

Communicating Biotechnology

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INTRODUCTION

The concepts behind biotechnology and molecular biology are increasingly relevant to everyday life. Individuals who remain unaware of the principles and techniques underlying rapid advances in these fields cannot make informed decisions about their health, the environment, and public policies. One avenue for introducing biotechnology to the public is as formal education at the secondary level using local resources. Another, particularly in less technologically advanced areas, is to convey concepts less formally by taking advantage of international outreach programs, and individuals devoted to science education. We describe here programs that have created and continue to foster both “professional learning communities” and “public learning communities” designed to enhance biotechnology and life sciences education (Figure 1).

The Fred Hutchinson Cancer Research Center's Science Education Partnership (SEP) provides professional development for teachers (including a research laboratory experience), ongoing support for teachers fostered through a kit loan program, and continual development of an active science education professional learning community (ProfLC). In places with access to few local resources, the process of disseminating information is more challenging. Both DNA Adventures, Inc and Biología Para Todos are international outreach programs that provide instruction, materials and laboratory training in life sciences outside of the formal education system. They have created successful public learning communities (PubLC) in remote locations of Tibet and metropolitan areas of South America by direct collaborations with those communities.

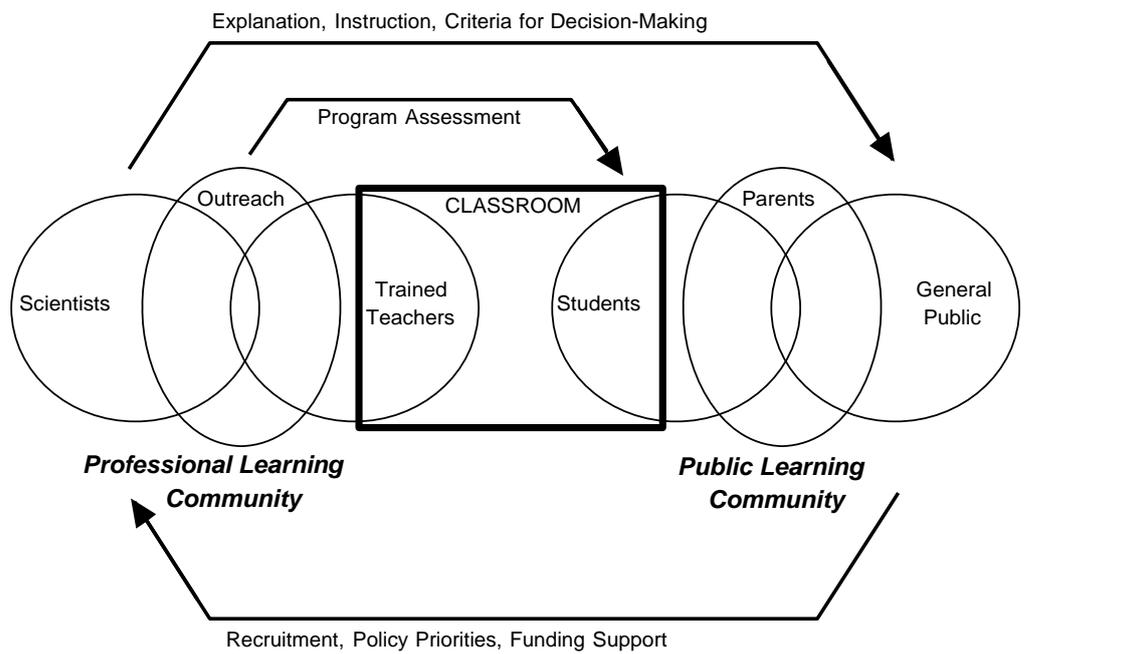


Figure 1. The classroom connection between a professional learning community (ProfLC) and public learning community (PubLC). Outreach organizations like Fred Hutchinson Cancer Research Center's Science Education Partnership bridge the gap between scientists and the general public through support and training of classroom teachers. Less formal outreach programs such as DNA Adventures, Inc. and Bioteología Para Todos can link directly with any or all components of the PubLC.

