From “Creating Connections: Museums and the Public Understanding of Current Research,”

David Chittenden, Graham Farmelo, and Bruce Lewenstein (eds.), Walnut Creek: AltaMira Press, 2004.

PRODUCTION ASPECTS OF PROMOTING PUBLIC UNDERSTANDING OF RESEARCH

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The characteristics of scientific research significantly impact the production of exhibitions and programs designed to foster public understanding of research (PUR). As a result, such efforts present museums with special challenges and opportunities. Drawing from PUR Conference presentations and discussions, this chapter identifies key production implications of those features and possible ways to address them.

Production Challenges

Producing exhibitions and programs for PUR is typically more complex than creating similar products based on more established science and technology. By its very nature, scientific research continually creates new findings. To capture this moving target, the time frames for production may need to be accelerated, and the products likely must include the means for continual updating. In addition, PUR producers can draw from only limited material that has already been translated for the public, and there are certainly no “cookbooks” of tested exhibits. This shortage is intensified by the technical complexity of most research today.

Because the scientific process itself is unfinished and messy, the research path may be difficult to present. Significance may be unclear without the benefit of perspective and hindsight. The relevance of new findings may not be obvious nor the implications yet clear. Unlike textbook science, where principles have been more thoroughly tested over time, current research deals with results that are far less certain. Thus PUR programs must communicate both tentative results and consequences. These uncertainties often fuel controversy within the scientific community and among the general public, leading to issues that are tricky to present because they are politically or emotionally charged.

These challenges also create opportunities, however. Because research deals with the unknown, the search for knowledge can be exciting to portray (though many steps involved may be tedious). The unfolding process lends itself to human-interest stories that capture the creativity of collaborating and competing researchers as well as their human frailties. In addition, because scientific research is an ongoing quest, the public may be able to participate through active supporting roles as well as engage in dialogue around potential implications and consequences.

Research Literacy and Production Formats

Recognizing these inherent challenges, museums can engage visitors in scientific research through a wide range of formats, each with its own production-related issues. The choice of production format depends on those aspects emphasized. Practitioners can think about enhancing three basic facets of public “research literacy”: 1) understanding the content of current scientific research, 2) understanding the nature or process of research, and 3) understanding potential research implications and consequences. For simplification, the discussion that follows is organized into these three categories, recognizing that each aspect is necessary and that any particular project may incorporate more than one. Examples are drawn from the Museums, Media and the Public Understanding of

Research conference, held at the Science Museum of Minnesota in September 2002, using case studies, poster sessions and discussions (Bossert and Ucko 2002 and see Appendix to this volume).

Research Content

Most museum-based PUR efforts have employed exhibitions and programs to communicate, translate, and create context for recent research, as with typical science content. Although the practice of presenting current science and technology findings is now receiving attention, it is certainly not new. Formats in the 19th century included international expositions and public lectures. One of my own first projects at Chicago's Museum of Science and Industry several decades ago was the *Science Alive* changing exhibition. Its goal was to present then-current science topics, such as genetic engineering and alternative energy sources, in forms easy for visitors to grasp through text, graphics and slides. This modest exhibition was eventually discontinued owing to the amount of work required to create what was essentially a three-dimensional science magazine.

Today computers and digital media allow exhibit developers not only to enhance presentation and add interaction but also to update content much more readily. For example, *ScienceNOW* at the California Academy of Sciences in San Francisco interprets headline news in the natural sciences and recent research or expedition activities of its staff scientists.[1] The changeable kiosk includes a touch-screen computer station along with a live animal tank and three vitrines for collections; cycle time for a complete change-over is one month. According to Carol Tang, senior science educator, this kiosk costs only $10,000 to update annually, including portions of salaries for seven staff, following an initial $35,000 investment for design and fabrication. Despite modest cost, this format requires the efforts of a dedicated interdepartmental team that meets weekly, and appears most successful when topics relate to major exhibitions. Their project demonstrates that quick turnaround can be accomplished through strong infrastructure, established graphic and stylistic templates, clear duty assignments, institutional commitment, and organization. Elsewhere, at the American Museum of Natural History in New York, changing video kiosks are used to keep permanent halls up to date. Their *Science Bulletins* are based on high-definition video, which raises cost but also production quality.[2]

An alternative format can be entirely programmatic, such as MIT (Massachusetts Institute of Technology) Museum's monthly two-hour FAST (Family Adventures in Science and Technology) program, which highlights new research areas, academic departments or projects.[3] Museum staff recruit faculty and students from MIT groups and departments who help develop demonstrations to illustrate their research and related activities. This format, which can be programmed to create synergies with permanent or traveling exhibitions, is facilitated by a close relationship between the campus and the museum. The Tech Museum for Innovation in San Jose does not share that advantage and must recruit scientists from local universities and nearby industry for its *Curiosity Counter*, which offers a similar type of forum.[4] The Tech also hosts special events for area researchers to showcase their work. On an even larger scale, SWR-ARD public television in Germany has organized "science markets" with local universities where many research institutes display their work, and scientists can meet the public in a popular setting. These types of events of course can be staged by museums as well. Purely programmatic formats such as these, often facilitated by partnering with other organizations, can be the most flexible and relatively inexpensive, depending on scale.

