U.S. Department of Health and Human Services
National Institutes of Health
Division of Program Coordination, Planning, and Strategic Initiatives
Office of Research Infrastructure Programs
Division of Construction and Instruments

Modernization of Biomedical Research Facilities Workshop

Tools for Biomedical Research

August 25, 2020
Virtual Meeting

MEETING REPORT

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Executive Summary

The Modernization of Biomedical Research Facilities Workshop was held on August 25, 2020, to gather feedback from the biomedical research community on how modern equipment supports operations and enhances the research-support functionality of shared resource facilities. The discussion was divided into three topics: (1) advanced equipment to improve management through automation of shared facilities, (2) advanced equipment to improve care and maintenance of research animals, and (3) advanced equipment to improve research-supporting functions of core facilities. Throughout the Workshop, several common themes emerged: equipment (e.g., upgrades, maintenance, automated monitoring, and small equipment purchases), data management, coordination across facilities, digitization, and training.

The importance of maintaining modern equipment was emphasized; several participants discussed the types of equipment required at their institutional facilities. Some facilities' equipment is old and aging infrastructure poses many challenges for efficient operations. Up-to-date equipment contributes to improved sample consistency, improved core throughput and productivity, and increased data rigor. Robotics-based equipment such as liquid handlers or automatic plunge freezer, address some of these challenges. Novel acquisitions (e.g., micromanipulators, antivibration tables, incubators, microscopes, sterilizers, replacement bio-bubbles, passthrough boxes, sterilizers, and individually ventilated cages) provide advanced capabilities for investigators. Gnotobiotic core facilities have constant needs for equipment updates, including isolators, support racks, supply cylinders and transfer sleeves, large autoclaves, decontamination systems, and other similar supporting resources.

Research facilities often require many small items of equipment that comprise larger systems and are necessary for systems' proper functioning and use. Examples of such equipment include safety equipment, automation accessories, sample preparation tools, spectrometry and spectroscopy accessories, and storage. While performing necessary functions, such small pieces of equipment often do not meet criteria for major equipment funding. Several participants expressed support for microgrants programs to fund small equipment. Such program would provide significant returns on investment.

Animal research facilities require robust monitoring systems. Participants emphasized the importance of environmental controls, building care, and support to complement new technologies. Backup monitoring and control systems are crucial to plan for emergencies. Several participants conveyed the importance of developing species-specific husbandry systems. Aquatic facilities have very specific needs. Water quality (e.g., filtration, de-chlorination, temperature control, flow rates, salinity, pH, and dissolved oxygen) is the driving force behind many husbandry challenges for aquatic organisms, and water monitoring is crucial for reproducible research. Regular water monitoring (e.g., for pathogens) also helps researchers assess the health of the facility. The modern operations of nonhuman primate facilities require essential equipment as well as innovative equipment such as automated feeders and tools for detection of social instability. Camera systems allow remote viewing of animals across multiple housing areas. New caging designs allow positive reinforcement training, social viewing, social group housing, and mobility accommodations for older animals. Animal identification metadata must be integrated with monitoring systems.

Several attendees discussed tracking of the experimental conditions and the digitalization of specimens from *in vivo* and *ex vivo* studies. Electronic medical records are critical for specimen identity tracking within and between studies and institutions, as well as for maintaining sample library records collected over the years. Further development in the digitization of glass microscope slides would significantly increase the scientific value of samples from past studies. Currently, institutions lack the high-throughput capabilities for full digitization of their records. Digital sample records are one example of data management that is crucial in modern research.

Core facilities face a growing burden of managing data. Several participants spoke on challenges and benefits of coordination of data management within and across institutions. They identify the need to enhance data coordination between facilities to promote collaboration, efficiency, and training. Increased efficiency (e.g., capacity, speed, and accuracy), and improved security contribute to enhanced experimental rigor and reproducibility. Electronic data management is crucial for addressing these issues. Challenges include communication among investigators and across platforms, sample and data tracking across core facilities, education of university administrators, and development of management systems. Different facilities have distinct and unique requirements, necessitating customized solutions. Standardized equipment placed in and uniform protocols implemented across different facilities would enable comparing results and sharing of data. A customized funding mechanism would allow support across different levels of the network of institutions. Such a network-level funding mechanism could encourage the establishment of a user base across institutions. Several participants also spoke on the value of networks for training, data management, and to facilitate the exploration of different models.