THE SCIENCE EDUCATION PARTNERSHIP: DEVELOPING AND MAINTAINING A PROFESSIONAL LEARNING COMMUNITY OF SCIENCE EDUCATORS

As a society, schools and the educational system are our primary means to prepare and guide our future citizens and leaders. For schools, clearly teachers and teaching quality intrinsically stand at catalytic leverage points within the educational system. Thus, fostering the ongoing professional growth of teachers rises high on the lists of strategic levers within the system. **Our question then becomes, how can we best foster high quality teachers and ongoing teacher professional growth, particularly in science, math, and technology?**

The challenge of teaching is harder than many have thought. “Outstanding teaching requires teachers to have a deep understanding of the subject matter and its structure, as well as an equally thorough understanding of the kinds of teaching activities

that help students understand the subject matter in order to be capable of asking probing questions” (1). Len Shulman, President of the Carnegie Foundation for the Advancement of Teaching, calls this **pedagogical content knowledge**—the professional knowledge, sometimes referred to as the craft, of teaching (see Resources at www.carnegiefoundation.org for works by Shulman, Hutchings, and others). Thus, veteran educational reformer and researcher Michael Fullan, in *The New Meaning of Educational Change* (2001) concludes that **professional learning communities in concert with accountability grounded in standards-based reform are essential for sustained improvement and reform.**

The Science Education Partnership (SEP) aspires to help develop thoughtful, productive citizens who are lifelong learners in a rapidly changing world increasingly shaped by science, math, and technology. To this end, since 1991 SEP has worked to create active partnerships between secondary school science teachers and the Fred Hutchinson Cancer Research Center (FHCRC or the Center), connecting teachers with scientists plus the multiple resources of the Center and collaborating institutions.

The integrated components of this teacher-focused program are designed to promote pedagogical content knowledge (PCK) and foster an ongoing life science ProfLC (PLC; Hord, 1997). Working collaboratively as a community of learners, educators, and scientists, our efforts are synergistic. Through the SEP “gestalt” we engage and influence an exponentially growing number of teachers and students and promote lifelong learning for us all. However, the change process for institutions and individuals is notoriously slow (hence the long term view of the Project 2061 designers); communities develop over time, through shared experiences, not by dictate. This effort, to be successful, must be a sustained, ongoing force that becomes part of teachers’ professional lives.

Our focus is secondary math and science teachers in Washington State. We have worked with over 250 teachers and over 70% are still actively connected with our community. While the components of SEP intentionally weave to yield a rich tapestry, the three major elements, or threads, are professional development for teachers, ongoing support for teachers fostered through the kit loan program, and continual development of an active and rich science education PLC. Participating teachers learn fundamental concepts, tools, and questions of molecular biology, genetics, and biotechnology while gaining experience with the activities and investigations included in SEP kits. During the Summer Session, SEP staff and Lead Teachers work closely with participants, guiding the preparation of classroom-ready materials tailored to each teacher’s unique teaching situation. Through these interactions, participants develop content knowledge, learn from

other effective practitioners, and build a personal network of colleagues. During the school year, SEP experiences are incorporated into the classroom, facilitated by SEP kits and ongoing support. Through this ProfLC participants are supported in their own professional growth while also supporting others (Hord, 1997).

SEP Goals

- 1) To develop active partnerships that link teachers, scientists, and biomedical research institutions.
- 2) To provide teachers professional development in science content, professional practice, and leadership
- 3) To develop rich classroom learning experiences with relevant instructional materials and learning assessments
- 4) To facilitate access to essential tools and materials for active learning and hands-on investigations
- 5) To prepare scientists to communicate the excitement, challenge, and results of their work with teachers, students, and the public
- 6) To facilitate teacher and student access to scientists as role models for careers in science
- 7) To build and maintain the emerging life science Professional Learning Community through our partnerships and resources. These resources include the SEP Web site (www.fhrc.org/education/sep), newsletter, Resource Center, and important collaborations and connections with other programs locally, regionally, and nationally.

