Instructing the Animal Physiology Graduate Student in Human Assisted Reproductive Technology\textsuperscript{1,2}

William R. Boone\textsuperscript{*},\textsuperscript{3}, Joseph F. Dickey\textsuperscript{†}, M. Elaine Richardson\textsuperscript{†}, Roxanne S. Bernard\textsuperscript{†}, and Jane E. Johnson\textsuperscript{*}

*Reproductive Endocrinology Associates, Greenville, SC 29605 and †Animal, Dairy, and Veterinary Sciences Department, Clemson University, Clemson, SC 29634

ABSTRACT: Animal physiology graduate students provide an excellent personnel resource for laboratories performing human assisted reproductive technology (ART) procedures. However, the basic training of these students falls short of what is required for this highly specialized field. We designed a course to enhance their education in this area via classroom and hands-on laboratory instruction in a hospital and university setting. Topics covered in the course included in vitro maturation, in vitro fertilization, embryo culture, embryo transfer, quality control, quality assurance, micromanipulation, and cryopreservation. These techniques were applied to a group project to evaluate the influence of spermatozoal quality and quantity on early embryonic development in cattle and humans. Student grades were based on 1) oral and written examinations; 2) demonstrated competency in laboratory techniques; 3) presentation of class project data at a state academy of science meeting; and 4) initiative, determination, and interest in the coursework. Three aspects of the course stood out as very positive. First, the team approach to accomplishing a class project was new to some of the graduate students. Second, a bond was formed between hospital- and university-based faculty that did and will continue to foster unique teaching and research opportunities between the two groups. Third, the opportunity for students to present research data in a formal setting was very rewarding. This course made the students keenly aware of the many aspects of ART and provided them with specialized skills that should make them more marketable in the field of reproductive technology.

Key Words: Education, Teaching, Assisted Reproductive Technology, Human Medicine, Reproductive Physiology

Introduction

Students who have taken animal physiology classes are a major resource for laboratory directors in the field of assisted reproductive technology (ART), especially when the field of ART applies to human reproductive medicine. However, we feel that most graduates of programs in animal physiology are not sufficiently versed in all the basic procedures needed to enter an established ART program and perform techniques such as in vitro maturation (IVM) (Jones and Schrader, 1988; Dunbar and O’Rand, 1991), in vitro fertilization (IVF) (Jones et al., 1986; Dunbar and O’Rand, 1991; Boone et al., 1994), embryo culture (EC) (Jones et al., 1986; Dunbar and O’Rand, 1991; Boone et al., 1994), embryo transfer (ET) (Jones et al., 1986; Boone et al., 1994), quality control (QC) (Boone and Shapiro, 1990), quality assurance (QA) (American Fertility Society, 1992), micromanipulation (Cohen et al., 1992), and cryopreservation (Jones et al., 1986). Expertise in these basic techniques is critical for entry into this career. We designed a course to instruct graduate students in these and related techniques. Our goals were threefold: 1) to provide students with “hands-on” experience in techniques used daily in an ART program, 2) to provide insight into the effective laboratory management of a human ART program, and 3) to train students in the team approach to problem solving. (This included exploring a problem, gathering and analyzing data, and reporting findings.)
Materials and Methods

This new course, titled “Concepts in Mammalian Assisted Reproductive Technology (ART),” stemmed from a consortium between the Greenville Hospital System and Clemson University and was offered in the spring of 1994. Because it was a techniques course requiring considerable time and laboratory space at both the university and the hospital, enrollment was limited to four to six students. Four Master of Science students in the field of animal physiology registered for the course, which was designed for three semester hours of credit. A graduate-level course in reproductive physiology was the only prerequisite. Objectives for the course included facilities, leadership, and supervision so that students could enhance their proficiency in reproductive techniques to obtain employment in a human or another mammalian ART laboratory.

No textbook was used for the course, but handout materials (describing procedures and listing selected references) were provided when appropriate. A discussion format promoted interaction among instructors and students.

Each of the three faculty members had over 20 yr of relevant teaching and research experience and had been professionally recognized for his/her teaching. The three professors participated in all formal classes and were available to assist in their particular area(s) of expertise. Preparation time was approximately one-third of their total time spent on the course. A certified cytotechnologist and a certified medical technologist were available to assist students with technical aspects of the course and were present during regular working hours at their respective facilities. Topics covered included the following:

1. A history of ART
2. Sterile techniques and media preparation
3. Superovulation and embryo recovery from the mouse
4. In vitro maturation, in vitro fertilization, and embryo culture techniques
5. Andrological procedures
6. Staining procedures for embryos and sperm
7. Cryopreservation of embryos and sperm
8. Evaluation and grading of embryos
9. Micromanipulation
10. Electron microscopy techniques
11. Quality control and quality assurance
12. Ethics

After the instructors discussed and demonstrated techniques, the students repeated them to become proficient. Students then applied the techniques in a class project.

Class Project

The subject of the class project was the influence of sperm quality and quantity on fertilization and early embryonic development in cattle and humans. The study population included frozen semen specimens from nine bulls of known background (Heartland Genetics, Adel, IA) and semen specimens from eight IVF couples with known reproductive dysfunction. Semen specimens from the bulls were classified as low, medium, or high fertility based on the performance of the sperm under IVF conditions. Semen specimens from the human subjects were classified as low- or high-fertility based on past IVF performance.

