



Envisioning the Future of Scientific Research Libraries : A Discussion

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The Banbury Center at Cold Spring Harbor Laboratory

Envisioning the Future of Science Libraries At Academic Research Institutions

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White Paper

Envisioning the Future of Scientific Research Libraries: A Discussion

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Table of Contents

Executive Summary	3
Abstract	4
Business Case	4
Background.....	4
The Issue	6
The Challenges	7
Challenge 1: Visions for a Sustainable Future	7
Challenge 2: Current State of Staff Skill Sets.....	9
Challenge 3: Redefining “Valued” Library Services	11
Challenge 4: Data Management	13
Challenge 5: Partnership Versus Servitude	14
Challenge 6: Research and Education (Beyond Info Literacy)	15
Challenge 7: Preservation of “Scientific Legacy”	16
Challenge 8: Library’s Role in Publishing Services	18
Challenge 9: Radical Collaboration.....	19
Challenge 10: Support of Open Access	20
Future Directions.....	21
Conclusion	22
Appendices	24
Appendix A - Meeting Participants and Contributors	24
Appendix B – Banbury Meeting Follow-Up Survey	26
Appendix C – References Cited	28
Appendix D – Other Resources (arranged by challenges)	29

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Executive Summary

A group of library leaders, scientists and administrators met to envision the future of scientific research libraries. The group examined how the world of research is changing and what impact these changes will have on libraries and librarians. An outcome of this meeting was the crafting of ten challenges impacting the vision of the 21st century research library.

The library and librarians have always been at the crossroads of information. However what "information" is, what it means, and how it is collected, curated, used, and disseminated is evolving as is the world in which scientists work. For example, there are constant advances in technologies, research is becoming more collaborative and the move toward "open data/open research" is reshaping the ways scientists conceptualize and carry out research. Librarians have been asked to manage a growing volume of data and published content, various flavors of open access, new forms of scholarship (data), to curate massive data sets while at the same time facing shrinking resources. The changes are not just in research and the academic world but everywhere attitudes are changing about how information is found and managed. Rapid growth of external competition for information search services is diverse (e.g. Google) along with competition from publishers, software companies, and solutions implemented by the researchers themselves to their disciplines.

Even archives, the most traditional area of information science, has morphed with technological advances and document format changes from print to "born digital" documents which has radically altered the role and function of archives. This is the role that is now being assimilated into research library services. The following are a few activities in which libraries have become involved in recent years and are likely to become more involved in the future.

Twenty-first century library leaders will be bolder, more entrepreneurial and savvy about transforming organizations. Libraries will pursue grant funding to help supplement their budget. Library leaders and their staff will develop the necessary expertise (e.g. in-depth science background) to enable librarians to 'get out of the library' and integrate their services and skill sets into the researchers' workflows (Science Informationist Model). Librarians will become key collaborators with the researchers. Librarians will be involved in the analysis of research impact, including the use of bibliometrics for impact assessment.

Libraries are the logical place to archive an institution's scholarly output, and are better positioned in terms of technical expertise than any of the university's other departments. Librarians will engage in data stewardship, as much to document and verify advances in knowledge as to protect and preserve potential new ways and things to learn from that data.

In the 21st century research institution, librarians/science informationists will play many roles: collaborator, educator, consultant, data manager, developer and preserver of metadata standards and ontologies, a connector, and the curator of the institutional identity.

Abstract

A group of librarians, other information professionals, scientists and research administrators met to discuss the challenges that research libraries are currently facing. After the meeting a survey was conducted to obtain additional input from the group on several key challenges that arose from the discussions. The purpose of the meeting and survey was threefold:

1. Examine in detail, from a variety of perspectives, how the world of research is changing and the impact these changes have on the direction of research libraries.
2. Create an informed vision of how research libraries can be a vital partner to researchers.
3. Suggest a strategic approach for realizing this vision.

The strategic approach presented in this white paper incorporates feedback from various sized research libraries, each with its own mission. The expectation is that individual libraries will use it as a guide in formulating strategies that are appropriate to their research communities, financial circumstances, and organizational reporting structure.

Business Case

The intention for this white paper is to provide a strategic approach for envisioning the research library of the future. Analysis of the discussions, survey feedback, and additional comments should open the door to possible solutions for addressing the changing research environment.

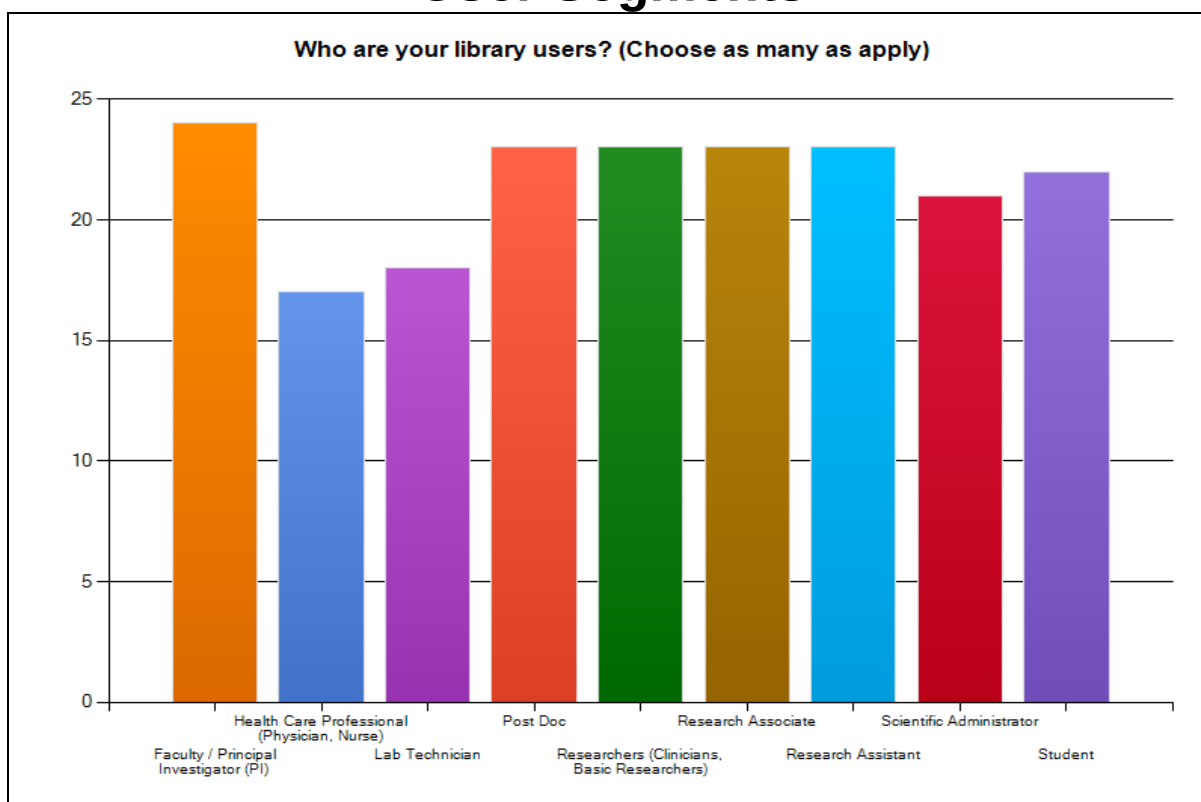
These recommendations are intentionally somewhat general, with the expectation that individual libraries will use them as guidelines in developing strategies that are appropriate to their specific research communities, financial circumstances, organizational/reporting structures, etc... By helping research libraries adapt and make informed decisions, this can only strengthen their partnership with the research community.