SEP Annual Cycle

Teacher Participants: We are not necessarily seeking the most prestigious teachers or those with the longest résumés; rather, we are seeking participants who are eager for experience working with a scientist, improving content expertise, and building ongoing connections with other teachers and the scientific community. Each mentor-scientist individually selects a teacher for partnership. SEP staff contact the teacher to introduce the scientist-mentor; who invites the teacher to work together and participate in SEP. This process generates a strong sense of “buy-in” for the volunteer mentors and contributes to the belief that the teacher chosen is exceptional or special.¹

¹ This streamlined selection process is commensurate with the duration of the lab research experience. In full summer research programs, interviews would be warranted.

Mentor Scientists and Collaborating Partner Institutions: Mentor scientists in SEP come not only from the Hutchinson Center, but also from 5 established and committed partner sites ranging across academia—UW Department of Genome Sciences, private research institutions—Seattle Biomedical Research Institute and the Hutch, and industry—Amgen and ZymoGenetics. In 1996, graduate students in the Molecular and Cellular Biology program (MCB) established an additional partner site and MCB students earn required teaching credit for their work with SEP. Through institutional collaboration, we maintain an engaged group of mentor scientists willing to share rich and unique research opportunities via partnerships with teachers. These partners typically share additional resources such as volunteers to help in classrooms, lab supplies and equipment, and stocks of organisms appropriate for classroom research.

SEP begins with a year of professional development that includes 16 days (~120 hours) of scheduled activities conducted by SEP Lead Teachers, SEP staff, and mentor-scientists at the Center and our partner institutions. As incentives, teachers are paid a \$500 stipend and may register for 5 graduate science credits. In our annual cycle, each new cohort of 25 teachers begins with a full day workshop in May to jumpstart the summer session. This Opening Day includes logistical information, networking, and introductory lab skills and kit training—preparing teachers for both their research experience and classroom use of SEP kits.

Mentor-teacher relationships are a key component of SEP and result in unique research experiences generally tailored to the teacher’s interests, experience, and needs. Mentors meet with their teacher on Opening day and many mentors make it a point to visit the teacher’s classroom before school’s end. These visits always prove to be an extreme reality checks for the mentors, who often have not been in a classroom in years.

In July, the group begins an intense 2.5 week Summer Session—the core of the SEP program. In the initial 3 days, all of the teachers work together in the Center’s Teaching Lab. They learn column chromatography, DNA extraction, gel electrophoresis, and bacterial transformation. During the 3rd day participants design and conduct their own experiments. SEP staff and Lead Teachers use questioning to guide the teaching, allow “wait time” for answers, encourage discussion, and look for more than one response to questions. Thus these activities match different learning styles through kinesthetic experiences, analogies, and small group discussions (Gardner, 1999; Renner, 1999). Participants build and critique models, brainstorm, practice communicating their results orally and in writing, giving many embedded assessment opportunities. Such assessments allow us to re-visit concepts and ideas that are not clear with the group or

individually, as needed. Thus the session's design and delivery model effective teaching practices, classroom management strategies, and inquiry-based learning (NRC, 2001b; Loucks-Horsley et al, 1998).

Participants then transition to working side-by-side with their mentors for 5 days in research labs at the Center and partner sites. From evidence in conversations and journals, this brief immersion experience working directly with scientists builds significant insight into the technologies, career paths, and habits of mind used in scientific research (AAAS Benchmarks, 1993; Hurd, 1997).

Upon return to the Teaching Lab, the focus shifts to students and the classroom as participants prepare or adapt class lessons customized to the specifics of each one's own teaching situation. Lead Teachers, SEP staff, and mentors help each teacher to shape appropriate class experiences and assessments. Typically SEP kits and related lessons are the starting point for many of the ensuing classroom lessons, augmented by materials from the SEP Resource Center, which includes more than 1500 books, curricula, videos, and educational software.

The Summer Session ends with an Open House where each teacher summarizes his/her work in a public poster presentation. Completing the challenging summer experience fills the teachers with a strong sense of accomplishment and membership in the broad life science research community. The Summer Session closes, as all SEP workshops do, with a written evaluation followed by a visit to the SEP surplus storeroom to select donated materials and equipment.