Workshop Report

ORIP Director's Opening Remarks
Franziska B. Grieder, D.V.M., Ph.D., Director, ORIP

Following introductions, Dr. Franziska B. Grieder, Director, Office of Research Infrastructure Programs (ORIP), welcomed the Workshop participants. She conveyed that the participants' insight and expertise will help ORIP plan for the future of biomedical research. She also thanked the Steering Committee members and ORIP staff members for their efforts in planning the meeting. She explained that ORIP is interested in listening to the participants' perspectives on how to improve operations of and research support for shared resource facilities.

Introduction to the Workshop
E. Albert Reece, M.D., Ph.D., M.B.A., John Z. and Akiko K. Bowers Distinguished Professor and Dean, University of Maryland School of Medicine

Dr. E. Albert Reece provided opening remarks to the Workshop. He spoke on the importance of forging partnerships across the biomedical research community. State-of-the-art research facilities, shared resources, and core facilities are a critical part of biomedical research. Core facilities require stable, ongoing support, and the National Institutes of Health (NIH) has served as a critical partner in supporting resources for researchers. Dr. Reece expressed his desire to continue to develop and foster this partnership.

ORIP plays a key role in supporting animal resources and infrastructure needs. Dr. Reece noted that researchers across the University of Maryland School of Medicine (UMSOM) make full use of funding opportunities available through ORIP. He highlighted successes resulting from ORIP's support of UMSOM faculty members. He stated that the Workshop would facilitate discussions to further support infrastructure for the advancement of biomedical research. The COVID-19 pandemic has created new challenges and limitations for institutions, and researchers are relying on NIH for additional support. Dr. Reece challenged the participants to envision the future of biomedical research.

Topic: Advanced Equipment to Improve Management through Automation of Shared Facilities
Lead: Robyn Tanguay, Ph.D., Distinguished Professor, Oregon State University

Dr. Robyn Tanguay explained that the session would address strategies for the improvement of resource management (e.g., rigor and reproducibility, capacity, speed, efficiency, and data security) via increased access to throughput technologies, data management tools, and systems to manage scientific data.

Dr. Joanna E. Burdette presented on the integration of core facilities for management. She explained that the Chicago Biomedical Consortium promotes shared access to core facilities among investigators from Northwestern University, The University of Chicago, and the University of Illinois at Chicago. Dr. Burdette explained that coordination across institutions is critical to providing access to cutting-edge technologies. Additionally, coordination promotes collaboration, efficiency, and training. She identified common needs of core facilities: improved sample consistency, improved core throughput, and increased data rigor. Dr. Burdette noted that her colleagues stated that liquid handlers and robotics would help address these issues.

Dr. Cory Brayton presented on the use of digital data management tools for pathological specimen identity and tracking. At Johns Hopkins School of Medicine, core facilities face a growing burden of managing data types and output. She emphasized that cooperative partnerships are maintained across the

Johns Hopkins University campus. Needs include enhanced rigor and reproducibility, increased efficiency (e.g., capacity, speed, and accuracy), and improved security. Dr. Brayton explained that electronic management is crucial for addressing these issues. The facilities track the experimental conditions and status of specimens *in vivo*, *ex vivo*, and *post vivo*. Electronic medical records are critical for specimen identity tracking within and between studies and institutions, as well as over long periods of time.

Dr. Suzanne Craig presented on the use of new resources for enhanced research capabilities. At the Medical University of South Carolina (MUSC), core facilities are coordinated via an online interface; information on the facilities is available on a single webpage. The core facilities are assessed annually by a committee. Dr. Craig noted that some of her facilities' equipment is old; recent equipment purchases (e.g., micromanipulators, antivibration tables, incubators, microscopes, sterilizers, replacement bio-bubbles, passthrough boxes, sterilizers, and individually ventilated cages) have provided new capabilities for investigators. Additionally, training in novel techniques (e.g., CRISPR/Cas-9) at other institutions would enhance the shared skillsets of facility personnel. Publication tracking would provide useful data for facility reviews.

