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Considerations When Writing and Reviewing a Higher Education Teaching Protocol Involving Animals

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The targeted use of animals in teaching at institutions of higher learning is fundamental to educating the next generation of professionals in the biologic and animal sciences. As with animal research, universities and colleges that use animals in teaching are subject to regulatory oversight. Instructors must receive approval from their IACUC before using animals in their teaching. However, the questions asked on many institutions' animal care and use protocol (ACUP) are often geared more toward the use of animals for research. These questions may not be wholly appropriate in evaluating a teaching protocol; some questions are not applicable (for example, power analysis to justify animal numbers) whereas other important questions may be missing. This article discusses the issues surrounding the rationale for animal use in teaching; it also proposes a framework that instructors and IACUC members alike can use when writing and reviewing teaching ACUP. We hope this framework will help to ensure the most appropriate IACUC review of the ethical use of animals in higher education.

Abbreviations: ACUP, animal care and use protocol; AWAR, Animal Welfare Act Regulations; PHS, Public Health Service

Higher education plays a key role in developing the knowledge and skills of tomorrow's workforce. As such, it has a duty to provide the highest standards. Critical to the success of those wanting to enter many fields within the biologic sciences is the ability to safely and ethically work with animals.

A clear need exists for the establishment of a common framework of understanding and expectation between an IACUC and faculty preparing animal care and use protocols (ACUP) that relate to teaching. This need is motivated by a desire to validate and document the ethical and effective care received by animals used in teaching, just like their research counterparts. In addition, institutions of higher learning are subject to regulatory oversight by various agencies (Figure 1) in regard to their use of animals in both teaching and research as well as to the internal motivation of providing an exceptional learning environment for students. Failing to meet these obligations could result in unwarranted pain and distress in these animals as well as an unpleasant, counterproductive learning experience for students. The consequences of such a failure could result in the temporary or permanent cessation of the use of animals for teaching and research at these same institutions. Furthermore, societal expectations regarding not only the use of animals but also the quality of the care given to them are increasing.

The prevailing opinion in science educational pedagogy recognizes that although a reduction in the total number of animals used in teaching is both necessary and ethical, their use cannot be completely eliminated.[2,5,15,36,48,50] Therefore, the question is not *if* we should use animals in higher education but rather *under what circumstances*. Now more than ever, when, where, and how animals are used in teaching needs to be considered carefully. Specifically, Russell and Burch's revolutionary concept of the 3Rs (that is, replacement, reduction, and refinement) asks that investigators using animals consider ways in which to optimize animal use.[56] For IACUC, the questions become *What specific standards or guidelines should be used to determine which educational experiences warrant the use of animals?* and *How are the concepts of the 3Rs to be implemented in an educational setting?*

In 2016, Purdue University's Associate Vice President for Research Compliance created a task force to examine the existing guidance on how institutions review teaching ACUP. The task force consisted of faculty from various departments on the main campus, where considerable teaching using animals occurs. These included the departments of Animal Sciences, Biologic Sciences, Comparative (Veterinary) Pathobiology, Forestry and Natural Resources, and Veterinary Clinical Sciences. Also included on the task force was a clinical veterinarian from the Laboratory Animal Program office.

After several early meetings of the task force, it became apparent that, in contrast to research protocols, very little guidance was available that focused on the evaluation of animal use in teaching protocols. Furthermore, a review of the current literature revealed that almost all published articles dealt with the feasibility and educational value of nonanimal alternatives.[1,8,10,19,24,31,34,57,58] Although these alternatives enable students to gain necessary fundamental skills and confidence, they are often not suited to wholly replace live animal experiences used to teach complex, multifaceted skills, such as animal handling and surgery. In addition, work with animals may increase the depth of understanding and retention of knowledge, [51,55,58,67] particularly those related to complex concepts and procedures.[22,51,58,60] For example, each year in many veterinary colleges across the country, veterinary students are asked to perform (under supervision) an ovariohysterectomy on a live dog in a surgical skills laboratory. During the ovariohysterectomy procedure, the student must be

