EVOLUTION OF A PARTNERSHIP
TO IMPROVE K-16 SCIENCE EDUCATION

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This article grew out of a presentation at the 82nd Annual Meeting of the American Association for the Advancement of Science Pacific Division in Irvine, California in June 2001. The symposium “Sharing Science: Successful Scientist Expert-Teacher Practitioner Interactions” was organized by Drs. Nancy J. Pelaez and Barbara L. Gonzalez of California State University at Fullerton. Goodman’s presentation was entitled “The Team Approach to Outreach Activities for K-12 Teachers in a Large, Rural State.” This personal view report describes the development and evolution of educational outreach programs at the University of South Dakota School of Medicine (USDSM) and the support provided by the administration. The number and strength of the programs at USDSM have grown in direct proportion to the commitment that the institution has been willing to make to faculty members with interests in science education. Currently, USDSM has three Basic Science faculty members who spend significant effort working with K-12 students and teachers and who have been called upon nationally as consultants and reviewers for similar programs.

10.1152/advan.00013.2002.

Key words: medical school; science education; outreach; pipeline

The mission statement of the University of South Dakota School of Medicine (USDSM) asserts that: The University of South Dakota School of Medicine is to provide to its students and to the people of South Dakota excellence in education, research, and service. To these ends, the School is to provide educational pathways leading to both the Doctor of Medicine and the Doctor of Philosophy degrees; and other degree programs. To meet its mission, USDSM is preparing the next generation of South Dakotans by getting actively involved in science education for kindergarten through 12th grade and undergraduate students. The Division of Basic Biomedical Sciences is located on the campus of the University of South Dakota in the extreme southeast corner of the state. USDSM is South Dakota’s only medical school, is relatively small, has minimal state funding, and has fewer than 40 Basic Science faculty members.

Outreach programs for improving K-12 science education in South Dakota were initiated by individual Basic Science faculty members and the dean of USDSM. USDSM has two long-term, ongoing training programs that provide summer research experiences for disadvantaged high school and minority undergraduate students. USDSM also has a large grant from the Howard Hughes Medical Institute (HHMI) Precollege Science Education Initiative for Biomedical Research Institutions to support educational activities on the USD campus for middle and high school students and teachers and to introduce disadvantaged high school students to various health careers. In
addition, the HHMI grant provides in-service training offered by USDSM faculty for middle and high school science teachers throughout the state followed by access to traveling laboratory kits. A new National Institutes of Health/National Center for Research Resources Biomedical Research Infrastructure Network (BRIN) grant is being implemented that targets several South Dakota undergraduate institutions as partners with USDSM researchers to enhance their science and research capabilities.

METHODS

Program Developers

Robert C. Talley, M.D., Dean of the School of Medicine and Vice President for Health Affairs of the University of South Dakota, initiated the efforts for science education outreach by responding to a request for applications for the National Institutes of Health Minority High School Student Research Apprentice Program in 1988. Subsequent grant-writing efforts have been made by several individual Basic Science faculty members with a broad interest in education and in enhancing the outreach capabilities of the School of Medicine. The chronology of grant opportunities at USDSM is shown in Table 1.

One of the faculty members dedicated to outreach activities for a number of years is Barbara E. Goodman, Ph.D., Associate Professor of Physiology. As is true with many scientists, her initial foray into educational outreach activities at the K-12 level came as a parent. She began by volunteering to be a scientist role model and to have her daughter’s second grade class conduct a field trip to her laboratory. Subsequently, she has given interactive presentations with fourth graders about the lungs and how to keep them healthy, helped sixth graders with heart dissections, developed (with the sixth grade science teacher) a new supplemental presentation on electrocardiography, and demonstrated principles of diffusion and osmosis with the use of human red blood cells for Advanced Placement Biology classes. The unusual aspect of Goodman’s parental volunteering has been that she has continued in the classroom after her children moved on. In the spring of 2000, Goodman was appointed the scientist-in-residence for the Vermillion School District with duties of assisting teachers with setting up new hands-on inquiry science activities for their classrooms and making or arranging interactive presentations on science, health, diseases, or science and health careers for the schools.

