Students receive a strong foundation in scientific reasoning, rigorous research design, experimental methods, and quantitative approaches to data analysis and interpretation. This is accomplished through training in Scientific Rigor and Reproducibility (SRR) at a level exceeding NIH recommendations. Students participate in **over 47 hours of ‘face-to-face’ SRR training** during their studies**.** They are exposed to **all recommended** **topics**, including critical evaluation of foundational research underlying a project, rigorous experimental design, consideration of sex and other relevant biological variables, authentication of key biological and/or chemical resources, and transparency within the contexts of the laboratory, scientific and public meetings, and in publication (see PAR-20-213). Since each student learns differently, the program employs different modalities to convey the concepts, including small- and larger-group discussions and SRR-based lab meetings. Additionally, an emphasis on ‘premise and design’ are threaded throughout trainee’s coursework, candidacy examination and thesis committee meetings. Biomedical Graduate Studies has developed an SRR website that describes policies, guidelines, methods for training, and provides a wealth of case-studies around which discussions are based.

**Year one, Orientation** (**4 hours**): Three well-integrated sessions cover *Laboratory Notebooks*, *RCR*, and *Experimental Design*. The session on Laboratory Notebooks discusses data acquisition, record-keeping, file organization and storage. It includes a deep dive into Electronic Notebooks (ELNs), featuring breakout sessions for hands-on work with ELNs. The second session, on RCR, presents *Rigor and Reproducibility* as the foundation for rigorous research. The presentation introduces the idea of using small workshops built around discussing ‘case studies’, which is a method choice to convey concepts. The third session introduces the main concepts of ‘*Rigor in Experimental Design’*, and uses breakout sessions of 10-12 students led by a facilitator to discuss case studies.

**Year one, Academic** (**40 hours +**): *[T32s and students affiliated with BMB or NGG will need to* ***substitute*** *a paragraph referring to* [*BMB 510*](https://www.med.upenn.edu/bgs/assets/user-content/documents/spring-2020-courses/bmb-510.pdf) *& 705 (see K. Sharp) or* [*NGG 605*](https://www.med.upenn.edu/bgs/assets/user-content/documents/spring-2020-courses/ngg-605-duplicate.pdf) *(see J. Gold)]* Two core classes in *Cell Biology* (BIOM 600) and *Regulation of the Genome* (BIOM 555) have SRR threaded throughout using problem sets, case studies, and exercises. Additionally, year one students take *Data Analysis for Life Science* (BIOM 610), combining lectures and scripting sessions from which trainees learn how to create transparent and reproducible analyses. The core competencies include knowledge within their program area (biostatistical method, statistical analysis in R, and high- dimensional data analysis and interpretation); computational methodologies (data analysis; programming and computing); scripting in an open-source programming language for statistics and plotting (R and R-based statistical packages).

**Year two** (**40 hours +**) Trainees take at least two elective, seminar-style courses in their field of study. The faculty directors emphasize discussion of ‘scientific premise and rigorous design’ throughout. Additionally, year 2 students develop a proposal relating to their dissertation research. Both the written proposal and the oral exam that follows require the student to critically evaluate the foundational research underlying the project, and also require the student to propose and defend a rigorous set of experiments, along with their analysis of it, in order to advance to candidacy. Examining faculty are tasked to ensure that students propose the proper validation for reagents used, as well as authenticate cell lines, antibodies and other research materials. Finally, second-year students participate in a 1.5-hr session dedicated to this topic in their research lab.

**Years three, four and five** (**1.5-hr** each year) Dissertation-stage students are required to participate in a 1.5-hr SRR-based lab meeting each year wherein the PI selects one or two topics for discussion. Basing these sessions in the lab has the significant advantage of promoting discussion about rigor and reproducibility as directly applied to the specific research area of the trainee. The lab PI reports these meetings to BGS, noting the topics covered, the materials used, and which trainees participated.