Graduate Student Symposium: From Hypothesis to Manuscript: How to Conduct Valuable and Efficient Research

733 Developing the research question, hypothesis, design, and protocol. D. E. Bauman*[1] and R. J. Collier[2], [1]*Cornell University, Ithaca, NY,* [2]*University of Arizona, Tucson.*

The first step in developing a research question is to undertake a thorough examination of the background literature. Review articles are often a good start to gain context, but this review should include specific investigations representing current and historical research. The end result is the investigator is able to identify current issues in this area. Nobel laureate physiologist Albert Szent-Györgyi described this as "seeing what everybody has seen and thinking what nobody has thought." The next step is to identify a researchable question and develop a hypothesis that will provide clarity and structure to the research question as well as a tentative explanation of the research problem and a potential outcome. Identifying a researchable question is one of the most challenging aspects of science. Nobel Prize-winning biologist Peter Medawar referred to science as "the art of the solvable," identifying which questions are solvable through scientific investigations, and then developing hypotheses and designs to address them. The research design needs to be structured to be quantifiable, verifiable, replicable, and defensible. The protocol is a logical outcome of the research design and should include methods for all of the procedures to be utilized. Methodology is a critical component of science; results will be judged on quality of the data, but also on the validity and accuracy of the methods used to derive the data. Likewise, variables being measured need to be thoroughly evaluated to ensure they are appropriate and essential to allow a critical evaluation of the hypothesis. The protocol should also include development of the data collection forms to be used for data entry. Presentations by others will discuss additional critical dimensions including statistical considerations, data collection and publication, but we emphasize that the principle investigator is responsible for the conduct of the study. This includes laboratory determinations and data analyses, summarization and interpretation of the results, and finally publication of the investigation in a peer-reviewed journal. Throughout the presentation, authors will draw on their experience to provide insight and examples.

Key Words: research, scientific method, review

734 Data collection and integrity. G. Hartnell,* *Monsanto Company, St. Louis.*

Accurate data collection is the foundation on which the integrity of research results is based. Procedures should be in place that results in the detection and minimization of errors (systematic and random) and ensures accuracy so results can be repeated with a high level of certainty by others. The protocol should contain sufficient detail so others can accurately repeat the study. Standard operating procedures should be in place to address the question "How do I know?" in regards to data and data collection. For example, how do I know the scale or balance is accurate? How do I know the corn used in feeding the animals was not contaminated with mycotoxins that could influence the outcome of the study? How do I know the animals were deemed healthy before the start of the study? How do I know the diets were mixed properly? How do I know the personnel were properly trained to collect and measure the information on the variables of interest? Good laboratory practice, quality assurance, and quality control are approaches to be considered. Researchers must be vigilant in preventing data integrity issues when selecting, collecting, recording, analyzing, handling, storing, reporting and publishing data. Data integrity must be preserved to ensure the scientific validity of study results and conclusions that in the end reflect on the integrity of the researcher.

Key Words: data collection, data integrity, GLP

735 I'm an animal scientist, why do I need statistics? D. K. Aaron,* *University of Kentucky, Lexington.*

The answer to the question posed in the title of this presentation should be obvious: Scientists conduct research and research is dependent upon statistics. Statistics plays an integral role in experimentation, starting with planning, continuing through execution, data collection and analysis, and ending with interpretation and presentation of results. This is the reason all graduate programs in animal (dairy) sciences require students to take one or more formal courses in statistics. The expectation is that understanding statistical theory and its application to experimental design and analysis makes better researchers. In other words, future researchers will know proper design, good execution strategies and correct data analysis procedures. Is this expectation being met? Are we training better scientists? Yes and no. On the positive side, completion of formal statistics courses results in graduate students who are generally adept in the computational aspects of experimentation; that is, they can "run" SAS (SAS Inst. Inc., Cary, NC). Give them a data set and the light comes on. On the negative side, graduate students often exit formal statistics courses deficient in the non-computational components (e.g., design, implementation, measurement, interpretation) of experimentation. Ask them to design experiments or interpret research results and the light flickers or doesn't come on at all. Whose fault is this? Whose responsibility is it to ensure that future researchers are proficient in both computational and non-computational aspects of experimentation? Is more formal statistical training the answer? Questions such as these will be addressed in this presentation. The importance of statistics will be discussed in a serious, but sometimes light-hearted, way. The result will be a greater appreciation and understanding of the role statistics plays throughout the entire process of research.

Key Words: science, statistics, research

736 It is not a scientific contribution until it is published: Tips from a journal editor. S. A. Zinn,* *University of Connecticut, Storrs.*

Graduate students meticulously plan and implement experiments. Data are generated, carefully analyzed, thoroughly discussed and presented at lab meetings and regional, national and international scientific meetings in a variety of formats. Students spend endless hours writing theses and dissertations to earn, and deservedly so, their advanced degrees in their chosen discipline. But without peer-reviewed publication of their work, a graduate student has little to show for their efforts, especially if they are trying to compete with their peers to be successful in a diminishing market of tenure-track faculty positions and laboratory-based industry positions. The focus of this talk will be on preparation of manuscripts from submission to acceptance in the *Journal of Animal Science*. Differences between thesis and manuscript writing will be covered and details regarding the submission and peer-revision process will be discussed.

Key Words: publication, peer-review, graduate students