In 1994, Gerald J. Yutrzenka, Ph.D., Associate Professor of Pharmacology, now Director of the Indians into Medicine Satellite Office at USDSM and Health Career Advisor at USD, wrote a successful grant application to the HHMI Precollege Science Education Initiative for Biomedical Research Institutions for the USDSM Indian Science and Technology Enhancement Program (InSTEP). He has continued as the director of both HHMI-funded precollege programs at USDSM InSTEP and its continuation South Dakota Science Education Enhancement Program (SD-SEEP).

In 1996, Robert Noiva, Ph.D., Associate Professor of Biochemistry, secured a five-year research and educational grant from the National Science Foundation CAREER Program. With this support and additional funding from the USD Research Experience for Undergraduates in Experimental Biology and Biometrics Program funded by HHMI, he established a molecular biology teaching laboratory in the School of

<table>
<thead>
<tr>
<th>Year</th>
<th>Program</th>
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<tbody>
<tr>
<td>1989</td>
<td>Research Apprentice Program begun (Dean Talley)</td>
</tr>
<tr>
<td>1993</td>
<td>Short-Term Training for Minority Students Program begun (Dr. Goodman)</td>
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<tr>
<td>1994</td>
<td>Indian Science and Technology Program begun (Dr. Yutrzenka)</td>
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<tr>
<td>1996</td>
<td>Gene Explorer Program begun (Dr. Noiva)</td>
</tr>
<tr>
<td>1996</td>
<td>Local Outreach Team begun (Dr. Goodman)</td>
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<tr>
<td>1999</td>
<td>Local Outreach Team Unit Development Team begun (Dr. Goodman)</td>
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<tr>
<td>2000</td>
<td>South Dakota Science Education Enhancement Program begun (Drs. Goodman, Noiva, Yutrzenka)</td>
</tr>
<tr>
<td></td>
<td>InSTEP becomes STEP. Gene Explorer continues, new outreach opportunities for K-12 teachers and students begun</td>
</tr>
<tr>
<td>2000</td>
<td>Scientist-in-Residence with Vermillion School District begun (Dr. Goodman)</td>
</tr>
<tr>
<td>2001</td>
<td>USDSM partners with Augustana College, Black Hills State University, and Sisseton-Wahpeton Community College (Dr. Goodman)</td>
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The program developer is identified in parentheses.
Medicine. During the summer, Noiva offers three different weeklong Gene Explorer workshops in molecular biology for middle and high school students and teachers. Additionally, Noiva offers miniworkshops on molecular biology for high school students involved in the USDSM summer research programs, for middle school students at the Governor’s Camp for the Gifted, and annually for teachers at the South Dakota Science Teachers Association meeting.

**Activities And Funding**

The purpose of the Research Apprentice Program (RAP; at USDSM since 1989) is to introduce disadvantaged high school students to scientific research. Since the inception of RAP, 66 different students from mostly reservation and rural schools in South Dakota will have participated by the end of the summer of 2002; 59 of these students are Native Americans. So far, 100 percent of the RAP students have graduated from high school; 15 of the students have already graduated from college, 4 of those are currently pursuing graduate or professional degrees, and 27 are still pursuing undergraduate degrees at universities or tribal colleges. Although many of the former RAP students have attempted or been successful in post-secondary educational opportunities, some of the students (74% female) have been temporarily side-tracked by marriage and/or pregnancy. For example, one of the RAP students from summer 1992 and 1993 almost graduated with a degree in chemistry from USD in 1998 but left to have a baby. She recently returned this past semester and obtained her bachelor’s of science degree in chemistry in May 2002. The funding sources for the programs at USDSM are shown in Table 2.