September Kit Signup Day and the Academic Year: In the fall, our energies shift to classroom kits and ongoing teacher support. The Kit Loan Program, comprising 30 total kits of 8 different themes, is extremely active during the academic year. Typically ~ 60% of ongoing participants annually use kits and/or supplies (augmenting their own school's equipment) and 95-100% of the current cohort use one or more kits. This translates into over 30,000 student uses of SEP kits and materials each year. Kit Signup Day includes a lively and timely research presentation. Along with the kit scheduling, the day focuses on networking, kit and lesson updates, opportunities for surplus, and use of the Resource Center. This annual meeting is effectively a reunion with ~80-100 teachers attending.

Throughout the school year, teachers are frequently in contact with SEP staff, Lead Teachers, mentors, and others within the broad SEP community. We field requests for classroom visits, technical assistance, tours, career talks, help with student questions, resources, and connections for job shadows or limited internships. We provide extensive support by e-mail and telephone.

Our newest development is The Elephant Project, a rich problem-based curriculum designed to help students discover how modern biomolecular research tools can help conserve species, in this case the African elephant. This curriculum, the product of two years' work by the Curriculum Team (including MCB students) and SEP staff, integrates Internet research, DNA analysis, and bioethical issues as students solve the mystery of a confiscated piece of ivory.

May Evaluation/Reflection Day: A key evaluation occurs in this session, required for those completing their first year in SEP, where teachers reflect on the implementation of their SEP experiences into their teaching. Teachers turn in Project revisions and short written reflections as well as completing formal evaluation instruments. Thus data for program evaluation spans survey instrument responses, journal entries, Projects, posters, Lead Teacher insights, kit use comment forms, and long-term reflections.

Program Evaluation and Lessons Learned

The Institute for Learning Innovation (ILI or the Institute), a non-profit research and evaluation organization based in Annapolis, Maryland, has been the external evaluator for SEP since 1997. ILI studies have consistently shown that SEP provides unique, highly valued professional and personal development experiences for teachers. In sum, ILI studies indicate that SEP has not only achieved many of its goals, but has developed as a program and a community in new ways that build on and advance teachers' experiences in the program.

Although there are many lessons that we have learned, we want to emphasize only one because it is the most important. The lesson emerges from advice offered very early by Bruce Alberts (now President of the National Academy of Sciences); he said, "to start small, have a passionate person direct the program, and have a steering committee that is mostly teachers help create whatever you do." Thus, while our Lesson 1 may not be original, we can now show that building a professional development program together with teachers and conceiving of it as a professional home and learning community yields powerful results.

ROLE OF THE TEACHER IN PROFESSIONAL AND PUBLIC LEARNING COMMUNITIES

Within a framework of traditional formal education, science teachers are trained in the process of education, to varying degrees in the language of science, but to a far lesser degree, in the process of scientific inquiry. Teachers, thus formed, often become

static instruments of instruction. Over years and absent further involvement with scientific professionals, pedagogy can become an end unto itself, rather than a tool to communicate scientific process. By focusing exclusively on the classroom, teachers stand to lose sight of the changing scientific landscape beyond classroom doors, and thereby risk becoming irrelevant to the public community.

Teachers can avoid irrelevancy by first understanding their role in the broad process of communicating science: that of translator. To be an effective translator, teachers must (1) remain conversant in the evolving language of science and (2) be cognizant of the needs and breadth of their audience.

As with any language, the best way to maintain fluency is to continually converse. A supportive ProfLC provides opportunities for such conversations and includes members who can explain the idiomatic idiosyncrasies of the language of science.

In a community, it is important to remember that a teacher plays before a larger audience than the students alone. Children have parents and relatives, who are members of larger groups of friends and acquaintances, all of whom are involved in daily communication, whether by example or by words.

If a teacher recognizes that he/she is the most tangible ambassador of science to his/her extended audience, e.g., a PubLC, he/she will recognize the benefit of belonging to a ProfLC.