Background

Thirty-five participants attended an invitation-only symposium held in early April 2012 at the Banbury Center, a unique conference space at Cold Spring Harbor Laboratory spanning 55-acres and nestled near the waters of Long Island Sound on the north shore of Long Island. The site was donated to Cold Spring Harbor Laboratory in 1967 by Charles Sammis Robertson and is designed for small scientific gatherings. The meeting was sponsored by Cold Spring Harbor Laboratory, the Sloan Foundation, and The Rockefeller University. This international meeting brought together librarians, scientists, research administrators, and other key stakeholders from the United States, Canada, United Kingdom, France, and Germany for a series of discussions on the future of science libraries at academic research institutions. The purpose of the meeting was to encourage open dialog on the role and contributions of science libraries, with a goal of constructing a model for the future (circa 2020) vision of the scientific research library. Based on active discussions of researchers' needs, best practices of libraries throughout the world, and emerging trends stemming from technologies, the "new" model will describe how the scientific research library of the future engages with its user community in support of research, collaboration, and education.

The majority of participants have over 30 staff members supporting various user segments in addition to basic research. The chart below shows the commonality of these diverse groups across the attendees' institutions.

User Segments



Response Count: 25; Completed Surveys: 25

- | | |
|---|---|
| 1. Faculty/Principal Investigator - 96.0% / (24) | 5. Post Doc - 92.0% / (23) |
| 2. Researchers (Clinicians, Basic Researchers) - 92.0% / (23) | 6. Student - 88% / (22) |
| 3. Research Associate - 92.0% / (23) | 7. Scientific Administrator - 84.0% / (21) |
| 4. Research Assistant - 92.0% / (23) | 8. Lab Technician - 72.0% / (18) |
| | 9. Health Care Professional (Physician, Nurse) - 68.0% / (17) |

Responses provided in both Percent% / (Count)

The meeting took place over the course of two days and included four sessions. Each session was devoted to a specific theme building on the one that went before:

1. Overview of Scientific Research Libraries
2. Our Changing System of Scholarly Communication
3. Transforming Scientific Research Libraries
4. Envisioning the Future of Scientific Research Libraries

All presenters were asked to address their topics in general, not simply in terms of their home institutions' experience, although specific examples helped focus debate. A general discussion and wrap-up took place which identified ten challenges that impact the future vision of the scientific research library.

A post-survey was also sent out shortly after the meeting to capture additional attendees' thoughts and allowed participants to share ideas after they had a chance to reflect on the presentations and sessions. The survey response rate was 71.4%, with 25 of 35 attendees completing all questions posed. The presentations, facilitated discussions, and post-survey feedback have been reviewed and form the foundation for this white paper.

The Issue

The world of research and scholarly publishing is undergoing a transformational change and it is clear that as research activities evolve, so too must research support and libraries. As competition increases in this arena, those involved are witnessing more collaboration among researchers, with a growing volume of data and published content being made available. In this climate of radical change, how do libraries keep pace, adapt, or stay relevant when the library as a primary gateway to information is obscured by technology and often competes with potentially unvetted and unauthoritative sources.

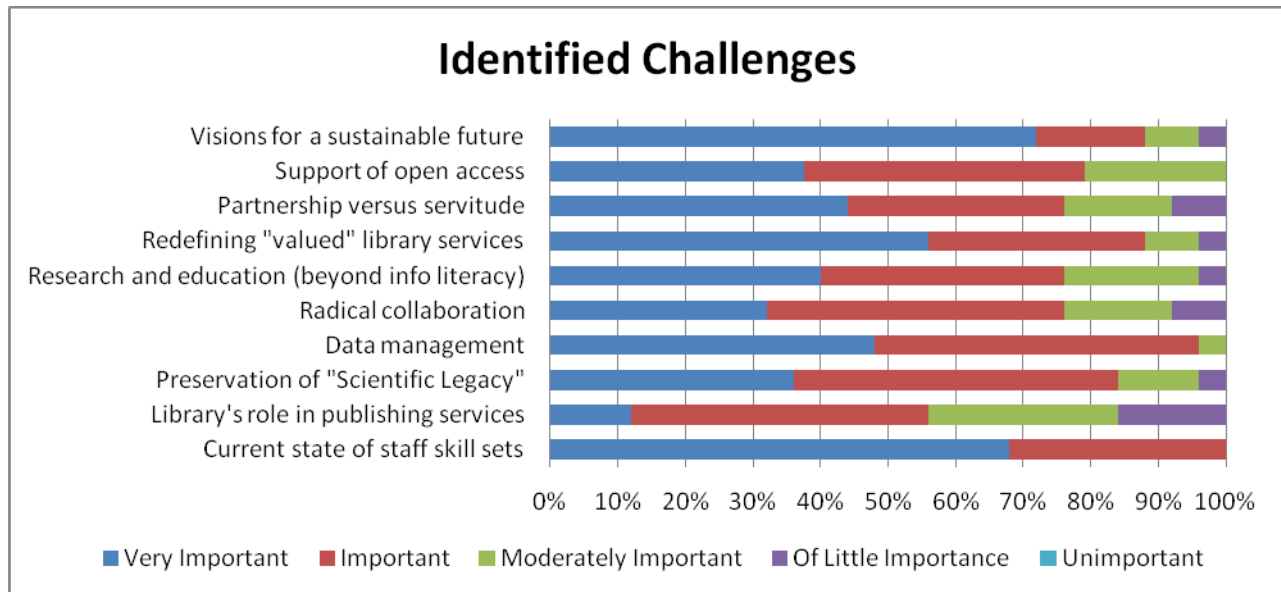
At the same time, libraries are faced with shrinking budgets, and must make careful choices regarding how to best apply their limited resources. If research libraries fail to adapt and/or make poor choices in applying resources, they risk becoming obsolete and being replaced by other entities, either internal or external, that will address researchers' needs and the continuous changes in their environment.