Some current science formats focus on specific content areas, such as *SpaceLink*, which serves as a space science and astronomy update center at the Maryland Science Center.[5] Equipped with many different audiovisual sources that can be displayed on large screens, it is part media center, part newsroom and part discovery room. According to president Greg Andorfer, its most important resource by far is staff, who include space science educators, amateur astronomers and community volunteers. In addition to teacher seminars and class programs, *SpaceLink* hosts events with guest scientists to highlight mission milestones and space-related anniversaries. Based on positive visitor response, this approach is being extended to other content areas with *BodyLink* and *TerraLink*.

One of the most ambitious examples is *Antenna*, a constantly changing exhibition devoted to science and technology news at the Wellcome Wing of the Science Museum, London.[6] Using a flexible exhibit case and graphics, four "rapids" convey "bite-size" news stories, with one renewed each week. A larger-scale "feature" gets changed every four to six months, allowing somewhat more leisurely development and greater depth. Exhibition treatment is consciously "edgy" to attract the greatest amount of public interest and media attention. These exhibits are complemented by Antenna Live, a BBC science news feed; Antenna Events, featuring scientists behind the headlines; and Antenna Web. Collaboration with the scientific journal *Nature*, the first of its kind for a museum, has been critical to obtaining "hot" news early.

The *Current Science and Technology Center* at Boston's Museum of Science represents a corresponding major investment in the United States (see Section 5 of this volume).[7] This installation uses live presentations supported by a sophisticated system comprising a server and 35 networked computers that control 17 live cameras, three news tickers, 18 audio inputs, a satellite feed, seven touch screens, six plasma screens, sound and lighting. Museum educators, scientists, and multimedia producers write and produce daily updates as well as program the presentations and events. Despite technology and back-of-house support, audience impact still depends heavily on the talent of the presenters and their ability to engage visitors in technical subjects. Few museums can afford such large-scale undertakings; as Tim McElroy (Liberty Science Center) commented at the PUR Conference, the staff requirement alone is "humbling to contemplate."

Whether on a small or grand scale, production of content-oriented PUR exhibit elements can be facilitated through the use digital media based on templates in which new topics and information can replace previous ones with reduced labor and expense. Similarly, creating larger exhibitions in modules allows elements to be replaced or modified without the need to replace everything. Use of templates and modules also facilitates sharing between institutions and helps mitigate the trade-off of quality reduction inherent in a more-rapid production cycle.

The use of digital content and live presentations allows more rapid updating than traditional methods. Yet the key question remains: How current should the "current" science be and what should be the turnover frequency? Don Pohlman (Science Museum of Minnesota) raised an important point at the St. Paul conference: Is PUR too focused on the news? Museums may be better off presenting topical issues that need refreshing less often than breaking news items, which may require daily change. After all, the core business of museums is interpretation and education, not presentation of the most recent developments, which is the primary province of the media. One possibility, consistent with a longer view, is production of a *Consumer Reports*-style annual review and analysis of scientific research for the public.

Museums must present current research in ways that differ from, complement, and expand upon other information sources. Providing “added value” is especially important in the content realm, since the Web offers many sites geared towards translating new scientific developments for general audiences. As described in the following sections, it may be in the area of presenting the process and consequences of research that museums have the greatest potential.

Research Process

The research process can be difficult for museums to document and to present. Formal science communication through peer-reviewed journals sanitizes the underlying research, revealing little of the actual day-to-day process or the personal aspects. Nevertheless, several exhibitions have been developed addressing this focus. *Catching Science in the Act: Mysteries of Çatalhöyük* by the Science Museum of Minnesota looks at the social interaction among scientists in which ideas get tested through the informal exchange of information. It is based on a Neolithic archaeological excavation in Turkey, where the dig site veranda became a featured exhibit element (see Section 5 of this volume for pictures and description). In addition, a graphic style adapted from cartoons employed word bubbles to convey the conversation and thoughts of archaeologists and other site staff.[8] Earlier examples are *Inquiry* at Chicago's Museum of Science and Industry (Ucko 1985) and *Investigate!* at Boston's Museum of Science.[9] The greatest challenge here is making the abstract and technical process of scientific research relevant and engaging to visitors through the exhibit format.