Dr. Robert Price presented on funding and challenges faced at core facilities. He noted that the University of South Carolina School of Medicine (USCSOM) is located outside the institution's main campus but supports about 300 users per year. USCSOM supports numerous core facilities, and collaborations are maintained across the institution. Core facility equipment has been funded primarily by S10 grants and the U.S. Department of Veterans Affairs Laboratory Animal Major Equipment (LAMb) Program and Shared Equipment Evaluation Program (ShEEP) grants. Presently, capabilities are being developed for the support of COVID-19 testing. Challenges include communication among investigators and across platforms, sample and data tracking across core facilities, education of university administrators, and development of management systems.

Q&As

Dr. Michael C. Schmale asked Dr. Brayton for her opinion on the digitization of glass microscope slides. Dr. Brayton expressed her support for further development in this area but noted that currently, some institutions lack the high-throughput capabilities for full digitization. Dr. Schmale added that slide digitization could serve as a valuable teaching tool. Dr. Brayton noted that summer trainees were assigned pathology cases using this approach; she affirmed that digital technologies are key for remote education. Dr. Brayton noted that many diagnostic laboratories have extensive throughput systems and are likely capable of utilizing the digital data technology.

Dr. Price asked for further clarification on the distinction between equipment and instrumentation. Dr. Malgorzata Klosek, Director, Division of Construction and Instruments, ORIP, explained that overlap exists between the two terms; definition is dependent on the intended use of the technology (e.g., to generate new data or to provide supporting activities). Dr. R. Balfour Sartor suggested that smaller pieces of equipment could be bundled into larger systems for funding. He noted that, in some cases, multiple copies of the same equipment (e.g., isolators) are needed. Dr. Melinda R. Dwinell agreed, noting that small pieces of equipment (e.g., micromanipulators) are necessary for the maintenance of larger systems for animal research.

Topic: Advanced Equipment to Improve Care and Maintenance of Research Animals
Lead: S. Randal Voss, Ph.D., Professor and Associate Chair of Research, University of Kentucky

Dr. S. Randal Voss explained that the session would feature speakers with a variety of expertise in the areas of research animal care and maintenance. He stated that the central themes of the session would be divided into practical considerations (e.g., diversity of animal models, "plug and play" versus specialty

equipment, needs, and equipment versus animal facility improvement needs), smart equipment (e.g., minimally invasive housing, isolation chambers, and animal monitoring), essential equipment (e.g., cage wash, autoclaves, water systems, and environmental monitoring), and smart solutions (e.g., enabling and increasing efficiencies of animal care facilities).

Dr. Schmale presented on resource infrastructure needs for animal models, focusing on aquatics. Aquatic researchers utilize a large diversity of animal models and thus require a wide array of facilities and equipment for animal maintenance. ORIP has funded many aquatic animal model resources. Widely used models (e.g., *Xenopus* and zebrafish) have husbandry systems that are well established but costly to maintain. Additionally, new models can address various biomedical needs but often require species-specific husbandry systems. Furthermore, complex life cycles contribute to the need for husbandry customization. Dr. Schmale also noted that water quality (e.g., filtration, de-chlorination, temperature control, flow rates, salinity, pH, and dissolved oxygen) is the driving force behind many husbandry challenges for aquatic organisms, and water monitoring is crucial for reproducible research.

Dr. Sartor presented on equipment for gnotobiotic facilities. He noted gnotobiotic facilities require many pieces of small equipment that result in major costs. Recent advances in microbial research have expanded the need for gnotobiotic facilities in recent years. Core major equipment includes isolators (e.g., flexible film, semirigid, iso-positive, and specialty), support racks, supply cylinders and transfer sleeves, large autoclaves, decontamination systems (e.g., high-pressure sprays, dunk tanks, and transfer hoods), and supporting resources (e.g., autoclaves, storage space, preparation areas, backup power, HVAC, timed lighting, and microbiological laboratory support). Dr. Sartor pointed out that personnel comprise a large portion of core facility budgets, and training is critical.