Case Study: Tom DeVries, Vashon Island High School

Vashon Island High School, located near Seattle, Washington, has 500 moderately affluent students and three university-educated science teachers. We teach a four-year sequence of physical science, biology, chemistry, and physics. Most students proceed to two-year and four-year colleges or universities.

Our program and students have benefited greatly from my serendipitous involvement with the FHCRC-SEP program. The Professional Learning Community fostered by SEP has supported my efforts to create a Public Learning Community on my island. Each educational success on Vashon has created conditions for additional successes. As the diversity of opportunities has increased, the boundaries between formal and informal education have begun to dissolve.

The following timeline illustrates how one teacher's chance participation in SEP's Professional Learning Community snowballed into a multifaceted biotechnology program that reached out beyond the classroom to the community.

- 1995 Enrolled in two-week summer SEP program, leading to:
access to loaned biotechnology equipment and reagents
purchases of electrophoresis equipment
adding biotechnology to biology and physical science courses
second teacher enrolled in High School Human Genome Project
biotechnology speakers at evening student/parent seminars
acceptance in...
- 1996-7 Murdock summer research placement for teachers, leading to:
working side-by-side with molecular biologists
greater expertise in conducting experiments related to molecular biology
advisorial collaboration from parents in molecular biology
placement of students in internships
career advice for students
community donation of equipment
school district matching grants
local press coverage of school science program
- 1999-2000 Contacts with Peruvian biology teachers, leading to:
laying groundwork for biotechnology instruction
serendipity in 2000 meeting with Essy Levy through SEP
encouraging her pursuit of South American biotech workshops
- 2000-2 SEP curriculum development - elephant DNA forensics, leading to:
teacher serving as outreach workshop leader
personal connections with teachers in region
piloting curricula in classrooms with students as co-testers
students accepted in regional biotechnology programs
students engaged in independent DNA research activities
exposure of Vashon program nationally and internationally
potential for international cooperation at high school level
increased familiarity with biotechnology, leading to...
- 2002-3 Enrollment in University of Puget Sound's Project GROWS, leading to:
first experience with restriction enzyme work
interactions with biologists from another local university

students collaborating in gathering salmon DNA data
new restriction work on mussels with little program support

What has been evident from these experiences is that a ProfLC enlarges with every act of participation. An ever-expanding ProfLC, in turn, creates more opportunities to augment resources for the local PubLC and to build links directly from the professional to public communities. Thus, an informed public is better placed to make informed decisions about science policy and younger cohorts of the public (namely, children) are more likely to consider science as an exciting and productive career choice.

THE ROLE OF TRAVELING SCIENCE EDUCATORS: TEACHING TEACHERS IN PROFESSIONAL AND PUBLIC LEARNING COMMUNITIES

The experiences of *Biología Para Todos* in South America and Mexico serves as an example of serendipitous contacts and the combined interests between teachers, science educators and international biotechnology companies working together in the process of developing professional and public learning communities in other countries.

Biología Para Todos translated, adapted, organized and conducted interactive laboratory workshops with curriculum developed by Bio-Rad's Biotechnology Explorer Program. With the full support of Bio-Rad Laboratories Latin America and its local distributors, *Biología Para Todos*, provided instruction to university professors, secondary school teachers, teachers of technological institutes and other science educators and administrators by introducing basic biotechnology and molecular biology techniques, as well as methods for teaching these skills in the classrooms. Workshops and presentations took place in Peru, Brazil, Chile, Argentina, Venezuela, and Mexico.

This project began as an opportune meeting with the Fred Hutchinson Cancer Research Center's Science Education Partnership (SEP), specifically with Nancy Hutchinson and Tom DeVries. They expressed to us the interest of science teachers in Lima, Peru to receive instruction and training in basic molecular biology concepts and laboratory techniques. With the help of Nancy Hutchinson and SEP direct contact was made with Ron Mardigian from Bio-Rad's Biotechnology Explorer and Hector Salinas from Bio-Rad Latin America. As a result of our combined interests in reaching out to teachers in Peru and the feasibility of using already prepared biotechnology kit based curricula developed by Bio-Rad, Bio-Rad Latin America agreed to fund and support the teacher workshops carried out by *Biología Para Todos*. What began as a month long

project in Lima, Peru evolved into a nine month tour that encompassed over 20 workshops and presentations in six Latin American countries; a project with the potential of reaching out to the communities in the thousands. The following is a brief summary of the contacts established that led to the various workshops in each country and the impact that these had.