If the current situation is not resolved, librarians will miss a window of opportunity to continue to engage and support their users. In addition, the consequences for research institutions can be tremendous, ranging from missed opportunities for collaborations and funding, to loss of potential income from business development or licensing of intellectual property, to extended human suffering due to delays in understanding and finding cures for diseases. Library leaders need to think more creatively and strategically about how best to mobilize their skills, the skills of their staff, and resources in order to ensure the success of their organizations.

The Challenges

Ten key challenges surfaced during the course of the meeting that research libraries need to address to remain relevant and valued by their user communities and institutions.

Attendees and survey respondents rated the importance of the challenges identified during the meeting.



Response Count: 25; Completed Surveys: 25

The challenges have been addressed and presented below based on how they were weighted by respondents in order of important.

Challenge 1: Visions for a Sustainable Future

The role of the research library has been to systematically collect, organize, and provide unrestricted access to information in many formats, from many sources, for use by its research community. As such, the library is a focal point for learning and development. It also may serve a role in coordinating educational programs for the general public and schools (outreach).

Traditionally, the research library provides professional assistance with research through its staff of librarians, who are experts at finding and organizing information and interpreting information needs. The modern-day research librarian uses a variety of digital tools to navigate and analyze very large amounts of information.

In addition to providing access to published literature and assistance with navigating it, libraries often provide support for producing new intellectual output to add to the growing volume of published literature, i.e., assistance with the process of scholarly publishing.

The library continues to provide quiet areas for study and common areas to facilitate group study and collaboration. The library functions as its community's memory, by curating the institution's history in the interest of scholarship. The library is responsible for assuring into

the future the evidence of the conducted research and knowledge at the institutions it serves; and, on a grand scale, it is responsible for seeing that it is integrated with all other knowledge from all other sources into a cohesive and accessible representation of the state of humankind's intellectual achievements.

In the 21st century, the role of research libraries is reaching far beyond these traditional roles. The changing external scholarly communication environment means the continued growth of open access and changing user attitudes towards self-discovery. In addition, the growth of external competition for information search services (e.g. Google) cannot be ignored. Competition from publishers, software companies, and solutions implemented by the researchers themselves to their disciplines must also be considered.

While libraries uphold many traditions they are entering a period of radical change. Similar cultural factors can come into play in academic research. For example, some researchers may experience cognitive dissonance when participating in scientific endeavors which are competitive in terms of funding and structure, yet best advanced through collaborative endeavors. The realities are that scientists do compete with one another, institutions compete with one another, and libraries compete with one another, too.

Leaders need to be bolder and take more risks. They need to be more entrepreneurial and savvy about transforming organizations. Leaders must think imaginatively, and trust that libraries of the future indeed have a role, but not the same one as they filled yesterday. Library leaders and their staff also must be willing to develop the necessary expertise. Librarians are perhaps the ultimate "generalists" when it comes to knowledge. As fields become more and more specialized, libraries need people who are expert at helping individuals find information outside of their own fields.

Budgeting/Fiscal Management

Like the researchers they serve, library leaders must be adept at budgeting and fiscal management. For example, changes in library resources and services will necessitate reallocation of funds into new services, activities, and resources. Such budgetary changes must be thoughtful, open, and smoothly implemented.

Increasingly, libraries must pursue grant funding to help supplement their budget. They must look to external sources in order to sustain new programs and services. Libraries must integrate their services and skill sets into the researchers' workflows. They must actively sell their value and prove that they are solid partners in the scientific discovery process, remembering that value comes primarily from the contributions of *librarians* and not from the library. In some cases, librarians are key collaborators with the researchers they serve. Librarians must also be involved in the analysis of research impact, including the use of bibliometrics for impact assessment. This, in fact, may be one of the opportunities and growth areas for librarians. Just as NIH is under pressure to evaluate the impact of research spending, all agencies and academic institutions are as well. Knowing how the library is spending its money, what the impact is of that spending, and helping the organization to tell its story is not only powerful, but puts the library in an indispensable position.

Communication

As before, library leaders and their staffs must continue to truly talk to their researchers, find “new” niches, continue to learn, and to maintain technical expertise. The needs of our researchers must continue to be put first. Some of our researchers may still think of libraries as storehouses or aggregators of resources/content, and don't necessarily understand the expertise that librarians have, and the many ways that librarians can collaborate to meet users' information needs (even the ones they don't know they have). This is not the fault of the researchers that libraries serve, but related to library professionals' reluctance to clearly articulate what can be done and how they can effectively partner with researchers.

Architecture, Design, and Space

In the 19th century libraries were designed as cathedral-like temples of knowledge (or rather of printed books); today, high walls full of print materials would be considered dysfunctional. This must be reflected by a new library architecture and design (“libraries without walls”). Libraries must adapt building architecture/interior design to the changing needs and habits of the next generation of researchers, who are being educated in futuristic university environments such as the Rolex Learning Center in Lausanne, Switzerland. However, it also must be kept in mind that sometimes people just need the library as place; simply being in an intellectual atmosphere devoted to knowledge can be inspirational.

While in the past the amount of space allocated to libraries has been important, library management cannot lose battles on value because a more traditional view is held. Just because a library has less or no space, does not make it less relevant. Institutional culture and priorities will dictate the importance of the library of the future more than any other factor.

Collections & Technology

Information expertise is no longer symbolized by the prominent display of physical collections. Special collections play a larger part in libraries today, and will play an even larger part going forward, both in terms of our internal and external users. The key is that everything is readily accessible. In addition, physical collections must be integrated into the evolving digital sphere and made discoverable.

Libraries must adopt the right technologies to keep their customers on the cutting edge to support successful outcomes. They also must facilitate the sharing of knowledge to benefit researchers.

Challenge 2: Current State of Staff Skill Sets

An area of heated debate today is the skills needed for the 21st century librarian. There are numerous articles, presentations and blog posts addressing this issue (see Appendix for resources). The skills the Banbury group reported as being necessary for libraries and librarians to remain relevant at research institutions and universities are listed in the side bar.

The library and librarians have always been at the crossroads of information. However what “information” is, what it means, and how it is collected, curated, used, disseminated, etc... is changing/evolving quickly. Libraries must provide their patrons with staff members who can meet these rapidly changing information needs.

A growing area of interest is around data related skills: data curation, data analysis, data management and adding appropriate metadata. Perhaps most significant is the concept of data and data analysis and bringing the analysis and math skills needed for this type of work to the library. Librarians need to improve their positioning to enable a larger role in the research enterprise. See Challenge 4 for a further discussion of the role libraries may play in managing data for research institutions. One thing is certain, if library staff does not have such skills, this avenue will not be open to them.