In an effort to provide similar summer research experiences for minority undergraduate students, Goodman submitted an application for the Short-Term Training for Minority Students Program (STMSP) through the National Institutes of Health National Heart, Lung, and Blood Institute (funded since 1993). STMSP will have served 35 different minority students since its inception. For the students who are still in

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**TABLE 2**

**Funding sources for K-16 science education activities at USDSM**

<table>
<thead>
<tr>
<th>USDSM Program</th>
<th>Funding Program</th>
<th>Funding Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Apprentice Program</td>
<td>Minority High School Student Research Apprentice Program, NCRR Minority Initiative: K-12 Teachers and High School Students</td>
<td>NIH National Center for Research Resources (program name change)</td>
</tr>
<tr>
<td>Short-Term Training for Minority Students Program</td>
<td>Institutional Short-Term Training for Minority Students Program, Short-Term Training for Minority Students Program</td>
<td>NIH National Heart, Lung, and Blood Institute (program name change)</td>
</tr>
<tr>
<td>Indian Science and Technology Program</td>
<td>Precollege Science Education Initiative for Biomedical Research Institutions</td>
<td>Howard Hughes Medical Institute</td>
</tr>
<tr>
<td>Gene Explorer Program</td>
<td>Research Experiences for Undergraduates in Experimental Biology and Biometrics; Faculty Early Career Development Award</td>
<td>Howard Hughes Medical Institute; National Science Foundation</td>
</tr>
<tr>
<td>Local Outreach Team/Unit Development Teams</td>
<td>Frontiers in Physiology of the American Physiological Society</td>
<td>APS, NIH NCRR Science Education Partnership Award, National Science Foundation, and National Institute of Diabetes and Digestive and Kidney Diseases</td>
</tr>
<tr>
<td>SD Science Education Enhancement Program Scientist-in-Residence USD BRIN partnerships with undergraduate institutions</td>
<td>Precollege Science Education Initiative for Biomedical Research Institutions None Institutional Development Award Program Biomedical Research Infrastructure Network</td>
<td>Howard Hughes Medical Institute Service by USDSM faculty NIH National Center for Research Resources</td>
</tr>
</tbody>
</table>
contact, 17 have graduated from college and 10 of
those have been accepted to or graduated from grad-
uate or professional schools including law school,
medical school, physician’s assistant programs, four-
year nursing school, and doctoral clinical psychology
programs. Five students have not yet graduated and
are still pursuing undergraduate degrees.

The HHMI Precollege Science Education Initiative
for Biomedical Research Institutions program at
USD SM, Indian Science and Technology Enhance-
ment Program (InSTEP) was funded from 1994
through 1999 and has been directed by Yutrzenka
since its inception. In the competing renewal of the
HHMI program, InSTEP continued under SD-SEEP as
the Science and Technology Enhancement Program
(STEP) for disadvantaged students. STEP provides op-
opportunities for American Indian high school students
to learn about health careers while participating in
activities at USD during the summer. STEP offers two
levels of participation. The initial summer of the pro-
gram is entitled Explore and involves the students as
a group learning about health and science careers
through specially designed activities. The second year
is called Apprentice and brings back those who com-
pleted the Explore component to investigate health
careers more deeply by shadowing health profession-
als. From 1995 through 2002, InSTEP/STEP has served
49 students for the Explore program and 27 of those
students have returned for the Apprentice program.
Students have been members of 12 different tribes.
Although complete information about former stu-
dents is not yet available, one of the two-year students
began to pursue her interest in health care while in
high school as a certified nurse’s assistant, went on to
USD, and is working in health care with the Army
National Guard with interest in a career in clinical
psychology or medicine.

In 1996, Goodman received a grant for a Local Out-
reach Team (LOT) from the Frontiers in Physiology
Program of the American Physiological Society
(APS). The program provided funding to train a team
of physiologists and teachers who would offer in-
service workshops for K-12 teachers using the APS
inquiry-based science curricular units in physiology.
Subsequently, the USD SM LOT wrote a new curricular
unit for middle school students entitled “Physiology
of Exercise” and received a subsequent Local Out-
reach Team Unit Development Grant. This grant
provided funding to train the team to design and write
another inquiry-based science unit on cell physiology
for middle school students entitled: “Cell-ebration:
What Makes Cell Membranes Selectively Permeable?”
Currently, the USD SM LOT is made up of Goodman
and another physiologist (Douglas S. Martin, Ph.D.,
cardi ovascular) and two middle school teachers. The
LOT provides in-service training for K-12 teachers in
inquiry-based physiology activities with funding from
SD-SEEP and the APS.