Dr. Matthew Jorgensen presented on essential equipment and innovative equipment and solutions for nonhuman primate (NHP) facilities. He noted that some facility needs encompass many animal models, but others are specific to the type of model studied (e.g., NHPs). Dr. Jorgenson recounted his experience at Wake Forest School of Medicine. He described the development of automated feeders and methods for detection of social instability. These systems monitor animal irregularities, allowing researchers to assess underlying causes. Additionally, camera systems allow remote viewing of animals across multiple housing areas. Dr. Jorgenson noted that he hopes this new system will provide similar benefits for researchers. New caging designs allow positive reinforcement training, social viewing, social group housing, and mobility accommodations for older animals.

Dr. Deborah A. Lazzarino presented on the repair and renovation of an animal care facility at Rutgers New Jersey Medical School. The facilities support research on a wide array of animal models. Dr. Lazzarino detailed challenges and needs, which included repairing aging infrastructure, advancing environmental controls, and building care and support to complement new technology inside and outside the animal care facility. Dr. Lazzarino emphasized that robust environmental systems are critical to animal research; the HVAC system poses a particular challenge for the facilities. Additionally, older environmental systems require extra manual labor and more room for error. Dr. Lazzarino emphasized that facilities should be designed to enhance animal health and scientific rigor; she explained that research and animal care should be coordinated to optimize the workflow. She also spoke on the need for a funding mechanism to support equipment and laboratory setup costs for animal research facilities.

Q&As

Dr. Craig voiced her support for the replacement of aging equipment, and she noted that coordinated systems help control labor costs. Dr. Brayton noted that electronic equipment (e.g., for remote monitoring) enhances research capabilities; she also emphasized that animal identification metadata must be integrated with animal monitoring systems. Dr. Schmale added that integrative automation (e.g., kill

switches to turn systems off when needed) mechanisms are crucial, but keeping pace with technological advancements (e.g., software upgrades) is challenging. Dr. Tanguay explained that extensive monitoring is crucial for aquatic systems; she also noted that regular water monitoring (e.g., for pathogens) will help researchers assess the health of the facility.

Topic: Advanced Equipment to Improve Research-Supporting Functions of Core Facilities
Lead: Sheenah Mische, Ph.D., Associate Professor, New York University Grossman School of Medicine

Dr. Sheenah Mische explained that the session would address the need for advanced equipment to improve research-supporting functions in the context of shared resource laboratories. Dr. Mische reiterated the unique importance of core facilities in advancing biomedical research and facilitating collaborative efforts among investigators.

Dr. Dwinell presented on rat resources available through the Medical College of Wisconsin. The facilities were established through NIH-funded cooperative agreements and resource grants. Dr. Dwinell explained that the development of animal models—and the technical skills required for animal model research—occurred alongside the establishment of the core facilities. She noted that rat models pose both common and unique challenges for researchers. Rat studies require regular replacement of small pieces of equipment and specialized housing for colony management. The COVID-19 pandemic has spurred the identification of gaps—in funding for infrastructure and specific equipment—for both investigators and programs. Dr. Dwinell also emphasized the importance of ensuring continuity in services by maintaining high-quality equipment. Advancements in gene editing technologies will likely increase the need for core facilities in the future. In some cases, method optimization is necessary for strain-specific protocols. Furthermore, redundancy and backup plans are crucial for anticipation of emergencies.

Dr. Gary J. Patti presented on compute infrastructure for big data analyses. Mass spectrometry–based "omics" includes studies of proteomics, metabolomics, and lipidomics; instruments required for such analyses are often costly. The workflow of omics studies is as follows: acquisition, processing, interpretation, and omic integration. Because data acquisition generates large data sets, analysis of omic data is often costly. Dr. Patti explained that cloud-based services help control for the costs of big data analysis, because cloud computing is less expensive and more convenient for users than local computing. Additionally, cloud servers enable cost sharing and collaboration across multiple laboratories. Dr. Patti highlighted Metabolomics Workbench, which enables data storage and processing on the cloud.

Dr. John A. McLean presented on the advancement of research opportunities through equipment microgrants. Major scientific pursuits (e.g., the *All of Us* Research Program) require high throughput and large-scale studies. Emerging challenges (e.g., the COVID-19 pandemic), however, necessitate funding for smaller-scale equipment. Research facilities must scale their operations upward and downward, depending on current needs. In many cases, smaller, fast-turnaround funding mechanisms are necessary. Dr. McLean highlighted examples of microgrants (e.g., safety equipment, automation accessories, sample preparation tools, spectrometry and spectroscopy accessories, reagents and consumable equipment, and storage). Dr. McLean emphasized that microgrants enable rapid scientific discoveries, promote inclusion and diversity, and support young investigators.