Setting up initial contacts in each country. Round one: The personal touch

A well-known characteristic of Latin Americans is their warm response to human contact. In a culture where nothing is taken for granted people require direct personal contact as assurance. No matter how many emails or faxes were sent, or how many phone calls were made it wasn't until direct personal contact was established that things got done. So much so is this human contact an imperative part of Latin America that in order to set up workshops in each country, other than Peru, two rounds of travels were necessary. The first round was done to meet directly with the representatives, professors, teachers and coordinators, and expressed to them, in person, the project, its goals and potential impact. The second round of travels was done for the workshops themselves.

Tijuana, BCN. Mexico: Before setting out to Lima Peru, an initial workshop was done in Tijuana, BCN, Mexico. This workshop was organized directly with the teachers of the Tijuana Technological Institute as a result of previous experience teaching at the institute. This offered the same opportunity for developing a professional dialog with our neighboring Mexican community as well as a means to streamline the workshops before setting out to other continents. A large workshop including teachers, professors and students from nearby research institutes, universities, training centers and medical schools in Tijuana and nearby cities was carried out and well received.

Peru: The initial contact was made directly with the teacher representatives of three schools coming from very different socioeconomic status. One was an elementary school, one a secondary school and the third, a private university in Lima, Peru. With the support of Bio-Rad representative Enrique Aguinaga, the goals, interest, and needs of each school were addressed directly and the workshops established.

Venezuela, Chile, and Argentina: For these three countries the development of the workshops was more or less the same. The initial contact was made through the Bio-Rad representatives. We would express to them the impact that this information can have as far as reaching a whole new audience that they had not considered before. In essence planting the seed for supporting the professional learning community in their country in more ways than just providing reagents and equipment to centers of higher education and research. The representatives in turn contacted their clients in universities (public and

private), technological institutes, and potential other interest groups. Meetings were set up to establish workshop goals, locations, participants and many times adaptation to the differences in teaching philosophies as well as the various political and bureaucratic maneuvers required.

Brazil: The initial contact was made with the Bio-Rad representatives. As a result of restructuring within Bio-Rad Brazil, the workshops were organized directly by the representatives and catered mostly to university and medical students, laboratory technicians and few educators. In this case, Biotecnología Para Todos functioned as the primary provider of the information to the students. The material was received with great delight.

Mexico: After the experiences in South America and as a result of the initial workshop in Tijuana, BCN Mexico, additional workshops and presentations were organized with in central Mexico. These included a presentation at a Biotechnology Conference as well as a training workshop for the Bio-Rad representatives themselves in addition to university professors and other science educator.

Round Two: The Workshops

The designed workshops provided a hands on approach in addition to theoretical back ground information for basic biotechnology and molecular cell biology techniques, as well as methods for teaching these skills. The topics included bacterial transformation, protein expression and purification, PCR amplification and analysis, DNA extraction, and DNA and protein electrophoresis and analysis.

All throughout the many countries and different workshop locations there was a constant need for flexibility and adaptability. We needed to constantly adjust to the various language idiosyncrasy between the various Spanish speaking countries, and more so with Portuguese speaking Brazil. Many times a word used in one country was an insult in another. In Brazil, a mix of Portuguese and Spanish was used (known as “porta-ñol”). Flexibility was necessary in order to adapt to the various “political” and “bureaucratic” situations of each country and institution. In addition adaptability was required to address the specific technological needs of each location. In some cases we resorted to using the immense creativity of the Latin culture such as occupying an incandescent light bulb in a box as an incubator, or a Styrofoam icebox as a temporary freezer in addition to promoting alternatives to the kits and their limitations.