Museums can learn a great deal from the media, which are well suited to portray the human side of research. As Nancy Linde (NOVA; see Section 6 of this volume) pointed out at the PUR conference, science makes wonderful drama, and such stories spell success in the television medium. It is hard to tell research-based stories involving dramatic tension in the nonlinear exhibition format; museums can incorporate media techniques to assist. For example, *Windows on Research: Nanotechnology*, a forthcoming exhibition by the Lawrence Hall of Science at the University of California, Berkeley, will make use of interactive stories and multimedia based on scientist interviews to convey the process carried out by teams of researchers. Connections with media are explored further later in this chapter.

Another very different PUR format involves virtual field trips to the laboratories and sites where scientific research actually takes place. Since 1989, the Jason Project has been connecting museums, schools, and other sites via satellite, telephone and now Internet to an annual expedition led by researcher Robert Ballard in locations around the globe.[10] Their slogan is "Real Science, Real Time, Real Learning." Only live for two weeks each year, the program can be extended over the school year through accompanying classroom curricula. In contrast, the Liberty Science Center stages daily visits to a working surgical suite with *Live From…Cardiac Classroom*, in which groups of students communicate with medical staff via two-way videoconferencing.[11] According to director of educational technologies Tim McElroy, taking students into medical and research settings works best as a 1.5- to 3-hour dedicated experience rather than as a brief drop-in component within a larger exhibition.

The Exploratorium in San Francisco has created a program based on scientific research settings worldwide, including Antarctica, Belize and Geneva (CERN) as well as remote eclipse-viewing sites, which are difficult for the public to access directly. *Live@Exploratorium* offers webcasts mediated by studio audiences on the museum floor.[12] The science center serves as an intermediary and interpreter in providing linked visitor and Web experiences. Executive associate director Rob Semper indicated at the conference that the key issue yet to be addressed for this Web-based program, as with many others, is financial self-sustainability. A less-costly approach has been taken by Science Center Torino through its *LAB-VR, Virtual Access to Research Labs*, where viewers can "tour" over 30 research labs in Turin, Italy.[13] The lack of any human presence, however, makes this type of online visit less compelling.

Perhaps the most effective way for the public to understand the process of scientific research is to engage in aspects of it themselves. That is the principle behind science fairs (assuming the student, not the parent or advisor, does the work!) and inquiry-based science learning (National Research Council 2000). Inquiry-oriented activities involve visitors in the scientific process through asking questions about aspects of the world around them, planning and conducting simple investigations, using data to construct reasonable explanations, and communicating results. One museum example was *Living Labs*, a 45-minute research experience for visitors at the Hall of Exploration at the Columbus Center, a research facility of the University of Maryland Center of Marine Biotechnology. Led by graduate student BioGuides, groups of visitors screened actual marine chemicals for their ability to emulsify oil, an activity relevant to the adjacent Chesapeake Bay. Although well received, this program could not sustain sufficient public interest in visiting this working research lab; the science center portion closed after only five months. Former co-director Carol Bossert observed at the PUR conference that tours had not turned out to be practical for providing behind-the-scenes experiences to visitors. This unfortunate outcome supports the case for visitor involvement with research rather than simple observation of others.

Natural history and other museums that carry out their own scientific activities have an advantage in finding ways to involve the public in research programs. Such institutions may offer visitors, students, and volunteers the opportunity to serve as “research assistants” at the museum or through field trips to research sites. Other museums will need to identify area research scientists with whom they can create programs relevant to local interests, such as water quality. Such programs can both provide the means to involve visitors in carrying out meaningful research functions as well as strengthen the museum’s civic engagement, supporting a recent call to action by the American Association of Museums (AAM 2002).

Involving the community at large in research is the basis for “citizen science” programs, such as the *Colorado Spider Survey* of the Denver Museum of Nature and Science.[14] It encourages residents across the state to collect, identify, and systematically report the spiders they find in diverse ecological niches. Or, as an alternative to creating their own programs, museums can consider working with national efforts such as *Project FeederWatch* of the Cornell Laboratory of Ornithology.[15] Here students collect information about birds and their environments following specific protocols; the data get sent via the Internet to Cornell, where scientists use it to assess changes in bird population distributions and the spread of infectious diseases. Director of education Rick Bonney noted at the conference that their programs have engaged over 100,000 citizens in research on biology, ecology, and animal behavior.

"Hands-on-research" programs, whether organized by museums or other organizations, can help make scientific research relevant to people's lives. They fit extremely well with science center expertise in creating and marketing hands-on activities in general. Successful implementation requires identifying engaging tasks that the public can carry out with limited time and training. Most museums will also need to find appropriate scientific partners for helping guide the research and evaluate the data. These types of programs will have greatest value when participants can actually contribute in a small way to meaningful research.