Libraries in research institutions need more staff with in-depth science backgrounds, preferably PhDs and crossover librarians who have advanced degrees in a domain specialty and in library and information science. In order to fully participate in the research process and collaborate with researchers, the domain knowledge and the insight into information workflows and data workflows of researchers are both necessary.

Steps to 21st century skills

It is very clear what kinds of staff should be in the “Library of the 21st Century.” What is not clear is how to train the current library staffs so they can evolve into 21st century librarians, how to educate new library school students and how to attract people with different skills into libraries.

Library leaders should encourage aggressive professional development of staff, documented competencies and periodically update job descriptions to include new skills. When filling new positions, candidates should clearly be identified with 21st century skills or the potential to develop these skills. As the number of staff is not going to increase in most cases, it is important to include professional development for current staff leading to higher value skills and tasks. This can be accomplished by outsourcing the low skill tasks. It is also possible to use short term contractors to bring skill sets to the staff for short defined periods of time. Skills need to increasingly diversify from traditional MLS training. Libraries should increasingly hire either dual degreed or non-librarian people to meet the changing mix. Important skills going forward include IT skills, researcher experience, and statistics.

21st Century

Librarian/Informationist Skills

DATA: conversion, curation, management, understanding of big data, metadata, domain repositories

TECHNOLOGY: understanding modern tools applications (tablets, mobile devices), Internet, semantic web (including standards, languages, linked open data), ontologies, ability to write code, create apps and interfaces that address local institutional needs more crossover computer science / information technology librarians (e.g. degree in CS + MLIS)

RESEARCH: Understanding of research methods, molecular analysis tools, statistical analysis, analytical skills, visualization, being ‘in tune’ with researchers – know what they use and what they need, understand the culture of science

SUBJECT EXPERTISE: Deep subject/domain expertise and crossover science librarians (Masters or PhD + MLIS), bioinformatics/informatics skills, ability to assist with systematic review more

GENERAL: Ability to assess research impact and dissemination, to evaluate library services, to analyze, assess, and find creative digital curation solutions, business understanding, legal expertise (copyright), teaching and pedagogical skills, comfort with technology, ability to communicate institutional vision, quick to learn new skills, project management

INTERPERSONAL: Collaboration, creativity, flexibility, passion, communication writing skills, marketing, outreach, social media savvy, innovation and risk discipline expertise, ability to work on high level distributed skills and role-diverse team

Barriers to creating a 21st Century Library Staff

A number of barriers were identified that need to be overcome to staff the 21st century library.

- Insufficient salary pool to recruit highly skilled staff.
- Low staff expectations.
- Scarcity of highly skilled individuals.
- Present (low skilled staff) have tenure and are difficult to retrain.

Solutions

Solutions to the barriers were proposed and include strong continuing education, professional development programs, strategic and creative approaches to hiring for vacant or new positions, retooling existing positions, and retraining the staff currently in positions. Since true subject/discipline knowledge is expensive, libraries can take advantage of the radical collaboration method described in Challenge 9 to share the expensive subject and technical expertise. There could be Centers that provide that kind of support across institutions. Other possibilities are to obtain grant monies to support some library staff.

Challenge 3: Redefining “Valued” Library Services

Redefining our user-facing services is a key element in changing how users perceive and collaborate with libraries. Each library needs to break down what matters to their constituents in order to craft appropriate support services. It is impossible and no longer practical to try and be everything to everyone.

Technical Services Activities to Target	Metadata creation becomes metadata curation
• Re-examine cataloging requirements • Minimize care and management of print content • Diminish or stop serial check-in • Move to a self-serve book check-out system • Evaluate content acquisition models (Patron-Driven Acquisition) • Re-visit the need for services that are user-driven and not library-driven	There was a definite shift to focus attention on metadata creation and curation; to expand the information professional's role in order to keep pace with user needs, such as supporting them in developing data management plans. Data-intensive research is continuously reframing the way libraries need to approach developing support services for open science. The University of Virginia Library, Scientific Data Consulting Group (SciDaC)⁽¹⁾ is an example of how a traditional role has been retooled to go beyond published content. There is a definite need to curate massive data sets, especially within the context of changing technologies, and the library can play a role in establishing the policies and processes necessary for this challenge.

Science Informationist model

“Models of Embedded Librarianship, Final Report”⁽²⁾ was sponsored by Special Libraries Association (SLA) and demonstrates the value of having an information professional integrated within a team. The embedded librarian's role is driven by developing strong relationships and the ability to collaborate effectively. Unlike the traditional reference librarian who receives a question and then returns the answer, the embedded librarian both receives and shares knowledge and contributes to the team in whatever ways are needed.

An Administrative Supplement opportunity was recently made available to eligible National Institutes of Health (NIH) awardees with active R01 grants ⁽³⁾ providing funds to supported research and center grants in order to enhance the storage, organization, management and use of electronic research data through the involvement of informationists, also known as in-context information specialists. The purpose of this supplement also outlines the value of integrating an information specialist into the research team so they can focus on improving the capture, storage, organization, integration, and dissemination of biomedical research data.

Redefining User Services
• Re-evaluate traditional reference desk coverage and job responsibilities • Develop tailored training programs • Re-think how the physical library space can best serve the organization (computer lab, lounge and collaboration spaces, learning commons, or host special events) • Pay attention to author-type services (focus on discovery, dissemination, and preservation) • Support users' workflows and decision-making by mining and proactively delivering data to researchers, administrators, and senior leadership

The Science Informationist brings to the table both librarianship skills as well as subject expertise and their primary role is to deliver tailored services to their assigned group. Much like the embedded librarian they need to focus on building relationships and increasing their understanding on what matters to their team. "The informationist: building evidence for an emerging health profession" published in the Journal of the Medical Library Association.⁽⁴⁾ outlines the long-term benefits to clinical research teams.

Just in time instruction and niche services

Developing a training program that will increase work productivity and better use of resources also needs to be tailored to the needs of individual groups. This includes exploring training formats such as webinars, drop-in clinics, and interactive self-paced tutorials. The emphasis is on increasing the return-on-investment for many of the resources that libraries support and demonstrating the value these resources bring to the organization. Providing just-in-time training is also far more beneficial than scheduling classes and is another way to establish the librarian's expertise.

Investing time in niche services such as "Bibliometrics" delivers value to the organization. Librarians and information professionals are experienced in evaluating the impact and value of library services and programs. As return on investment of the research enterprise becomes of increasing importance to institutions, government officials and taxpayers, a strategic move will be to support the use of bibliometric methods to determine the influence our researchers have within their fields and to help describe publication patterns within a given body of literature.