These workshops were well received throughout the different countries. There was a general agreement as to the importance and impact that such dissemination of this information could achieve. As a result, many new contacts were created, dialog between

teachers, scientist and supporters (such as biotechnology companies) was promoted, and ideas for further dissemination, as well as ideas for funding, were proposed.

When all is said and done, it is the impact that one has on others that makes the difference. By the conclusion of the ever-developing project, 17 workshops in six different countries each with 15-35 participants along with four presentation to 20-60 participants had directly reached over 500 people. Most of the participants contacted are educators which themselves that can reach hundreds, this having a secondary impact in the community in the thousands. By participating in the critical process of developing a public learning community throughout South America and Mexico, Biotecnología Para Todos served as teachers to teachers in the professional learning community, promoting these kinds of interactions and opening the doors for further communication and growth.

COMMUNICATING BIOTECHNOLOGY TO AN EXILED TIBETAN COMMUNITY

In a system where the worldview is dominated by religious ideation, it is a particularly strong challenge to insist on a standard that insures religious and scientific truth be compatible. Despite this problem, His Holiness the Dalai Lama has determined concern that Buddhism be in harmony with proven scientific truth. To this end he has founded a science program that provides a series of science workshops for Tibetan Buddhist monks. As the principle leaders and information source in the Himalayan Mountains so far from urban centers of science and learning, the monks will play a leading role in communicating how biotechnology fits into their community and the world.

DNA Adventures, Inc. was asked to teach the monks a general program of biotechnology. The goal was to provide the monks with a sufficiently comprehensive understanding of biotechnology to prepare them for the task of meaningful dialogue and exchange of ideas with western scientists as well as equipping them to teach the fundamentals of biotechnology in their monasteries. In providing Buddhist monks and Tibetan scholars with information and tools to help identify connections that exist between biotechnology and Buddhism, a “safe way” can be created to effect a change in the general Tibetan community. The aim is to create an imbricated reticulum. It is a bold attempt to create a curriculum that overlaps and supports in a consistent pattern the truth science presents and the philosophy of Buddhism. This educational aim supports modernity and deters any rigidity or resistance to demonstrable fact.

An unambiguously remote setting faces one with formidable teaching challenges. Our classroom was the basement of the temple at Drepung Monastic University and had

no electricity. The temperatures soared to one-hundred degrees Fahrenheit each day and the heat compromised one's ability to concentrate, conduct experiments, or utilize the usual equipment associated with teaching biotechnology. The monks did not speak English and a translator was regularly required to communicate the course content. Perhaps most interesting of all was the strength of rumor and folklore that influence the students from such a rural environment and subvert acceptance of scientific explanations for the phenomena under discussion. During one session I was asked if ghosts also had cells.

In addition to the monks science program, DNA Adventure, Inc. independently contacted Tibetan Children's Village (TCV), a Tibetan school in India that cares for and educates orphan and refugee children. An offer to organize professional development biotechnology workshops for their teachers was received with excitement and enthusiasm. A series of steps were taken to equip the classrooms and build a curriculum.

The first task was determining how, with transportation limitations a paramount consideration, we could bring equipment and supplies necessary to furnish a quality, hands-on workshop. Once this evaluative step was accomplished the required biotechnology equipment was purchased, transported and donated by DNA Adventures, Inc. A major component of this step in the process was a fund raising art show.

At TCV, hands-on, inquiry-based workshops focused on the concepts of biotechnology. Proving that nothing in learning is as important as the desire to know, the openness and eager interest of the teachers surmounted the environmental hurdles with ease. Twenty biology teachers attended the workshops from four different TCV schools. All equipment remains at the Head Office of TCV and is safely stored at this central point allowing easy access and use by four participating Tibetan High Schools. This permits classroom teachers to effectively pass on information to their 4,500 student body.

In contrast, the sixty student monks through discussion and explanation will share the information they acquired with other monks from their monasteries and local TCV schools. Ten of the student monks reported they had direct contact with 1,000 students in a single week. Both monks and teachers will play a leading role in communicating how biotechnology fits into their community and the world.

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