**PLAN FOR INSTRUCTION IN METHODS FOR ENHANCING REPRODUCIBILITY**

Duke University is committed to providing both course specific and experiential training in principles and practices for enhancing research reproducibility, critical evaluation of the rigor of the foundational research underlying a project, rigorous experimental design and data interpretation, consideration of relevant biological variables such as sex, age, background strain (animal studies), source/supplier, body mass index, socioeconomic status, and underlying health conditions, authentication of key biological and/or chemical resources, data and material sharing, record keeping, and transparency in reporting. Embedded within the comprehensive responsible conduct of research (RCR) curriculum and broader graduate curriculum is instruction in many of these Rigor and Reproducibility (R&R) topics. Outlined below are specific areas where methods for enhancing reproducibility have been integrated into the **<INSERT NAME HERE>** training program.

**Integrated curriculum elements and institutional resources**

**BIOTRAIN courses.** BIOTRAIN is a collection of RCR/R&R focused preparatory courses specifically designed to build essential skills and knowledge for pre-doctoral trainees in the biomedical sciences throughout their PhD track. A brief description of each course and the relevance to enhancing reproducibility is provided. Complete course descriptions and syllabi are available on the Office of Biomedical Graduate Education (OBGE) BIOTRAIN website:

*BIOTRAIN720 Grant Writing for Biomedical Scientists-* Introduction to scientific grant writing for second- or third-year PhD students. This course contains lecture-based and active learning sessions. Relevant topics include lectures combined with class discussions of: best practices in articulating study design and data outcomes; rigor and reproducibility in a research plan; and crafting biological significance and training statements.**<INSERT TRAINING PROGRAM NAME HERE>** faculty including <INSERT Faculty if appropriate>, participate as grant reviewers/study section leaders for this course.

*BIOTRAIN730**Data Visualization for Biomedical Sciences*- Learning to manage, display, communicate scientific results effectively and ethically is an important component of professional development for all scientists. This course will fully integrate rigor and reproducibility best practices in data visualization. This course is open to students of any year in SoM PhD programs.

*BIOTRAIN750 Introduction to RCR for Biomedical Scientists-* an orientation and introduction to Responsible Conduct of Research (RCR) at Duke. This half-day in person event that is **required** for all incoming first-year students in SoM PhD programs. Relevant topics have included: Research Data Management; Diversity, Equity, Inclusion, and Cultural Awareness at Duke; and Graduate School: Expectations, Professionalism, and Resources for Students.

*BIOTRAIN751 The Responsible Scientist I-* **required** for all 1st year students, this course utilizes in person lectures and small group discussions to provide formal instruction in RCR and R&R topics adapted for early-stage graduate students. **<INSERT TRAINING PROGRAM NAME HERE>** faculty participate as small group facilitators and instructors for this course. Relevant topics covered include: rigor of the prior research; scientific rigor in experimental design; biological variable considerations; resource authentication; data acquisition and laboratory tools; and data management, sharing and ownership.

*BIOTRAIN753 Data Management and Quality for Biomedical PhD Students-* **required** in the second or third year or training, this course is offered online with interactive graphics, text-based activities, short videos, and discipline specific scenarios. It contains 3 modules: Research Quality and Reproducibility; Data Management; Data and Resource Sharing.

*BIOTRAIN754 The Responsible Scientist II-* **required** for all 4th year students, this course utilizes in person lectures and small group discussions to provide formal instruction in RCR and R&R topics adapted for advanced graduate students. **<INSERT TRAINING PROGRAM NAME HERE>** faculty participate as small group facilitators and instructors for this course. Relevant topics covered include: rigor of the prior research; scientific rigor in experimental design; biological variable considerations; resource authentication; data acquisition and laboratory tools; and data management, sharing and ownership.

**Duke Office of Scientific Integrity (DOSI) Advancing Scientific Integrity, Service and Training (ASIST).** Postdoctoral trainees participate in the RCR program run by DOSI ASIST. Several elements of programming offered by the ASIST office include R&R relevant topics and training. A brief description of each element and the relevance to enhancing reproducibility is provided. Complete descriptions are available on the DOSI ASIST website:

*Research Town Halls*: The Duke Research Town Hall Series is a recurring, engaging series developed to support and enhance a strong research culture at Duke University. Monthly sessions feature research best practices, research tools, and new research initiatives. Most events are recorded, with the video and associated slides available on the website as a resource for trainees. A sample of relevant presentation titles from the past year include: Best Practices and Resources for Qualitative Research at Duke; Enabling the Environment for Conducting Research with Integrity at Duke; From Regrettable Research Practices to Rigorous and Reproducible Research; Fundamentals of the Scientific Process.

*Level 100 courses*: Online Self-Directed Courses that are designed to ensure that all postdoctoral trainees engaged in research have a sound understanding of the critical components of research integrity and are all using a common language to approach these complex topics including, but not limited to research reproducibility, research misconduct, data management, conflicts of interest and unconscious bias. The ASIST office offers a rotating list of online courses available on their website. All postdoctoral trainees are **required** to complete one 100 level course every 3 years.