Like any business, librarians need to be proactive and work smart to identify priority research areas at their institutions and then determine how to support these areas; they can no longer provide comprehensive support in all areas. Understanding and defining, mapping the institution's "strategic activities" and aligning them with relevant services ensures that a decision-based approach is taken to deliver greater value to the organization and user community.

Challenge 4: Data Management

Data management involves the various modes of representing, identifying, organizing, and disseminating research data. This activity can greatly contribute to the reuse of data.

Libraries are positioned and are ready to handle the data issue for their research institutions. Libraries are also the logical place to archive an institution's scholarly output, and are better positioned in terms of technical expertise than any of the university's other departments. Libraries have been in the business of curating, and making discoverable, research outputs for millennia. Librarians think about the full life cycle of data curation.

Data issues are very much like the role of libraries in scholarly communications which typically focus upon activities around scholars sharing and publishing research. By considering the concept of "sharing and publishing data," similar activities come to mind where librarians can be involved and a host of new possible roles emerge.

This area is a particularly significant opportunity for libraries at research institutions. It is something these libraries should pursue aggressively because it is an important institutional need. If libraries do not address these needs it will be done without them.

Some libraries have already begun educating researchers, faculty and students about data management plans. The University of California Curation Center's data management is a notable example of activities in this space.⁽⁵⁾

Librarians as collaborators

A strong data management program is vital to the flow of scientific communication and knowledge preservation. Data management would be collaboration across an institution, involving the library, IT and other experts. They would contribute a diversity of skills to various groups of users in order to manage an organization's current and historical intellectual output. If the day comes that the National Science Foundation (NSF) or other funding bodies require implementation of data management plans, the librarian/informationist needs to be at the table with the researcher and technologist, applying their expertise to organizing data and making it discoverable. Librarians will serve as a bridge between researchers and research services offered by the institution, helping researchers cite data and provide access to data. A key role is to assure properly described data that is discoverable and to provide appropriate storage and continuous curation.

Librarians as educators and consultants

Librarians can provide guidance about data plans and orchestrate the understanding of data issues. They can be instrumental in the development of an effective and rigorous institutional data policy, as well as facilitate Open Science/Open data initiatives. They can develop preservation strategies and promote best practices for data management. Librarians can also provide help in developing workflows that embed processes to capture metadata. Librarians will be liaisons to external data repositories as appropriate, and provide assistance in deposition of content to them. Just as librarians/informationists help researchers navigate the world of bibliographic databases and publications, this role is well positioned to assist them with understanding data repositories.

Librarians as developers and preservers of metadata, standards, ontologies

Librarians offer critical and foundational skills that are important to the management of research data: organizing, describing, and controlling. Librarians can, and will, identify standards for data, and data descriptive ontologies. They will be able to develop specialized ontologies as needed or requested, most particularly to provide precise access and retrieval of specialized data. Librarians are already the world's citation and bibliographic control experts, and will continue to be so. They will be able to provide appropriate bibliographic control for unusual documents and data sets such as laboratory notebooks, assays and various types of images.

Librarians as connectors

Librarians play a vital role in linking information and data seekers with the resources appropriate to their need. They can facilitate establishing relationships and links among multiple resources and resource types. They have the vision to provide metadata enhancements that position data sets for more interdisciplinary discovery and reuse. They can make these linkages between both internal and external resources and repositories.

Challenge 5: Partnership Versus Servitude

We've all heard it said, "Perception is everything." One's perception can definitely impact the type of relationship that is developed between two parties – in this case the Library and current/potential users. Libraries have built their business and relationships on providing requested research information and acquiring the necessary resources to support their institution's mission. The relationship can generally fall into two categories: partnership or servitude. In the definition of these words, an important distinction is that a partnership is a relationship where the parties are generally equals. Each contributes to the task at hand and brings ideas to the table, respecting each others' work and expertise. A servitude relationship is one where the patron sees the Library as not part of their team and assigns specific tasks, often without context to the overall goal. In many instances, the request is a single short-term transaction.

Delivering highest priorities

The first step for librarians is to ask their users to identify what their highest priorities are and the second is to deliver against them. It is important to evaluate their real workflow needs and conduct agile, iterative experiments in adding innovative services. Librarians/Informationists must not be afraid to take risks and make mistakes. Instead they must proactively implement innovative ideas as pilots and keep the ones that have traction. Continuous needs assessment in the form of surveys, focus group sessions, face-to-face communication, and participation in scientific meetings or in-house symposia can lead to opportunities to work collaboratively with users on long-term goals.

Integration of services into research workflow

Library services offered should parallel the research workflow. Librarians need to be aware that workflows can and do change and to be nimble in order to adjust accordingly. The aim should be to establish librarians as viable partners in their daily work and ultimately as one of their "starting" and "destination" points.

An overall meeting theme was to "get out of the Library" to develop stronger relationships. Craft a staff elevator speech to market the value of using library services and collaborating

with information professionals – most importantly let researchers know the value proposition for them should they partner with a librarian. Every time there is a connection with a library user, there is an opportunity to contribute to their research outcomes.

Challenge 6: Research and Education (Beyond Info Literacy)

The role of librarians as educators and partners in the educational mission of colleges and universities is foundational and unquestioned by librarians. Everything else has changed - how librarians are viewed by faculty, administration and students and what librarians, should be teaching. Also, the tools, systems, resources, and available technologies that libraries need to stay abreast need updating. Some futurists claim that universities themselves will become anachronisms and will end as the world knows them today.

Research is a special case of education. While education is exploring and assimilating what is already known and has been illuminated by others, research is standing at the boundaries of what is known and seeking to extend the boundary, adding new knowledge. Researchers educate themselves first, about something previously not known by anyone, and they expand what is available to all to be known.

So how should libraries plan to adapt to an increasingly complex, rich, and ubiquitous learning environment? In fact, libraries are part of that environment and should make it their mission, as it always has been, to continue to organize, preserve, and make available, the ever growing universe of knowledge. The role of libraries is not ending, it is growing, and libraries need to pick up the pace. Serendipitous discovery is a delight, but purposeful and planned learning is what education is all about: understanding and catering to the needs of the learner. And that has not changed. A teacher in a classroom or a lab, poses questions and situations to the students, and then admonishes them to learn. No matter how great a teacher is, a student who does not wish to learn will not learn. It is the teacher's role to motivate the learner to want to know. The librarian is the extension of what begins in the classroom or lab. Libraries teach individuals how to learn.