Dr. Christopher F. Cuff presented on leveraging NIH investment in cryogenic electron microscopy (EM). The technique is quickly gaining popularity among structural biologists, but it incurs a significant cost. The Transformative High Resolution Cryo-Electron Microscopy Program supports three national service centers, broadening access to the technology and cultivating a skilled workforce. Dr. Cuff consulted with investigators from the West Virginia University School of Medicine who utilize cryo-EM centers for their research. The investigators identified resources that would enhance their productivity: an automatic plunge freezer and sufficient cryo-storage space for physical grids. New funding mechanisms are needed

for improved access to cryo-EM technologies. He suggested adding regional sites for lower-end cryo-EM investment, which would enable improved efficiency for high-end systems.

Dr. Terrence R. Tiersch presented on network-level funding. He provided an overview of the Louisiana State University Aquatic Germplasm and Genetic Resources Center, which is located next to the main campus. The facility is dedicated to protecting genetic resources for aquatic biomedical models through interdisciplinary collaboration. The facility's pipeline from research to application is as follows: protocol development, technology development, repository development, and commercial development. The facility is dedicated to assisting other facilities in the establishment of biorepositories. Automated processing, freezing capabilities, mobile laboratories, and aggregate throughput help ensure quality control for biorepositories. Dr. Tiersch explained that the facilities have distinct and unique requirements, requiring a network of customized solutions. The network connects existing centers and extends to a broad user community. He emphasized the need for mentioned the need for standardized equipment and protocols across the network, which would enable comparing results and sharing of data. This unique design requires a customized funding mechanism to allow support across different levels of the network.

Q&As

Dr. Tanguay expressed concerns related to the security of cloud computing. Dr. Patti explained that academic cloud servers maintain data security agreements with providers. He also noted that unauthorized users likely would be unable to interpret unannotated data.

Dr. Nicholas Ambulos, Steering Committee Chair, asked about mechanisms to encourage broader usage of certain animal models across research institutions. Dr. Schmale noted that many researchers are actively pursuing efforts to reach out to new user communities. He added that such outreach can be challenging. Dr. Ambulos suggested developing a central website listing resources for different animal models. Dr. Klosek noted that animal resources are listed on ORIP's website.

Dr. Tiersch commented that switching focus to a new animal model is challenging. Education, training, and tools for transitioning would help facilitate the exploration of different models. Dr. Schmale noted that many core facilities offer resources in that area.

Several participants expressed support for a microgrants program. Dr. Tanguay emphasized that such programs provide significant returns on investment. Dr. Brayton expressed concern about small grants that cannot functionally be networked. She noted that networking and data management are crucial in modern research. Dr. Ambulos pointed out that many NIH Institutes, Centers, and Offices (ICOs) fund small equipment to supplement R01 grants. He suggested that the ICOs form partnerships with ORIP to apply this funding for shared use.

Exchange of Ideas: Assessment of Needs for Modern Equipment

Dr. Brayton asked ORIP staff for their insight on networking infrastructure, data management, and electronic specimen identification. Dr. Klosek noted that the Office of Data Science Strategy is dedicated to developing NIH data policies. She emphasized that data management is complex, and the NIH recognizes the challenges of this issue. Dr. Klosek also noted that the ORIP Division of Comparative Medicine supports a program for animal identifiers.

Dr. Ambulos stated that the Workshop highlighted creative approaches across such topics as sample preparation, collaborations across institutions, sample tracking, upgrades to outdated equipment, monitoring external conditions, providing opportunities for training and staff development, and maximizing utilization of resources. He expressed his appreciation for the diversity of ideas discussed. In

response to a comment from Dr. Tiersch, Dr. Ambulos stated that a network-level funding mechanism could encourage the establishment of a user base across institutions. Dr. Tanguay expressed her appreciation to NIH for its innovative approach and service to the research community.