Yutrzenka, Goodman, and Noiva are involved together
with USD SM’s current HHMI Precollege Science Educa-
tion Initiative Program-SD SEEP. SD-SEEP has three
major components. The first component is the Sci-
cence and Technology Enhancement Program (STEP
continuation of the former InSTEP program) for dis-
advantaged South Dakota high school students. The
second component is the Gene Explorer Program
(molecular biology summer workshops for middle
and high school students and teachers). Gene Explor-
ers is a continuation and expansion of support for
Noiva’s workshops. The final component of SD-SEEP
empowers USD SM to offer in-service workshops for
middle and high school science and health teachers at
various locations throughout South Dakota. Once
teachers have been trained, they are eligible to check
out the traveling science laboratory kits to carry out
the workshop activities in their own classrooms.
These kits include all of the equipment and supplies
needed to offer experiments on cloning and electro-
phoresis of DNA in their home classrooms with mul-
tiple student stations. In year one of the grant, the
initial training of teachers and assembly of one kit
occurred. That kit was checked out by four different
schools. Now, in year three of the grant, there are
three complete kits that travel continuously from Sep-
tember to late May with an average of two weeks at
each school.

Goodman is Director of the new USD Biomedical
Research Infrastructure Network (BRIN) funded
through the National Institutes of Health National
Center for Research Resources Institutional Develop-
ment Award Program. BRIN has a training and men-
toring core that complements the other efforts of
USD SM in improving science education for South Da-
ka to students. BRIN has targeted three undergraduate
institutions (private Augustana College, state Black Hills State University, and tribal college Sisseton-Wahpeton Community College) to enhance the science and research capabilities of both the faculty and the students at each institution and to share resources and seminar presentations with USDSM. A new program for undergraduate research fellows has been instituted by BRIN that includes financial support for the fellows and their sponsoring laboratories either at their home institutions or at USDSM. In addition, all undergraduate fellows will participate in a three-day summer event at USDMS in Vermillion to be introduced to the graduate program in the Basic Biomedical Sciences and to the research opportunities at USDMS.

DISCUSSION

K-16 Educational Outreach by a School Of Medicine: the Pluses

These opportunities for enhancing K-16 science education in this large rural state with only one school of medicine continue to provide South Dakota students new educational opportunities that introduce professional and research careers. Some of the good aspects of these outreach activities for the community as a whole include the following: both the teachers and the students have enjoyed the hands-on and inquiry activities in the classroom; students and teachers are reminded that science can be fun; one’s own children and the children of others receive better opportunities in science, students realize confidence, and their interest in science, math, or engineering is stimulated; and deficient science programs at rural and reservation schools are improved. Participating students are likely to become the more scientifically literate citizens of the future. Some of the good aspects of delving into K-12 science education for the educators include the following: scientists learn about pedagogy from teachers and thus become better teachers at all levels; teachers learn about science from scientists; scientists begin to appreciate what it is like for teachers on a daily basis; and scientists learn to communicate more effectively with the lay public. Some of the good aspects of these kinds of programs for the institution include the following: the reputation of the university and the medical school is enhanced throughout the state; politicians should become less concerned about whether institutions of higher education are doing enough to benefit the state as a whole; and individual scientists actively involved in educational outreach gain regional and national recognition for their efforts and expertise.