Semen analysis was performed on each bull and human specimen using light microscopy (manual method) and a Computer Automated Semen Analyzer (CASA) (Johnson et al., 1990; Davis, 1992) (Hamilton-Thorn Research, Beverly, MA). A viability evaluation was performed also on human semen specimens. Smears of human semen made at the outset of the experiment (0 h) and again at 1 h and at 2 h were examined and percentage of live and dead sperm was determined for each (Lasley et al., 1942). Aliquots of each semen specimen were processed for EM (Hayat, 1986). Bovine oocytes from donors of unknown age and breed were aspirated from ovaries obtained from a local abattoir, and the frozen bull semen was thawed and used in an IVM, IVF, and EC procedure (Jones and Schrader, 1988; Dunbar and O’Rand, 1991). Students used the analysis of variance (ANOVA) to evaluate their data (Cochran and Cox, 1950).

At the end of the course, students were required to present their data at the annual meeting of the South Carolina Academy of Science (SCAS) (Bailey et al., 1994; Cromer et al., 1994; Poole et al., 1994; Robbins et al., 1994). Each student had been designated as the “captain” of one of the following four sections of the class project: 1) sperm morphology using light microscopy, 2) sperm morphology using electron microscopy, 3) sperm concentration and motility using manual and CASA techniques, and 4) bovine in vitro fertilization and embryo cryopreservation. Each student made a 12-min presentation that was followed by a 3-min discussion.

Grading

Grading of the students was based on the following criteria: 1) demonstrated proficiency in laboratory procedures (40%); 2) exams: A) oral midterm exam (10%), B) oral and written final exam (15%); 3) research report and presentation (20%); 4) initiative, interest, and determination (15%). Evaluation was based primarily on subjective grading; therefore, all students were evaluated separately by each faculty member and laboratory technologist. The evaluations then were averaged to calculate the final grades. Input from the technologists was important because of their role in overseeing the procedures and their constant contact with the students in the two laboratory sites used during the course.
Results and Discussion

A course such as the one we have described is very time-consuming for students and instructors. Ideally, it should be taught when classroom workloads for students and instructors are minimal. The use of discussions and the emphasis on laboratory procedures required the students be present for more than the 7 h/wk that were blocked for the course. Proficiency attained by each student was directly related to the amount of time the student was willing to dedicate to learning and refining individual techniques.

Positive aspects of the course included the students' learning to operate as a team. They dealt with friction among themselves when they had to schedule time for conducting procedures and when they needed to compromise for the good of the overall project. The team approach provided valuable experience in handling differences among personalities. Cooperation between hospital and university personnel was very rewarding. Interaction between the faculty members created a bond between the two groups that has initiated the writing of three grant proposals as well as discussion of future joint teaching ventures. In the opinion of the instructors, the most productive part of the course was the requirement that the students organize their data and present the results of their class project to an outside audience. Their papers were well received at the SCAS meeting.

We will consider several changes when we teach the course again. The EM portion of the class would be deleted due to the extensive amount of time necessary to obtain acceptable results. Techniques that could replace EM in future ART courses might include colorimetric assays for protein analysis or HPLC for carbohydrate analysis of semen specimens.

A limitation of the course was the time required for each student to become proficient in each technique. Instead of designating each student as a “captain” for a particular section of the class project, an alternative approach would be to have one student responsible for collecting specific data with a different student designated to analyze and report the results. This approach would necessitate each student having a working knowledge of all aspects of the overall project instead of being responsible for only one specific area. Granted, this approach would reduce students' proficiency in the one area assigned to them, but it would enhance their knowledge base of all of the reproductive techniques used to complete the project.

The students were asked to evaluate the course at its conclusion. Their responses are summarized below.

Aspect of the Course Liked Most
1. Fascinating and interesting techniques
2. Hands-on procedures
3. Working at the hospital
4. Valuable techniques

Aspect of the Course Liked Least
1. Project for the South Carolina Academy of Science (SCAS)
2. Time spent on the project
3. Analysis of data
4. Slide preparation for SCAS presentation

Suggestions to Improve the Course
1. Need for instructors to be present during all procedures
2. Revise timetable to receive more technical training prior to starting the class project
3. Drop the project
4. Exchange project for a smaller, less technical, in-class project

We believe a graduate education should create independence and scholarship, develop initiative, help students master research techniques, enhance their confidence, establish effective use of time, and develop presentation skills. Previous experiences of the instructors indicate that students at the Master of Science level often have not developed an understanding of differences between undergraduate and graduate education. They tend to expect coursework to be more structured and to fit a specific time schedule. The evaluations given by the students in this course reflect these observations and are similar to comments given in another techniques course (Electron Microscopy) taught by the same instructors.

The instructors’ expectations should be described in greater detail in the course outline and schedule. More emphasis should be placed on techniques and collection of data earlier in the semester. This timetable would allow students to complete the project and prepare for the presentation in a timely manner. When the course is taught again, perhaps it should be taught using a contract grading system to help meet the needs of the students and allow them to accomplish their goals. A contract grading system would eliminate some of the uncertainty of the grading and place the emphasis on learning (Boone et al., 1979).

The course made four graduate students keenly aware of the many different aspects of assisted reproductive technology currently being used in human reproductive medicine. These ART techniques also are applied in the field of animal science for domestic and exotic animals as well as endangered species. The students gained an appreciation for using a team approach in an effort to identify and solve a problem in the field of reproductive biology. (In this course, the problem was to determine differences in semen parameters between low- and high-fertility males.) We feel that if these students choose to pursue careers in ART, experience gained from this course would place them in good standing in the field and perhaps provide them an “edge” in their search for employment.
Implications

The field of science, and thus the teaching of science, is constantly changing. The scientific techniques described in this paper are relatively new procedures that had their beginnings in animal science and have been refined for use in human reproductive medicine. Our programs utilize these techniques of assisted reproductive technology on a daily basis. All four of the students are in the Master of Science program and are obtaining their degrees in the field of animal physiology. Two of the four students are using one or more of the techniques to complete the research aspect of their degrees. Courses such as this one better prepare animal physiology students for leadership roles not only in their own field but also in the field of human reproductive medicine.

Literature Cited