Research Implications

The newest and most challenging role is for museums to serve as places for discussion and debate on the complex issues derived from current research. The critical nature of this task was underlined by Cornelia Dean (*The New York Times)*: "Today, more and more of the day's political issues involve scientific questions [such as] stem cells, antimissile defense, nuclear waste disposal, and other topics. So as our job gets more difficult, it gets more important" (see Section 6 of this volume).

For many years, museums have offered talks in which scientists describe their research and its implications. Such presentations, whose impact is highly dependent on the researcher's ability to translate her work and its consequences for the public, can now reach much larger audiences at low cost through webcasting. Presentations also may include various degrees of visitor involvement. For example, partnering with Adrian Ivinson from the Harvard Center for Neurodegeneration and Repair, Carol Lynn Alpert at Boston's *Current Science and Technology Center* created a program on xenotransplantation (moving cells, tissues, or organs across species) based on a dialogue between two speakers, one representing expert opinion and the other acting as devil's advocate. The audience was asked to vote on key issues both before and after the presentation of scientific, medical, and ethical arguments. Ivinson noted at the conference that the topics that work best are those that audiences can identify as relevant to their own lives or communities and those that include significant drama, excitement, controversy, or "yuck factor." He cautioned, however, that this format might not be suitable for all audiences because they must be willing to both think and listen.

Theater provides an excellent format for dealing with the implications of scientific research. The recent popularity of Michael Frayn's play *Copenhagen*, which deals with a WWII meeting between physicists Niels Bohr and Werner Heisenberg, is encouraging. It demonstrates a significant willingness by the theater-going public to attend dramatic productions based on scientific topics and their consequences. Targeting a younger audience, The Wellcome Trust (United Kingdom) has funded performing arts and interactive children's theater, including a National Festival of Science Drama for secondary schools, to stimulate debate on issues raised by advances in biomedical research.[16] For museums to incorporate theater programs requires skilled actors on staff or contract to perform on a stage or the exhibit floor. Finding or creating well-written scripts that engage audiences in technical subjects is no easy undertaking, however. Neither is producing these performances on a limited budget. The International Museum Theatre Alliance provides an entry point for exploring this form of emotionally engaging programming.[17]

European science museums have gone farthest in establishing themselves as centers for empowering citizens on issues arising from current research by means of forums, debates, and conferences. François Vescia (La Cité des Sciences et de l'Industrie, Paris) explained at the conference that since science and the public have both changed, the role of mediators, such as museums, must change as well. La Cité has responded by creating a program of regular debates, conferences on science and society issues, and participative conferences with an emphasis on life sciences, information technology and the environment.[18] In a similar vein, the Deutsches Hygiene-Museum in Dresden, Germany organized a nationwide Citizens' Conference on Genetic Testing.[19] This forum involved 19 citizens randomly selected from a pool of 10,000 who met with scientific experts, formulated recommendations and discussed them with decision makers.

The *Café Scientifique* is a more informal format that takes place in bars and restaurants as well as cafés, primarily in the United Kingdom and France.[20] For the price of a cup of coffee or a glass of wine, anyone can join a scientific expert in exploring the latest ideas in science or technology. The goal of these gatherings is to make science accessible and promote public engagement through an appealing forum for debating scientific issues. Whether it occurs in a museum or more casual setting, this aspect of fostering PUR offers an opportunity for many institutions to extend their audiences beyond children and youth to adults.

Compared to several of their overseas counterparts, U.S. museums have limited experience in dealing with controversy, and most have deliberately chosen to stay away from doing so. Yet much of current research deals with "hot" topics that stimulate debate. They may raise moral issues, particularly among the 59% of those the United States for whom religion "plays a *very* important role" in their lives (PEW Global Attitudes Project 2002). These strong feelings became evident while conducting a front-end study for a new National Academy of Sciences museum being planned to address controversial current issues. A significant number of respondents strongly opposed topics that others had ranked high because they suspected the museum would present a point of view different from their own. Such topics need to be portrayed in ways that help audiences view science as a necessary but not sufficient tool for guiding personal decisions and national policy; many other factors typically must be considered as well.

Formats based on the implications of research such as those described provide another way for museums to increase their community involvement, particularly if they focus on local science- and technology-based concerns. Raising an institutional public profiles in this way entails some risk, but serving as a neutral public forums for engaging and informing citizens on critical regional issues can only increase the value and importance of museums. In this way, they can become much more than places to visit occasionally for an enjoyable educational experience. Museums can transform themselves into community centers in the truest sense.