An unexpected outgrowth of this commitment to educational outreach has been developing. A group of USDMS faculty members (including Goodman and Yutzenka) has been working on addressing some of the needs of the Native American population of South Dakota. This USDMS/tribal initiative has been designated the Dakota Native American Health Collaborative and has been meeting with tribal leaders to assess the needs of their constituents. Needs identified so far by the Collaborative include a cooperative epidemiological study center, health professions training opportunities on the reservations, focus groups to support medical research, additional opportunities for mentoring and career awareness, and the enhancement of the teaching of science in reservation-based schools. Goodman is the facilitator of the Mentoring and Career Awareness/Enhancement of Teaching Science Task Force for the Collaborative. The task force will be providing web-based Native American role models for science and health careers and is expanding educational outreach programs to reservation-based schools. Future plans include obtaining grant funding for designing and implementing summer science day camps in the reservation communities. Thus the efforts of the Collaborative are meshing nicely with the ongoing efforts, ideas, and capabilities of educational outreach programs at USDMS. The Collaborative has the potential to lead to long-term and far-reaching health and educational improvements for the American Indian people of South Dakota.

K-16 Educational Outreach by a School Of Medicine: the Minuses

Although the previous section discussed numerous pluses for involving a state school of medicine in the sponsorship of programs for improving K-16 science education, offering educational outreach activities also has minuses. These include the following: outreach activities take time (and, in a state with long distances and potentially inclement weather six months of the year, excessive amounts of time); outreach activities cost money (particularly for schools with little financial support for their science curricula); some scientists do not know how to relate to K-12
teachers as equals or to their students at appropriate levels; some teachers do not feel comfortable having an “expert” in their classrooms; and sustainability of science enhancement opportunities after the initial offering is virtually impossible in poorly funded and geographically isolated rural and reservation schools that have frequent turnover of their inexperienced and grossly overworked and unsupported teachers. There are also potential problems for the K-12 teachers who want to make changes but do not know how to make changes and still maintain the support of their administrations.

Another minus is that grant writing, coordinating, and reporting require an extensive time commitment from individual faculty members (fortunately, however, there are numerous sources of funding for educational outreach programs). Sometimes supervisors of the faculty who are program developers undervalue the importance of these kinds of activities for the scientists, to the medical school, and for the state. Furthermore, as the scientists develop curricula and write grant proposals for outreach activities, they become more in demand throughout the state and recognized as consultants and grant reviewers at the national level. Although these national opportunities are interesting and challenging for the scientist and may lead to collaborations with other scientists/educators, the recognition for and value of these experiences are difficult for promotion and tenure committees and administrators at the home institutions to evaluate. In addition, scientists often get minimal encouragement from their colleagues for their efforts and time in being actively involved in educational outreach.

K-16 Educational Outreach by a School Of Medicine: the Future

The pluses and minuses described in the previous sections are likely to be debated for years to come. However, one institution, the University of South Dakota and its School of Medicine, has recently made an effort to deal with some of these issues in its contract negotiations. USD administration recognized the need for better communication among science and medical school faculty members and science education faculty members at the School of Education to improve K-16 science education. Thus the Dean of Research and Graduate Education at USD recently appointed Goodman Director of Special Programs and Science Education with joint appointments in the School of Medicine, the College of Arts and Sciences, and the School of Education. Her responsibilities are to apply for and supervise educational and training grants, teach medical students, undergraduate biology students, and undergraduate preservice secondary science education majors, and coordinate university efforts in science and math education.

CONCLUSIONS

One conclusion of the experience at the University of South Dakota School of Medicine is that, in order for educational outreach efforts to develop successfully, individual faculty members or administrators need to be willing to carry out focused volunteer efforts for the good of the institution. When such individual efforts are met with strong encouragement and support from higher administration, educational outreach programs grow as the applications for funding become successful. The programs described have helped USDSM to meet its mission to provide to its students and to the people of South Dakota excellence in education, research, and service. This description of the process of evolution of a partnership between a school of medicine and middle schools, high schools, and undergraduate institutions to improve K-16 science education may be useful to other institutions as they seek to develop successful educational outreach programs.

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Received 19 March 2002; accepted in final form 24 June 2002