of the IRB is essential, if human subjects research is to be conducted on the Reynolda campus," commented Tony Marsh, Health and Exercise Science. "Alternatives to having an accredited IRB—outsourcing— would severely affect faculty ability to conduct human subjects research. [Serving on the IRB] can also be very helpful in the review process, when board members are from the same department as the investigator submitting the protocol. General questions on recruitment and study methods can often be answered by the board member rather than going back to the investigator."

Christy Buchanan, Psychology, noted: "Benefits to me: being more aware of IRB regulations in their detail; being more aware of the kinds of concerns IRBs have."

Nancy Crouch of Information Systems, the nonscientist on the IRB, said, "From a staff perspective, being more educated about campus research and the entire research process is a plus. Staff can get very disconnected from faculty if we don't work on such committees."

As Dr. Marsh observed, "The board's mission—protection of human research subjects—fulfills the WFU motto, *Pro Humanitate*, and is critical for those faculty who are actively engaged as teacher-scholars." Without doubt, IRB members serve the university and its researchers well, and we thank them.

## NSF PROJECT EVALUATION HANDBOOK

From *Grantseeker Tips* 153 (14 February 2005)

The National Science Foundation has developed a basic guide for evaluating educational programs. It targets people who want to learn more about what evaluation can do and how to do one rather than those who already have experience. Specific sections in the *User-Friendly Handbook for Project Evaluation* include types of evaluation; steps in doing an evaluation; overview of quantitative and qualitative data collection methods; strategies that address culturally responsive evaluations; and finding an evaluation. The primer can be found online at [www.nsf.gov/pubs/2002/nsf02057/start.htm](http://www.nsf.gov/pubs/2002/nsf02057/start.htm).

## IRB EDUCATION REQUIREMENTS CHANGE

As of July 2005, *all key personnel and faculty advisors involved in research with human participants must complete mandatory training*, either CITI or the Wake Forest University Health Sciences' Human Subjects Research Program, prior to submitting an application to the Institutional Review Board.

The CITI programs correlate with the type of research proposed:

- Group 1:** Social/Humanistic/Behavioral Research program for graduate students, faculty, and staff (9 modules); average completion time = 4-6 hours;
- Group 2:** Social/Humanistic/Behavioral Research program for graduate education students (13 modules); average completion time = 6 hours;
- Group 3:** Biomedical research program for graduate students, faculty, and staff (11 modules); average completion time = 6 hours

To access the CITI modules, go to <http://www.citiprogram.com/>. Remember to register as Wake Forest University (WFU), not Wake Forest University Health Sciences (WFUHS).

A score of 80% correct is required to receive credit for the course. ORSP will issue a certificate upon successful completion.



## NEW PHS 398

In September 2004, the Public Health Service released new versions of the grant application forms that the National Institutes of Health require. After 10 May 2005, proposals submitted to the NIH using instructions and forms other than PHS 398 (rev. 9/04) *will be returned*.

Some important changes:

- Allowable title length has increased to 81 characters.
- Arial-11 and Helvetica-11 are the *only* acceptable fonts/sizes.
- Form page 2 is now 2 pages and includes 2 additional sections, *Other Significant Contributors* and *Stem Cells*. Significant contributors are those who “contribute to the scientific development or execution of the project but are *not* committing any specified measurable effort.” Their biographical sketches are required but not Other Support information.
- The Description (abstract) section now *requires* 2-3 sentences describing the project’s public health relevance. Plain language is advised.
- Consortium F&A (indirect) costs are no longer included in the \$250,000 direct cost limit for using the modular budget format.
- Personal Data Page: Applicants are now asked to volunteer only the last 4 digits of their Social Security number. NIH hopes they will be more receptive to providing this information, as it allows accurate identification, referral, and review of applications and management of PHS grant programs.

The forms (<http://grants.nih.gov/grants/funding/phs398/phs398.html>) are linked to the ORSP website under Proposal Preparation. *See also* <http://grants.nih.gov/grants/guide/notice-files/NOT-OD-05-006.html> for a detailed description of the changes.

## QUICK REVIEW FOR URGENT RESEARCH

From *Federal Grants and Contracts Weekly* 29, 3 (10 January 2005)

When calamity strikes at home or abroad, special federal grants can put researchers to work fast, capturing data that won’t wait for the usual months-long application, review, and awards process.

At the **National Science Foundation**, Small Grants for Exploratory Research (SGER) fund projects characterized as severely urgent. They include scientific and social science research on natural or man-made disasters and unanticipated events. Brief proposals—2-5 pages—for up to \$200,000 (although most do not exceed \$100,000) are quickly reviewed and approved by program officers, who are internal NSF staff, bypassing peer review.

Funded across NSF directorates and divisions, SGER may also support untested, novel ideas; emerging and potentially transforming research concepts; application of new expertise or new approaches; and other efforts likely to catalyze radical advances. Be sure to talk to the PO, however; if s/he doesn’t think it is urgent, it’s dead.

The **National Institute of Mental Health’s** RAPID program (for Rapid Assessment Post-Impact of Disaster) serves a similar function. It addresses traumatic stress and psychological effects of disasters. Investigators who would typically wait 9 months between submission and award can be working within weeks.