In summary, the following list identifies the strengths and challenges associated with each of the main PUR production formats:

Research Content

Exhibitions represent the primary museum medium and strong suit.

- But they require frequent updating that may be staff intensive.
- Digital media and modularity can reduce time and cost.

Examples: ScienceNOW, Science Bulletins (kiosk); SpaceLink, Antenna, Current Science and Technology Center (large)

Programs provide the most flexible format and are relatively inexpensive.

- But they require skilled presenters who may be hard to find and train.

Examples: FAST, Curiosity Corner

Research Process

Exhibitions (see Research Content above)

- But the process may be difficult to portray effectively.
- Using story-telling techniques and media may help.

Examples: Çatalhöyük, Inquiry, Investigate!

Virtual field trips make distant research settings accessible.

- But access and interaction may be limited.
- Using live staff to mediate increases impact.

Examples: Jason Project, Cardiac Classroom, Live@Exploratorium

Hands-on research engages visitors in inquiry-based learning.

- But finding meaningful activities and partners may be challenging.

Examples: Citizen science (Colorado Spider, Cornell Ornithology)

Research Implications

Programs (see Research Content above)

Theater offers an effective format for raising issues.

- But integrating quality art and science are difficult.

Examples: Copenhagen, Wellcome Trust

Forums, debates and conferences provide important community forums.

- But dealing with charged, controversial topics is challenging.
- United States museums can learn from their European colleagues in this area.

Examples: La Cité College, citizen’s conferences, Café Scientifique

Overall, in selecting formats for addressing PUR, museums should assess what their strengths are, where their impact can be greatest, and how their efforts can best complement those of others. Based on these criteria, two directions appear most fruitful. By engaging the public in meaningful hands-on-research activities, museums can build on their expertise in hands-on learning and make effective use of inquiry-based learning techniques. By providing forums for discussing research implications, they can build on the community respect their institutions hold and further civic engagement. Both these roles fill important niches not generally filled by other organizations and supplement the PUR programs available through news media, television documentaries, and the Internet.

Of course, such efforts do not occur in isolation. Museum planners would do best by connecting and integrating diverse PUR experiences throughout their facilities. Exhibitions and other types of programs can effectively complement hands-on research and community forums. All these activities can be enhanced through partnering with scientists and the media as described in the following section.

Role of Scientists and Media in Production

In addition to the general concerns for staffing and funding, development and implementation of PUR exhibitions and programs, as just noted, carry additional requirements of timeliness and the communication of complex, changing content and issues. By working closely with scientists and the media, museums can find ways to mitigate these complicating factors.

The characteristics of PUR efforts make them nearly impossible to create and deliver without collaboration. Scientists, who conduct the research and produce the ongoing results, are obviously essential as sources for content and process. They are also needed to provide different points of view on research findings, especially since the tentative results have not yet withstood the test of time nor have the researchers necessarily yet become established.

The media also bring valuable resources that support museum-based PUR efforts. Science news organizations follow the hot areas of research. They offer the potential to access human-interest stories and interviews, as well as images, video, and computer graphics having high production value. Partnering with news sources may eliminate or reduce the need to create a separate museum news bureau, an investment few museums should consider. The media offer multiple channels that can complement, reinforce, and potentially cross-promote museum PUR programs. Museum forums and debates, particularly those that focus on community issues, lend themselves to media coverage and partnership.

Most conference participants would agree that the meeting in St. Paul was a step toward breaking down barriers among museums, researchers, and media but that further efforts are much needed. Mark Shelley (Sea Studios) noted that many of us seem to still be living on "different planets." What is needed is a common mutual understanding of how each field can benefit the others, demonstrating value that aligns with mutual self-interest. As noted by Tobias Wolff, exhibition manager for the Universum Science Center in Bremen, Germany, which is adding a current-science issue area to its new Visionarum wing, the museum, media, and university scientists each can benefit in the following ways[21]:

Benefits for Visionarum: Current science news; newspaper articles, pictures; film material from science programs.

Benefits for Media: Forum in a science leisure facility; "playground" for material evaluation; scientist network.

Benefits for Scientists, University: Public understanding of science; presence in the media; reputation.

Further potential benefits provided by museums to the media include added opportunities for dissemination; a setting for focus groups, screenings and other means for obtaining public input; a venue for events with an opportunity to greet audiences and supporters in person; a source for on-air, issues-based programming; and complementary public programs with local connections that enrich and cross-promote media offerings.

Additional potential benefits to scientists include a vehicle to help recruit undergraduate and graduate students, a source for volunteer research assistants and data through citizen science, the means to satisfy grant requirements for education and public outreach, and further ways to become involved with their communities.