*Level 200 courses*: Collaborative 200 level courses are designed to engage our community in open, in person or virtual discussions about RCR topics. A large variety of events and workshops can count towards a 200 level course credit. A complete list of maintained on the ASIST website. Research Town Halls as described above are one example of an event that could fulfil the 200 level course requirement. All postdoctoral trainees are **required** to complete one 200 level course every 3 years.

For postdoctoral trainees, completion of coursework-related R&R trainings is monitored by the Human Resources department. Postdoctoral researchers will receive automated emails reminders when their RCR course due-dates approach, and may check their RCR education progress at any time through the RCR training tracker app or through the "my Portfolio" or "myTraining" widgets in myRESEARCHhome, an omnibus website maintained by Duke.

**<INSERT TRAINING PROGRAM NAME HERE>** **program specific meetings**. <Customize as appropriate; see below for example text> All trainees and program directors participate in annual orientation events, a weekly seminar series, and biannual Symposia. Discussions led by faculty and/or trainees about R&R and RCR issues will be included as a regular part of these meetings to communicate the program’s commitment a rigorous science.

**Experiential learning and support**

**Mentored PhD Research**. **<INSERT TRAINING PROGRAM NAME HERE>** faculty provide the day to day mentorship of pre- and postdoctoral trainees and are responsible for exemplifying and reiterating key concepts and best practices for RCR and R&R in their specific lab environments to augment the curricular training. Discussion of R&R concepts and standard operating procedures (SOP) for data management and reporting will be integrated with the design and implementation of PhD dissertation and postdoctoral research projects. For predoctoral trainees, implementation of these principles and practices and the trainee’s progress will be monitored and reported by the dissertation advisor and dissertation committee in T3, a trainee tracking tool overseen by OBGE, as outlined below.

1. Evaluation of R&R during laboratory rotations. At the end of a laboratory rotation, faculty will fill out an evaluation form in T3 that includes rating on a numerical scale the trainee’s competence in experimental, computational, and statistical skills, RCR, and research ethics.
2. Evaluation of R&R in preliminary exams. Beyond the specific project, the preliminary exam committee will evaluate trainees on their understanding of experimental, computational, and statistical skills, the rigor of prior research, the rigor of the proposed research (experimental design, data interpretation, data and material sharing, record keeping, transparency), biological variables such as sex, and authentication of key biological and/or chemical resources. Evaluations are entered into T3 during the preliminary exam.
3. Evaluation of R&R in annual committee meetings. For each annual committee meeting, faculty will fill out an evaluation form in T3 that includes rating on a numerical scale the trainee’s competence in experimental, computational, and statistical skills, RCR, and research ethics.
4. Evaluation of R&R in the dissertation defense. Predoctoral trainees will be evaluated on rigor and reproducibility in their final dissertation. Sections in the written thesis will document the rigor of prior research, rigor of research conducted, relevant biological variables, data management and sharing, statistical analysis, and resource authentication. Evaluations are entered into T3 during the dissertation defense.

OBGE oversees evaluations at all predoctoral training stages and compiles the program level data. This will allow **<INSERT TRAINING PROGRAM NAME HERE>** to quantitatively evaluate the overall development and improvement of trainees in a variety of R&R topics as they progress through the program. **<INSERT TRAINING PROGRAM NAME HERE>** annual reviews of postdoctoral trainees by the Trainee Review Committee will be used to assess postdoctoral trainees’ engagement with and incorporation of R&R in their research. These processes will also allow for the identification of weaknesses in the curriculum and areas for individual or programmatic improvement.

**Supplemental online training and resources**

In addition to the training available directly through Duke, there are many resources and online modules available to be used to create individualized training plans as appropriate for a particular student based on their research project, experience, and goals. A compilation of links to these vast resources is available on OBGE’s website on the “Responsible Conduct of Resources” page. Summarized below are several key trainings that are highlighted on OBGE’s website.

The NIH Reproducibility Training website provides a series of online modules with specific instruction and training to enhance reproducibility through rigor and transparency. The specific module topics are listed below:

Module 1: Lack of Transparency

Module 2: Blinding and Randomization

Module 3: Biological and Technical Replicates

Module 4: Sample Size, Outliers, and Exclusion Criteria

The NIGMS Data Reproducibility website provides links to several additional training modules hosted by a variety of institutions that address various topics in reproducibility and transparency. Below are listed some particularly relevant ones:

Improving Reproducibility in Research (Indiana University)

Let’s Experiment: A Guide for Scientists Working at the Bench (iBiology)

Pragmatic and Group-Randomized Trials in Public Health and Medicine (NIH Office of Disease Prevention)

Controls in Animal Studies for Rigor and Reproducibility (American Physiology Society)

Statistical Topics for Reproducible Animal Research (Indiana University & University of Alabama)

Improving Reproducibility of Computational Microbiome Analysis (University of Michigan)

Principles, Statistical and Computational Tools for Reproducible Science (Harvard University)

Society for Neuroscience Rigor and Reproducibility Training Webinars (Rutgers University)

Cell Line Authentication Training (Global Biological Standards Institute)