Workshop Adjourns

Drs. Grieder and Klosek thanked the participants for sharing their time, expertise, and perspectives. Dr. Klosek encouraged the participants to send any additional information for incorporation into the meeting summary, noting that the summary would be distributed for their review.

Appendix A: Workshop Agenda

Modernization of Biomedical Research Facilities Workshop
Tools for Biomedical Research

Time and Date: 1–4 p.m. EDT on August 25, 2020

Venue: Virtual Meeting (Zoom)

Workshop Agenda

12:00 p.m. – 12:05 p.m. **Welcome**

12:05 p.m. – 12:10 p.m. **ORIP's Director Opening Remarks**
- Franziska Grieder, Director, ORIP, NIH

12:10 p.m. – 12:20 p.m. **Introduction to the Workshop**
- E. Albert Reece, University of Maryland School of Medicine

12:20 p.m. – 12:25 p.m. **A Word from the Chair**
- Nicholas Ambulos, University of Maryland School of Medicine

12:25 p.m. – 1:25 p.m. **Topic: Advanced Equipment to Improve Management through Automation of Shared Facilities**
- Lead: Robyn Tanguay, Oregon State University
- Cory Brayton, Johns Hopkins University School of Medicine
- Joanna E. Burdette, University of Illinois, Chicago
- Suzanne Craig, Medical University of South Carolina
- Robert Price, University of South Carolina School of Medicine
- Q&As

1:25 p.m. – 2:25 p.m. **Topic: Advanced Equipment to Improve Care and Maintenance of Research Animals**
- Lead: S. Randal Voss, University of Kentucky
- Matthew Jorgensen, Wake Forest School of Medicine
- Deborah A. Lazzarino, Rutgers New Jersey Medical School
- R. Balfour Sartor, The University of North Carolina at Chapel Hill
- Michael C. Schmale, University of Miami
- Q&As

2:25 p.m. – 3:25 p.m. **Topic: Advanced Equipment to Improve Research-Supporting Functions of Core Facilities**
- Lead: Sheenah Mische, New York University Grossman School of Medicine
- Christopher F. Cuff, West Virginia University School of Medicine
- Melinda R. Dwinell, Medical College of Wisconsin
- John A. McLean, Vanderbilt University
- Gary J. Patti, Washington University in St. Louis

- Terrence R. Tiersch, Louisiana State University Agricultural Center
- Q&As

3:25 p.m. – 3:50 p.m.	**Exchange of Ideas: Assessment of Needs for Modern Equipment**
3:50 p.m. – 4:00 p.m.	**Future of Research-Supporting Technologies**
4:00 p.m.	**Workshop Adjourns**

Appendix B: Workshop Attendees

Steering Committee

Nicholas Ambulos	University of Maryland School of Medicine
Sheenah Mische	New York University Grossman School of Medicine
Robyn Tanguay	Oregon State University
S. Randal Voss	University of Kentucky

NIH Staff

Lola Ajayi	ORIP/DPCPSI/OD/NIH
Michael Chang	ORIP/DPCPSI/OD/NIH
Franziska B. Grieder	ORIP/DPCPSI/OD/NIH
Alena Horska	ORIP/DPCPSI/OD/NIH
Malgorzata Klosek	ORIP/DPCPSI/OD/NIH
Guanghu (Jeff) Wang	ORIP/DPCPSI/OD/NIH

Guest Speaker

E. Albert Reece	University of Maryland School of Medicine

Speakers

Cory Brayton	Johns Hopkins University School of Medicine
Joanna E. Burdette	University of Illinois, Chicago
Suzanne Craig	Medical University of South Carolina
Christopher F. Cuff	West Virginia University School of Medicine
Melinda R. Dwinell	Medical College of Wisconsin
Matthew Jorgensen	Wake Forest School of Medicine
Deborah A. Lazzarino	Rutgers New Jersey Medical School
John A. McLean	Vanderbilt University
Gary J. Patti	Washington University in St. Louis
Robert Price	University of South Carolina School of Medicine
R. Balfour Sartor	The University of North Carolina at Chapel Hill
Michael C. Schmale	University of Miami
Terrence R. Tiersch	Louisiana State University Agricultural Center

Science Writer

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