Scientists

Some museums, especially some natural history museums, have an easier time involving scientists in production because they are on staff. In several, staff hold joint appointments as research faculty (such as the Adler Planetarium, where four astronomers are affiliated with the University of Chicago and two with Northwestern University) and thus can facilitate contact with other faculty. The small numbers of university-affiliated museums, such as the MIT Museum, obviously have ready access to campus researchers, although only a fraction will be willing and able to become involved. Most museums, however, must seek out and recruit partners from university, corporate, and government research institutions in their communities.

But who should be recruited? If the scientist is to be a content source, this question gets answered based on the importance of her work, potential audience interest in the topic and a willingness to participate. If the scientist is to play a more visible role, other requirements become paramount. Scientific expertise may not translate into communication skills to lay audiences without training–or at all. Unfortunately, there are few formal programs such as the Aldo Leopold Leadership Program for environmental scientists who want to be more effective communicators. Some conference participants made the case for working with mature scientists, who may face less pressure to publish. Others argued for graduate students, who are closer in age to younger audiences and who would benefit by learning early in their careers the value of science communication. The answer ultimately depends on the researcher's priorities and commitments, as well as background, skills, training, and personality.

How to find scientists? The paths from museum to researcher and from researcher to museum are not well defined. The conference revealed the value to museums of university public information officers or press officers, who can serve as guides to university scientists on campus. Aligning that field's Science Communicators conference to coincide with the annual Association of Science-Technology Centers (ASTC) conference was suggested. Some universities, often those with extension services, have excellent science outreach programs already. The University of Wisconsin's Why Files is an outstanding Web-based example.[22] Among the lessons its editor Terry Devitt shared in St. Paul were to: 1) pick a niche, 2) keep looking for the edge, 3) take risks, and 4) humor is power. Another route to scientists can be through the local chapters of Sigma Xi, the honorary research society.[23] Although corporations may first come to mind as donors and sponsors, they can also be sources for cutting-edge research scientists as in the biotech and information technology industries; in fact, relationships with research staff are likely to improve long-term funding prospects. Connections can and should also be made at an institutional level nationally, such as by linking content-rich organizations like The National Academies with audience-rich museums (Ucko 2001). One such effort, being led by the emerging National Health Museum in Washington, DC is the creation of a National Public Health Partnership,[24] whose goal is to link the resources of the public health community with museums and science centers.

A less-obvious possible source of scientists for museums might be the Society for Amateur Scientists, which promotes citizen-science activities.[25] Another nontraditional channel is offered by the new generation of "science shops," more common in Europe where they are linked to universities.[26] In contrast with academic or corporate research centers, science shops assist or carry out socially-oriented, community-based research projects in such fields as environmental issues, energy conservation and public health. In the United States, the Loka Institute, a nonprofit research and advocacy organization concerned with the social, political and environmental repercussions of research, science and technology has identified approximately 50 community research centers.[27] The potential for this type of partnership will depend on the willingness of a museum to engage in advocacy along with education.

One of the challenges of working with scientists and other content experts raised at the conference by Bronwyn Terrill (Dolan DNA Learning Center, Cold Spring Harbor, NY) is that stakeholders may grossly overestimate the amount of information that an exhibition can actually convey. Thus, establishing realistic expectations upfront is critical. Because researchers may not make the best presenters, many museums have instead used staff, actors, and others in that role, choosing to train them in science. Each application must determine whether actual scientific research experience or presentation ability is most critical for a particular program, since the combination is uncommon. Finally, nonscientist experts may be essential, especially for programs based on the implications of research, where humanists, social scientists, and clergy become valuable participants.

Media

Despite their differences, print, television, radio and Internet media share common production characteristics. For most, the time frame is far more rapid than museums. Media channels are proprietary and competitive, seeking to “scoop” their rivals on breaking developments. As emphasized at the conference by Cornelia Dean *(The New York Times)*, the focus for news media is clearly information, not education. For most publications, “entertainment” value is also a vital factor.

These features complement museum PUR efforts and as noted provide resources that can enhance production and reduce cost. But for museums to take advantage of media products, they first need to better understand the media field and potential barriers to working together. As explained to PUR conference participants by Eliene Augenbraun (ScienCentral), corporate and legal issues relating to fees, internal approvals, liability protection, branding, and intellectual property rights can stand in the way of sharing materials and require considerable persistence to overcome. These issues should be addressed early in development of media projects to allow appropriate permissions to be obtained or perhaps even produce museum-based versions at the same time to lessen expenses. Walter Sucher of Germany’s SWR public television also pointed out that exploratory discussion between potential partners over “versioning” could ultimately lead to fruitful collaboration.

