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, sex and gender in scientific studies, and consideration of 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. 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**): Two sessions covering *Laboratory Notebooks*, *Responsible Conduct of Research (RCR)*, and SRR/*Experimental Design are required, forefront events held during new student orientation before students begin conducting experiments. These are well-regarded as evidenced by post-surveys and longitudinal feedback*. 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 delves into RCR and SRR, focusing on ethical considerations and shared values essential to biomedical research. Students are familiarized with useful resources designed to uphold scientific integrity, enhance experimental precision, and foster collaborative, open science practices. Following the main presentation, students engage in an interactive workshop with breakout sessions where groups of 10-12 students are guided by a facilitator through case studies. These small-group discussions highlight key aspects of robust experimental planning and design, providing practical insights into RCR and SRR principles.

**Year one, Academic** (**40 hours +**): Two core courses in *Cell Biology and Biochemistry* (BIOM 6000) and *Regulation of the Genome* (BIOM 5550) have SRR threaded throughout using problem sets, case studies, and exercises. Students learn to analyze data critically and effectively in collaborative and interdisciplinary small group sessions (~10 sessions in each course). This approach develops student proficiency in experimental methodologies while realizing accompanying limitations, ensuring students understand the importance of rigorous experimental design and obtaining scientifically valuable results. Principles underlying the design of robust experiments, including clear hypothesis, research question, and model formulation, identification and control of experimental variables, and method and reagent validation are major themes. With these elements integrated throughout the first-year curriculum, students become equipped with the skills necessary to uphold high standards of research conduct and practice.

**Year two** (**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)*0 & 7050 (see K. Sharp) or* [*NGG 605*](https://www.med.upenn.edu/bgs/assets/user-content/documents/spring-2020-courses/ngg-605-duplicate.pdf)*0 (see M. Ma)]* Students take *Foundations in Statistics* (BIOM 6100), or an equivalent course, to 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). Trainees also 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.