Proposals must be submitted within 6 weeks of the event for quick review: 10-page project descriptions for small grants of up to \$50,000 a year for 2 years or larger developmental grants of up to \$125,000 a year for up to 2 years.

Under both programs, the first step is to discuss the project with program officers.

For SGER, *see* Grant Proposal Guide ([www.nsf.gov/pubs/gpg/nsf04\\_23/2.htm](http://www.nsf.gov/pubs/gpg/nsf04_23/2.htm)), Chapter 2, D. Special Guidelines; for RAPID, <http://grants.nih.gov/grants/guide/pa-files/PA-02-133.html>

## WHITE HOUSE SCIENCE OFFICE BACKS CO-INVESTIGATOR CREDIT

From *Federal Grants and Contracts Weekly* 29, 7 (7 February 2005)

Federal policy to acknowledge more than one principal investigator on a research grant is coming, according to the White House Office of Science and Technology Policy. In January, Director John Marburger, the president’s science adviser, sent a memo to federal departments and agencies mandating multiple PIs. The memo states that all federal research agencies “should accommodate the recognition of two or more principal investigators on research projects.”

Current policy at some agencies and practices at grantee institutions can prohibit listing more than one PI. Concerns center on complicating project administration, blurring lines of authority, and diminishing accountability. Advocates for change argue that failure to share credit is an anomaly at a time of increasing collaboration in science and could seriously hamper advances in areas that depend on cooperative endeavors.

As Marburger observed, “collaborators are often from different institutions. Careers of these investigators are driven by credit for the work performed, and we should strive to recognize contributors across disciplines and institutions.”

For the *Federal Register* notice, *see* [www.access.gpo.gov/su\\_docs/fedreg/frcont05](http://www.access.gpo.gov/su_docs/fedreg/frcont05) and click on 28 January.

## DECREASING DISCRETIONARY PROGRAM FUNDING

From *Federal Grants and Contracts Weekly* 29, 8 (14 February 2005)

President Bush's FY 2006 budget would squeeze discretionary grant accounts, end many competitive programs, and scrimp on increases even for favored grantmakers. The Education Department, with a 0.9% proposed decrease in funds for competitive grants, would see 48 programs eliminated.

Totals funds for new and competing grants would increase 0.7% at the National Institutes of Health, but the actual number funded would lag behind recent highs. Other health agencies would see cuts, including the Health Resources and Services Administration, where a \$304M increase for community health centers would not offset a \$252M cut in health professions training and termination of services for traumatic brain injury, newborn hearing screening, and pediatric emergency. The winners in health and social services are the Compassion Capitol Fund, which seeds faith-based and community activities and abstinence education; their total allocation would top those of several NIH components.

The National Science Foundation, whose 2005 budget was cut, would receive a 2.4% increase, but math and science partnership programs would be transferred to ED, and elementary, secondary, and informal science education and undergraduate education programs slashed by 22.6% and 12%, respectively. In addition, the increase cannot keep pace with the number of applicants. Competitive awards are expected to drop from 10,360 in 2004 to 10,010 in 2006 to sustain increasing amounts.

The Environmental Protection Agency's Science to Achieve Results program would continue its funding slide. Total research grants and fellowships could be in the \$65M range, down from about \$70M this year and \$100M in 2004.

Not all is bleak for science, however, especially in nanotechnology, information technology, homeland security, and other priorities. One program set to gain is the Agriculture Department's premier competitive National Research Initiative, which would increase \$70M to \$250M.

## NSF SUCCESS RATES

From *Federal Grants and Contracts Weekly* 28, 27 (28 June 2004)

Success rates for competitive grant proposals at the National Science Foundation fell to their lowest in a decade, slipping to 27% overall from 30% in 2002. The decline is the flip side of increased submissions; since 1999, the number of proposals reviewed has increased 40%.

Good news for successful applicants: the average annual amount for research grants increased to \$135,609, up 17%. Duration fell just short—an average 2.9 years in contrast to the hoped-for 3.

Engineering applicants had the tightest race, with a 21% award rate, closely followed by the education directorate and computer science, both of which funded 22%. Directorates for the mathematical and physical sciences and the polar programs office had the highest rates, at 34% and 43%, respectively.

Success rates ranged from 19% for new investigators to 28% for female investigators. Although women edged out men by one percentage point, success rates for women were down from 30% in 2002 and the high of 35% in 2000.

Rates for minority investigators also declined, from 30% in 2001 to 27%. The total number of awards to minority investigators increased to 569 in 2003, about 4% over 2002. The number of minority applicants—winners and losers—was up 12% last year and has increased 49% over the past ten.

For the "Report to the National Science Board on the National Science Foundation's Merit Review Process," see [www.nsf.gov/nsb/documents/reports.htm](http://www.nsf.gov/nsb/documents/reports.htm).

## NSF MERIT CRITERIA: BROADER IMPACTS

National Science Foundation proposals are evaluated on 2 criteria: intellectual merit and broader impacts. Proposals that do not separately address both criteria within the one-page Project Summary are returned without review.