Some types of media-related museum activities offer fewer constraints, such as building on existing national shows like NOVA using local researchers to answer questions from the most recent program, to give related demonstrations, to discuss issues raised, and so on. In fact, local PBS stations may be willing to cross-promote these kinds of mutually beneficial educational programs.

In addition to gaining access to science news and research-based resources, museums can learn from media experience. Incorporating an emotional component, a media strength, into museum exhibitions and programs would enhance their impact. The three critical elements, as noted at the conference by NOVA's Nancy Linde, are "story, story and story." Although museum visitors do not have a remote control allowing them to instantaneously flip channels as attention wanes, they are certainly free to walk away from less-than-engaging exhibits or activities. Adding the emotional "hook" advocated by Linde reduces that risk.

Museums can also learn from media audience research, marketing studies, and program evaluation. For example, based on a survey of listeners to the 90-second Earth and Sky radio segments, Marc Airhart recommended: 1) focusing on people and process rather than simply results, 2) explaining the relevance of new scientific findings, and 3) presenting themes rather than simply news. Although not earthshaking, these findings support the knowledge museums have about their audiences from other sources.

Collaboration, termed an "unnatural act" by some, requires overcoming multiple barriers whether based on working with scientists, media, or other museums. As noted by conference-goer Christine Roman, whose St. Louis Science Center participated in the Mississippi RiverWeb℠ Museum Consortium (along with the University of Illinois National Center for Supercomputing Applications, the Illinois State Museum, and the Science Museum of Minnesota), concerns included a long learning curve (everyone had to become a learner in new areas), cultural differences, the difficulty in creating common understandings of design and production process, and decision-making issues. Had a media partner been included, additional issues undoubtedly would have been raised as well. Training in how to build a collaboration based on best practices would likely have helped.

The ideal relationships with scientists and media are ongoing, institutional, and long term rather than project based. Such interactions naturally take time to develop and nurture. One participant noted that continuity is essential because it takes time to understand audience needs, establish connections, build trust, and just make things happen.

Regional and National Production Strategies

In addition to one-on-one partnering, regional and national interactions could significantly enhance PUR production efforts. For example, Susan Norton (Science Channel, Discovery) suggested to conference participants that museums could host monthly or quarterly meetings in their communities involving researchers and media representatives, creating forums and networks for sharing information and resources. Regional directories would be beneficial as well.

PUR consortia, like exhibition consortia, could enable participating institutions and organizations to each develop resources for sharing with other members, leveraging individual efforts. Products might include programs, scripts or changeable exhibit modules, with an opportunity for customizing by each institution. One suggestion was for ten museums to develop and share materials on ten different topics to support presentations by local experts. Agreement on common frameworks and standards would facilitate such exchanges. A series of PUR kits based on a template might even be feasible; kits could include objects, digital media, scripts, contacts for scientists, and promotional materials.

Finding ways to help small museums address PUR is a major need. One idea is that large museums could produce products for dissemination to smaller institutions where they can be tailored to their needs. The creation of national PUR centers with specialties in particular areas, like National Science Foundation-funded scientific research centers, would be another approach for producing materials for wide dissemination.

Another good idea is the formation of “intellectual alliances,” suggested to the conference by Rob Semper, which would increase communication and interaction across professions. Such alliances could be furthered through such mechanisms as

- website for posting information, article and, projects;
- electronic mailing lists and cross-registration on existing lists;
- Internet newsgroup;
- printed publications and cross-disciplinary articles in existing ones, such as regular columns in *ASTC Dimensions*, *Science,* and media publications;
- regular national conference and PUR threads in existing museum, scientific, and media conferences (including the World Congress of Science Producers); and
- national PUR organization and special-interest groups within existing ones, such as the American Association for the Advancement of Science (AAAS), whose annual conference already includes both scientist and media participation.

Through these and other means, each profession could exchange information with those interested in PUR, facilitating resource sharing and collaboration. Another way to encourage cross-fertilization would be through internships or fellowships in which museum staff devote a period of time to working in a research or media setting. Professional development programs could serve a similar function of breaking down barriers. Sharing best practices both within and across fields would also be valuable.

Museums would clearly benefit from the creation of some form of national PUR clearinghouse to enable sharing a wide range of information and resources, such as

- contacts and interested organizations;
- content, background research, and interviews;
- graphics, photographs, and other images;

- computer animations and simulations;
- audience research and evaluation data;
- audio and video clips;
- exhibition and program information and demonstrations; and
- educational curricula.