This is the educational mandate of the 21st century academic librarian. "Information literacy" has become irrelevant at the university level. Libraries face a tremendous opportunity to explore, create, and offer, new ways to capture preserve, organize, manipulate, and present knowledge. More than ever now is the time not to wait for formal publication, which librarians can then abstract and index with author/title/subject. It is the time to partner with the researcher and educator at the moment of creative thought and exploration for the learner. Librarians need to work in ways that enrich the teaching and learning experience for both teacher and learner and be directed by what they need to know.

These are some of the ways for research libraries to improve and enrich the teaching and learning experience:

- Support open science - discover, promote, develop apps to support active and continuous scholarly communication.
- Support open access - knowledge belongs to humanity and should not be a commodity.

- Re-envision the knowledge universe - classification systems and other tools for organizing knowledge must become more sophisticated. Knowledge is not linear and neither are the ways in which to manage it.
- Engage in data stewardship, as much to document and verify advances in knowledge as to protect and preserve potential new ways and things to learn from that data.
- Align specific library support activities and services to the specialized teaching and research activities of each individual institution.
- Focus on facilitating research collaborations; these are frequently interdisciplinary and highly innovative.
- Do more to integrate disparate resources.
- Provide supportive, comfortable and appealing physical spaces for students where they can contemplate or collaborate; explore knowledge where their own intellectual curiosity takes them or find expert guidance and knowledgeable librarian educators.

Learning is an experience, and it should be positive, engaging, and interactive -- just like a laboratory. Universities used to be called “ivory towers” because they were viewed as being special and somewhat isolated places where individuals engaged in very cerebral activities of study and inquiry. They are now places that are very much engaged with their communities, with the public, business, and government. They are competitive, and challenging. Learning is also competitive and challenging. The library remains a unique place, and librarians a unique breed of teachers, providing an infrastructure of spaces, resources and skills that supports and enhances teaching and learning.

Challenge 7: Preservation of “Scientific Legacy”

One of the traditional roles of the research library has been to preserve the published scientific works and other artifacts of research constituting the “scientific legacy” of the institution it serves. This role will continue to be a very important one in the future, pointing to the need for strengthened and continuing partnerships between libraries and archives. Although present day scientific researchers and administrators may not see the value in preserving the institution’s unique scientific legacy, they may become more interested toward the end of their careers, or as milestone institutional anniversaries approach. For libraries and archives, this role provides the opportunity to offer a unique service that differentiates the library and archives from other departments and centers on campus.

Current and traditional activities

With regard to preservation of scientific legacy, there are several well established activities in which libraries have been engaged or have established in recent decades:

- Institutional archives (physical and digital) - The institutional archive collects in one place the records of the institution’s output and ensures that these records will be preserved for the long term. The archives continuously collect original materials from the institution’s current scientists, as well as from alumni.
- Publications databases - Many research libraries have a database or other system to curate the institution’s published works, particularly print publications.
- Education - As with library resources, such as reference works and bibliographic databases, the library has a mission to make researchers aware of the services it provides in terms of preserving the institution’s scientific legacy.

Emerging and future activities

Technological advances and document format changes from print to “born digital” documents has radically altered the role and function of archives. Formerly archiving was something that happened at the end of a research career when an entire corpus of work would be delivered to an archive center for processing. Now archiving is a continuous process, something that can happen to any and every document at the moment the document is complete. In modern science there is interest and pressure to make new knowledge and the evidence of the research surrounding it immediately available. This was not the expectation of a traditional archive, however this is the role that is now being assimilated into research library services. The following are a few activities in which libraries have become involved in recent years and are likely to become more involved in the future:

- Expertise databases - Through such databases, libraries and archives serve as stewards of the institution's intellectual output and research subject expertise. Expertise databases are important tools in developing collaborations in this age of interdisciplinary and translational research.
- Institutional repositories (IR) - An IR allows for curation and preservation of unpublished content, such as poster presentations given at scientific/research conferences, images, and other materials voluntarily provided by the institution's scientists and administrators. Links can be created from IRs to digital archives. (See also Challenge 8, Library's Role in Publishing Services and Other Aspects of Scholarly Communications.)
- Data repositories - Some libraries work with scientists to archive, curate, and make accessible their research data, computer code, and similar items, especially that which supports their publications. Libraries also work with other groups on campus, such as the IT department, who can provide secure and compliant data storage.
- Data curation tools and systems - Libraries participate in the creation of metadata descriptions and standards, the development of systems to address data curation challenges, and methods to support data legacy systems.

The importance of collaboration

Libraries, archives, and museums have critical roles to play in the preservation of an institution's scientific legacy, but few have the infrastructure to do this locally on a large scale. While many libraries and archives are capable of providing the repository space for preserving the institution's scientific legacy, this model needs to be carefully considered to determine whether it makes sense in a particular case.

In the past, when all publications were in print only, the library was the local point of preservation of the scientific record. With the shift to digital publication, the publisher now has the primary responsibility for preserving the digital copy of record. However, at some point the long tail will be unaffordable in publisher silos. It is therefore essential for libraries, archives, and museums to partner with other organizations (both commercial and not-for-profit) to develop new tools and systems for preserving the record of science.

Several collaborative solutions have emerged including services such as Portico⁽⁶⁾ and LOCKSS (Lots Of Copies Keep Stuff Safe)⁽⁷⁾ which ensure the preservation of tens of thousands of e-journals, e-books, and digitized historical collections.

Thus the task of preserving materials “just in case” has fallen largely on academic libraries. This is where libraries must work together to make the cost economically sustainable. Library consortia will need to be ready to step up to address issues such as these.

The library as curator of institutional identity

As curator of institutional identity and achievements, the library and archives is uniquely positioned to tell the story of the institution's history. No institutional department or division, other than the Office of the President, has such a broad, comprehensive picture of the whole organization. Thus it is important for the library and archives to work with the public relations/public affairs department and other experts within and outside the institution to build relationships, teach about the library and archives collections and services, and demonstrate that the library and archives is an appropriate place to house and preserve public relations materials.

Challenge 8: Library's Role in Publishing Services

Being involved with publishing and other aspects of scholarly communications is a natural fit for libraries, and many libraries have already found success on their campuses with their efforts in this area. The library's potential roles in publishing/scholarly communications include roles both within the institution and outside the institution. Within the institution, the library may be involved, for example, in developing an institutional repository; partnering with scientific staff and/or the university/institutional press on scholarly communication endeavors; performing bibliometric analysis of the institution's publications; and co-authoring works with scholars.

The current system of scholarly communications is a complex and broad network. The support services that libraries provide, and retraining/recruiting necessary personnel to provide these services, should be in line with institutional needs, whether it be educating scientists on relevant issues, assisting with development and production of publications, or collaborating with scientists at a co-author level. The library can bridge gaps working in the space between researchers, publishers and funders. An example would be the Marine Biological Laboratory/Woods Hole Oceanographic Institution Library's efforts to develop best practices for archiving data supporting published articles, specifically focusing on the “backbone data” used to generate the figures and tables in an article. In addition to provide a place to store the data the library assigns digital object identifiers (DOIs) to the datasets making them easily available and retrievable.