Most researchers understand that intellectual merit means the work must advance scientific frontiers but are less clear about broader impacts. Thomas Weber, Director of the Division of Materials Research, sought to clarify. "Broader impact activities...contribute to our professional development and that of our co-workers, to wide dissemination of our research breakthroughs, to recruitment of our future workforce, and to effective communication with non-specialist audiences" (see [www.nsf.gov/pubs/2005/nsf0507/nsf0507.htm](http://www.nsf.gov/pubs/2005/nsf0507/nsf0507.htm)).

Broader impacts include:

⊙ Professional development and future workforce:

- training graduate and undergraduate students to be future professionals
- hosting students, teachers, or other professionals, especially underserved demographic groups
- updating curricula by writing texts or developing new instructional materials and laboratory experiments
- devising safer or more economical research practices
- forging links with other scientific disciplines

# WFU FUNDED RESEARCH

November 2004 – February 2005

## ANTHROPOLOGY

### Kenneth Robinson

- *Archeological Survey, Naked Run and Stewarts Creek Outfall Corridors, Mt. Airy, Surry County, NC*, Adams-Heath Engineering, Inc., \$14,625
- *Survey and Backhoe Testing, Manorcas Creek, Phase I Stream Restoration Study Area, Historic Bethabara Park*, Trustees of Historic Bethabara Park, \$24,384

## BIOLOGY

**William Kirby Smith**, *Alpine Treeline Stability: Mechanisms of Conifer Tree Seedling Establishment*, National Science Foundation (NSF), \$9,809

## CHEMISTRY

**Rebecca Alexander**, *Dissecting Protein and Nucleic Acid Contributions to Efficient tRNA Aminoacylation*, National Foundation for Cancer Research, \$50,000

**Paul Jones**, *Ionic Lubricants Incorporating Nanomaterials*, Air Force Office of Scientific Research (AFOSR), \$31,000

**S. Bruce King**, *Nitric Oxide-Producing Reactions of Hydroxyurea*, National Institutes of Health (NIH), \$276,994

**Abdessadek Lachgar**, *Design and Self-Assembly of Cluster-Based Materials*, NSF, \$165,000

**Mark Welker**, *Preparation and Tandem Reactions of Main Group Substituted Dienes*, NSF, \$360,000

## COMMUNICATION

**Allen Loudon**, *Southeast Europe Youth Leadership Institute (SEELYI)*, Open Society Institute, \$137,178

**Ananda Mitra**, *Needs Assessment*, Forsyth Technical and Community College, \$19,966

## COMPUTER SCIENCE

**Victor Paul Pauca**, *Computational Methods for Quantum Molecular Dynamics*, National Institute of Standards and Technology, Targacept subcontract, \$66,338

**Robert J. Plemmons**, *Post-Detection Processing and Inverse Problems in Ground-Based Imaging*, AFOSR, University of New Mexico subcontract, \$59,000

## HEALTH AND EXERCISE SCIENCE

**Shannon Mihalko**, *Recovery Strategies Following Breast Cancer Treatment*, US Army, \$137,506

**W. Jack Rejeski**, *Lifestyle Interventions and Independence in Elders (LIFE)*, NIH, \$67,958

**Paul Ribisl**, *Physical Exercise to Prevent Disability Pilot Study (LIFE)*, NIH, \$142,003

## LAW SCHOOL

**Kate Mewhinney**, *Elder Law Clinic, Client Needs Fund*, NC Bar Foundation, \$2,000

**Robert Walsh**, *Professionalism Program*, NC State Bar, \$10,000

## MATHEMATICS

**Robert J. Plemmons**, *Post-Detection Processing and Inverse Problems in Ground-Based Imaging*, AFOSR, University of New Mexico subcontract, \$59,000

## PHYSICS

**Keith Bonin**, *Optical Torquing and Nanofluidics*, Research Corporation, \$49,771

**David Carroll**, *Charge Transfer Nanocomposites: The Effects of Scale*, AFOSR, \$151,000

**Daniel B. Kim-Shapiro**, *Nitrite and Nitric Oxide in Sickle Cell Blood*, NIH, Independent Scientist Career Development Award, \$103,680

## Z. SMITH REYNOLDS LIBRARY

**Susan Smith**, *"Digital Forsyth" Collaborative Project Planning Grant*, State Library of North Carolina, \$11,992

(continued from page 6)

- consulting with industrial and government colleagues
- ⊙ Dissemination
- presenting seminars
  - organizing workshops and symposia
  - writing scholarly review articles or articles describing research to nonspecialist audiences
  - establishing collaborations with scientists from around the world
  - forming start-up companies to disseminate new technologies

- sharing laboratory methods, instrumentation, software for data analysis, or samples of novel materials
- creating websites enhanced by animations and movies
- developing new art forms to communicate about science to wider audiences
- working with science centers on new exhibits

Further information and general guidance on broader impacts can be found at [www.nsf.gov/pubs/2002/nsf022/bicexamples.pdf](http://www.nsf.gov/pubs/2002/nsf022/bicexamples.pdf).

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