Such a clearinghouse, say in the form of a searchable database or archive, could reduce duplication of efforts, production time, and costs even if only a portion of this "shopping list" were implemented. Its creation raises many questions yet to be answered, however: Who would run it? How would it be funded? How could we deal with competition and intellectual property rights? How does it ensure accuracy and quality? Suggested homes for such an enterprise include the National Science Foundation, National Institutes of Health, Association of Science-Technology Centers, or a new organization similar to a newswire service, ideally international in scope. A peer-to-peer computer file sharing system, such as Napster or Kazaa, was also proposed as an alternative that would eliminate the need for maintaining a central database.

"Matchmaking" is a related valuable function. It could occur passively, as in the giant-screen film industry where the status of various projects gets regularly communicated, indicating where they are in the production pipeline. Museums, media, and researchers interested in participating in a PUR project could then choose to make contact. More active models are ProfNet (Professors Network),[28] which links reporters with expert sources through university public relations and information officers, and the Sigma Xi Media Resource Service[29]. This kind of approach could be broadened to connect researchers, museums, media, and funders interested in PUR topics or projects. For example, it might match scientists who have education and outreach funds available with potential museum partners.

Involving others in addition to museums, scientists, and media would further enhance the impact of PUR programs. As previously noted, collaboration can be difficult but rewarding. Educators at different levels are essential, to create curricula that relate museum and media PUR programs to classroom activities. Libraries could support local or national themes through complementary programs. Although more limited in number, science writers and their national association are another possible resource.

In conclusion, this overview has presented a range of measures and strategies for producing exhibitions and programs designed to foster PUR. The following is a summary of key museum recommendations:

- Identify the most appropriate mix of the components of "research literacy" (content, process, implications) based on audience, project and institutional needs.
- Employ digital media, templates and modularity to facilitate updating and sharing content communicating new research developments.
- Present hands-on research through such programs as citizen science to engage the public in meaningful research experiences.
- Consider creating forums for discussing the issues raised by current science and technology as a means for civic engagement.
- Explore recruiting researchers through diverse channels, including university public information officers and community research centers.
- Nurture long-term media partnerships to create synergies as well as to obtain resources for enhancing production and reducing cost.
- Form or join a regional consortium to share material development and production.

- Establish connections and communications that break down barriers between organizations and institutions involving scientists, media, educators, and others involved in PUR activities.
- Support efforts to create a national clearinghouse and related mechanisms for sharing and disseminating information and resources.

Identifying production strategies such as these is just the beginning. Which ones individual institutions and national organizations choose to pursue, and ultimately how their audiences respond to those efforts, will determine the success of the emerging PUR endeavor.

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[1]http://www.calacademy.org/science_now/ (04/03/03)

[2]http://sciencebulletins.amnh.org/ (04/03/03)

[3]http://web.mit.edu/museum/programs/fast-sunday.html (04/03/03)

[4]http://www.thetech.org/exhibits/Co_cam.html# (04/03/03)

[5]http://www.mdsci.org/exhibits/spacelink/index.cfm (04/03/03)

[6]http://www.sciencemuseum.org.uk/wellcome-wing/antenna/index.asp (04/03/03)

[7]http://www.mos.org/cst/ (04/03/03)

[8]http://catal.arch.cam.ac.uk/catal/smm2001/ (04/03/03)

[9]http://www.mos.org/exhibits/current_exhibits/investigate.html (04/03/03)

[10]http://www.jason.org/ (04/03/03)

[11]http://lsc.org/cardiac/cardiac.html (04/03/03)

[12]http://www.exploratorium.org/webcasts/archive.html (04/03/03)

[13]http://www.torinoscienza.it/lab-vr (04/03/03)

[14]http://www.dmns.org/spiders/ (04/03/03)

[15]http://www.birds.cornell.edu/whatwedo_citizenscience.html (04/03/03)

[16]http://www.wellcome.ac.uk/en/scs/activities.html (04/03/03)

[17]http://www.mos.org/learn_more/imtal.html (04/03/03)

[18]http://www.cite-sciences.fr/francais/ala_cite/college/ (04/03/03)

[19]http://www.buergerkonferenz.de/pages/start_en2.htm (04/03/03)

[20]http://www.cafesci.org/ (04/03/03)

[21]http://www.smm.org/pur/documents/digital_posters/Universum.doc (04/03/03)

[22]http://www.whyfiles.org (04/03/03)

[23]http://www.sigmaxi.org/chapters/lists/index.shtml (04/03/03)

[24]http://www.nationalhealthmuseum.org/initiatives/nphp/ (04/03/03)

[25]http://www.sas.org/ (04/03/03)

[26]http://www.bio.uu.nl/living-knowledge/ (04/03/03)

[27]http://www.loka.org/crn/cbr.htm (04/03/03)

[28]http://www2.profnet.com/ (04/03/03)

[29]http://www.mediaresource.org/index.shtml (04/03/03)

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