Institutional repositories (IR) have already been discussed in Challenge 7, Preservation of “Scientific Legacy.” In the work of developing IRs, libraries may be charged with stewardship of research results, focusing on locally produced grey literature. (The jury is still out as to whether there is value in creating IRs that focus on deposited copies of peer-reviewed published articles.)

In terms of educating and advising scientific staff, the library may be involved in supporting open access (OA)/open research/open science initiatives, or assisting scientists in complying with the NIH Public Access Policy. The library may also advise authors on choosing a publisher for a book or a journal for an article; and educate staff regarding copyright, intellectual property (IP), and OA. If in a position to do so, the library may develop funds that can be used to defray article transaction fees for publishing in OA journals.

Some libraries have recently fostered stronger relationships with university/institutional presses. Libraries may be involved in supporting university/institutional presses by providing bibliographic services, citation verification, archival photos, etc... They also may partner with institutional presses on certain activities, such as promoting new books. Indeed, in a few cases where institutions have reorganized, the university press now reports to the director of libraries and/or has been incorporated into the institution's center for scholarly communication.

With the institutional press, or independently, the library may be involved in providing alternative venues for publishing that better serve scholars' goals. Libraries may work with researchers to create workflows and sustainable systems for publishing research results and the corpus of the historical sources used in an open access environment. If feasible, the library may also provide the infrastructure to support small-scale ejournal publishing, partnering with subject experts at the institution (however, this can require substantial effort and expertise). The library may also provide platforms such as websites, social networks, or blogs, which support informal scientific communications within the institution.

Collaboration is a key for many achievements in the library field today. The library may work together as a sector with other libraries on issues of importance to all libraries. Libraries may work together to influence publishers and the government to implement policies that allow broad access to knowledge. In the current scholarly communications environment, libraries may also partner with publishers in new and varied ways, shedding the adversarial relationships that often exist in such relationships, especially in regard to OA. Lastly, libraries may work with publishers to design better content platforms or jointly creating new products and services with a "service" and "answer" mindset, rather than a "collection" mindset.

Challenge 9: Radical Collaboration

Historically libraries have been models of collaboration, even deep collaboration. Witness what OCLC, begun in the mid 1960's by a creative group of Ohio academic libraries, has become. And perhaps this sterling example demonstrates why it remains unique, and there are not many more striking, very large, collaborations: the library founders lost control of the project when the project expanded beyond the borders of the state. So is it possible to think again about extreme collaborations without libraries losing their identities, or compromising restrictions of governance, budget, licenses, copyright, and institutional goals? Radical collaborations are not a trivial undertaking.

Deep collaborations are both an opportunity and a challenge. Often they are precipitated by uncertain economic times. Though they may be viewed as ways to share costs and operate more efficiently, uncertainties remain, and the collaborations bring new problems to be solved. It is generally the case that collaborative arrangements with non-library entities are more easily managed because they tend to involve less in the way of dollar commitments or joint budget management, and more in the way of inventive services and activities or jointly sponsored events where partners contribute in kind. Also the partners have complementary goals and are less likely to be wary of overstepping boundaries where conflict may arise.

In early collaborations, such as OCLC, the goal was to leverage technology to reduce redundancies and share cost and effort for routine processing of physical materials that all

libraries do. The emphasis is shifting to seeking ways that libraries can creatively share subject and technical expertise to provide a higher level of value added services that they cannot each provide on their own. Many libraries are interested in providing a data visualization expert....but very few need a dedicated person to do this. How do 10 libraries acquire 10% of one data visualization expert's time? States (California, Pennsylvania, New York) have provided models of state-wide academic collaborations, but they are more consistent with the OCLC construct, sharing core administrative services, like purchasing, but leaving teaching and service under local control. That said, State Boards of Higher Education do have a hand in selecting the locations of some programs, such medical and law schools, from the state level.

There is agreement that collaboration doesn't have to be radical to have impact. Libraries seem to be moving in the direction of seeking a host of different models, and opportunistically entering into almost any relationship that offers a tangible benefit. This is likely to lead to administrative chaos for library directors, but interesting experiments in new services and new library roles to support and please library users. Those of us in academic libraries know that no matter what the outside perception may be, our libraries are competitive, just as our institutions and our researchers are. Radical collaborations will need to focus on how to design cooperative ventures that advance the missions of disparate members and that will allow libraries to work and expand successfully beyond institutional boundaries.

A more recent large collaborative effort that is working extremely well is the Biodiversity Heritage Library (BHL). This project has grown from ten loosely affiliated libraries, museums and research centers, to a global initiative with over sixty participants. This project has little formal command and control hierarchy, but what it does have is an extremely clear, limited, and well articulated vision and set of goals. There is no actual sharing, except for the created end product itself. Everyone contributes to the extent their own resources and abilities allow. They are taking what is unique from their own resources, and pooling these together into something that is greater than the sum of the parts.

This will be one of the keys to library survival and success in the future. What is it that libraries have that is unique to their organization? How do librarians leverage these special resources, and use them collaboratively with other libraries to create entirely new constructs that enhance learning, advance the growth of knowledge, and facilitate research and scholarly communication. This is a vision and goal that can be shared by all.

Challenge 10: Support of Open Access

The move toward "open data/open research" will reshape the ways in which scientists conceptualize and carry out research allowing greater opportunities for collaborations.

Librarians or Science Informationists can place themselves at the forefront of this process and play a vital role in implementing and facilitating these changes. The key will be in promoting and supporting greater author control over the dissemination of their research and ensuring that author rights are clearly assigned.

The University of California Curation Center's 'Manage Your Data' page⁽⁸⁾ provides some examples of services that libraries can offer in this area. Each library must learn more about

the implementation of open data/open research at their institution and then determine what their role is. This movement will continue to evolve and libraries need to stay abreast of developments so they are able to adapt staff skills as well as ensure that the younger generation of information professionals has the appropriate training. They also must realistically recognize the concerns and barriers to sharing scientific data and address these appropriately.

It is clear this is an opportunity to integrate possible library services within the researcher's workflow. As open research advocates and research partners, we can:

- Encourage researchers to think strategically about sharing data and address their concerns about this endeavor.
- Help to draft and promote open research standards and policies (where appropriate).
- Develop ontologies to aid in the discovery of open research.
- Work with those ready to move ahead (including bioinformatics groups) and let others see the value libraries can bring.
- Develop partnerships with other institutions and help facilitate collaborations.
- Participate in projects that leverage the power of the semantic web and open linked data.
- Provide assistance in the creation of data management plans, deposit data and other materials into external repositories, and curate this new form of scholarly output.

Future Directions

None of us have a crystal ball to foresee the future however it is within the control of library senior management to determine the best path to take to stay relevant in the work lives of researchers and the organization's library user community. Librarians are well aware of the need to change and must go beyond simply supporting the creation and dissemination of new knowledge. The economic environment, constant advancements in technologies, new forms of scholarship represents just a few factors that challenge current approaches in meeting the demands of users.

Transformation is required and redefining what should be under the auspices of research libraries will help to construct our vision and future role. This transformation has already begun with many Banbury attendees having addressed:

- **Budget** – identifying new sources of funding, minimizing overlap in content, reducing expenses in non-key areas
- **Content collections** – “selective & unique” content subscriptions, move to “renting” content based on need, pay-per-view (article based) model, token model, just-in-time approach
- **Library staff** – developing new job descriptions to fit evolving user needs, re-training staff, re-organizing staff structure to align with priorities, eliminating low value tasks
- **External collaborations** – looking for opportunities to work with other libraries (similar to our researchers) on related interests and projects

- **Library as place** – repurposing space to address need for collaboration and instruction, information/research commons, reflection and study, meeting place, hosting key events
- **Deeper integration** – point of need services, embedded librarians/informationists, subject specialists
- **Customized support services** – institutional repositories, preservation of institution's intellectual output, translational science support, bioinformatics, high-level data analysis & visualization, data management plans, creative commons for data sets, metadata services

The long-term focus should be to continue to explore and improve the areas listed above as well as to seek and share new ideas with colleagues and most importantly, library users.

The world in which our scientists work is transforming so how do we support their discovery process? Libraries still need to maintain links to digital content but how can discoverability and use be enhanced? How can librarians slice and dice the enormous volume of information to make it manageable for various user groups? How can librarians point them to content that complements their research? What innovative services can librarians develop to support designed serendipity and expand research community networks? How can information professionals help scientists preserve and possibly share their data? How can librarians offer personalized data and research services? These questions should test librarians as a group to think about how we can change them to actionable items.

The future of libraries is now and ultimately librarians are here to enhance the user's information experience, seamlessly integrate services in their daily work flow, and establish the research library as a critical contributor towards the mission and goals of the institution that the library is a part of.

Conclusion

The challenges outlined here form the basis of how to develop a new model for the future research library. In the end each research library will need to prioritize these challenges based on their organization's mission and their researchers' needs. While there are commonalities among each library, librarians should also seek to explore areas that are unique to their user communities. In the print world, each library did the exact same kinds of things to a greater or lesser extent. Now there will be a greater range of diversity depending on the librarian's skill sets required to fulfill the priorities of the institution.

It is the responsibility of all information professionals, to take the lead in shaping how the research library will function and be viewed in the future. In closing and based on the comments from Banbury attendees, librarians need to make calculated changes and shift to:

- an awareness of institutional needs rather than a library-centered focus,
- supporting specific groups and not the entire user population and contributing to high-value projects,
- enabling the development of new job roles (i.e. Science Informationist, Metadata Librarian) rather than continuing to advertise and hire for "traditional" positions,
- being a collaborator and participant and not a spectator,
- supporting "big data" as a new form of scholarly output,

- facilitating the sharing of data sets to accelerate research discovery and increasing a researcher's network of collaborators,
- promoting the term and the value of "open science" so that it is better understood by researchers,
- developing new/more subject-specific ontologies,
- addressing the need for content to be mobile-enabled and viewable on the small screen,
- taking the necessary financial, managerial, and related risks to transform our research libraries into expert, lean, and nimble organizations they need to be to continue to support scientific research.

As long as research and education continues, libraries will remain integral partners in the advancement of science.

Appendices

Appendix A - Meeting Participants and Contributors (**primary authors have been identified)

Banbury Center - The Future of Research Libraries - April 1 - 3, 2012

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Appendix B – Banbury Meeting Follow-Up Survey

SurveyMonkey (<http://www.surveymonkey.com>) was used to collect additional feedback from meeting participants. Survey was sent via email on Tuesday, April 17, 2012 and closed on Monday, April 23, 2012.

Survey Questions

1. Who does the library report to? Please provide their job title and division.
(e.g.: Chief Information Officer, Information Systems)

2. What is the size of your library staff?

1-5, 6-10, 11-15, 16-20, 21-30, Over 30

3. How many individuals on your staff are NOT devoted to traditional library tasks? (e.g.: cataloguing, circulation, acquisition)

1-5, 6-10, 11-15, 16-20, 21-30, Over 30

4. Who are your library users?
(Choose as many as apply)

Faculty / Principal Investigator (PI)
Health Care Professional (Physician, Nurse)
Lab Technician
Post Doc
Researchers (Clinicians, Basic Researchers)
Research Associate
Research Assistant
Scientific Administrator
Student
Other

5. In terms of your "user community" - how large is the group of constituents you serve?

Under 500, 501 – 2,000, 2,001 – 4,000, 4,001 – 6,000, 6,001 - 10,000, Over 10,000

6. We identified several challenges during our meeting. Please rate their importance.
(Very Important, Important, Moderately, Important Of Little, Importance Unimportant)

Current state of staff skill sets
Library's role in publishing services
Preservation of "Scientific Legacy"
Data management
Radical collaboration
Research and education (beyond info literacy)
Redefining "valued" library services
Partnership versus servitude
Support of open research

Visions for a sustainable future

7. What is the skill sets required to support the vision of a “new” research library?
8. What is our role in publishing? (e.g.: partnering with publishers to produce customized products, supporting OA initiatives, coauthoring, involvement with scholarly communications)
9. What is the future role of libraries in the preservation of “scientific legacy” or research?
10. What is your vision of the library’s role in data management?
11. What is your vision for inter-institutional radical collaboration? (building effective work environments that extend past our library walls)
12. Should libraries invest time in providing research and education that goes beyond Information Literacy? What should we focus on?
13. What library services should continue to be offered? What library services should be dropped?
14. How do we improve our partnerships with our user community? How do we stay effective? How do we get them to integrate the library into their workflow?
15. What is the future role of the library in open research and data sharing (e-science / e-research)?
16. What would you consider the first step in creating a sustainable ecosystem?
17. What elements should not be forgotten when envisioning the future of research libraries and their value within their institutions? Can you list any challenges that were not discussed?
18. Assuming you had no financial or other constraints, name one thing your library would do to support your research user community. Feel free to share more than one project, activity, or service!
19. Survey Respondent (Name, Organization)

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Appendix D – Other Resources (arranged by challenges)

Challenge 1: Visions for a Sustainable Future

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