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Government or grant agency	Oversight
US Department of Agriculture – Animal Plant Inspection Service (USDA-APHIS)	Anyone working with live or dead warm-blooded vertebrate animals in research, teaching, and testing (excludes rats of the genus *Rattus*, mice of the genus *Mus*, and birds bred for research)
Public Health Service – Office of Laboratory Animal Welfare (PHS – OLAW)	Grantees awarded PHS funding are required to follow the PHS Policy when using animals. Some institutions opt, in their assurance statement to OLAW, to review all ACUP as if they were receiving PHS funding, although this is not required. PHS Policy covers "all live vertebrate animals used or intended for use in research, research training, experimentation, or biological testing."
Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC)	Institutions that are accredited via this voluntary accreditation body are expected to follow all animal welfare policies and regulations in their home country. Additionally, AAALAC uses three primary standards in its evaluation of animal care and use programs. These are the 8th edition of the *Guide for the Care and Use of Laboratory Animals*; the *Guide for the Care and Use of Agricultural Animals in Research and Teaching*; and the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes, Council of Europe (ETS 123).
Funding agencies, public (e.g., NIH)	Grantees receiving funding
Funding agencies, private (e.g., Morris Animal Foundation)	Grantees receiving funding

Figure 1. Selected governmental and grant agencies with regulatory oversight of institutions of higher learning.

able to perform the procedure by using aseptic technique while making near-instantaneous evaluations of the patient's welfare and health status. *Is there evidence of hemorrhage? Are the tissues and organs pale, indicating loss of blood pressure or blood volume? Is my tissue handling technique appropriate or will it lead to excessive tissue damage?* Learning to rapidly assess and correctly react to situations that may arise during surgery is a skill that can only truly be developed on a higher-stakes activity such as a surgery lab using live animals. Laboratory experiences like this allow students a safe and supervised introductory experience working with animals when compared with on-the-job animal training, with its additional pressure of public expectations (for example, on-the-job training of a veterinary assistant).

The purpose of this document is to serve as guidance to faculty writing teaching protocols and IACUC members evaluating those protocols regarding how the concepts of the 3Rs should be implemented when using live animals in teaching. Furthermore, this document provides a framework for future discussions to refine expectations and responsibilities in the use of live animals in teaching and other educational purposes.

Number of Animals Used in Higher Education

In striving to implement the 3Rs in education, it is useful to know how many animals are used in teaching currently. However, the current reporting requirements of the USDA do not separate animals used for teaching from those used for research. Further hampering an accurate count of animals used in the United States in either research or teaching is the fact that only institutions subject to the AWAR are required to report animal numbers. In addition, reporting is not required across all species. For example, institutions are not required to report the annual usage of rats (*Rattus* spp.), mice (*Mus* spp.), and poikilotherms. In addition, on protocols using minimally invasive activities, such as animal husbandry classes, animals may be used for more than one protocol, further obscuring the total number of individual animals used. Because elementary and secondary schools are not required to adhere to the AWAR, they are not required to provide United States federal agencies with animal use numbers even when they use AWAR-covered species (for example, hamsters, guinea pigs).

The European Union, in contrast, requires that its 27 member states classify the purposes of experiments. During the year 2011 (the latest report available), 179,981 (1.56%) of the 11,481,521 total animals reported were used in experiments classified as "education and training."[23]

The Need for Animals in Current Teaching Pedagogy

One of the core missions of higher education is providing education and training that will prepare its students for the career of their choice. For individuals seeking a career involving animals, it is critical that institutions provide appropriate instructional opportunities for students to gain familiarity and proficiency in animal care and handling. Clearly, there are times when the use of animals in teaching is justified, whereas other circumstances exist when nonanimal models can effectively be used for reducing the number of animals used in teaching (for example, synthetic 'skin' for learning to suture skin, computer simulations demonstrating Mendelian genetics; Figure 2). We believe that the distinction regarding when the use of live animals is justified relative to alternatives is a complex function of the effectiveness of the alternatives as well as the learning objectives of the relevant curricula, classes, and assignments. Several key associations involved in science education have written position statements that specifically address the need for animals in education.[2,5,15,36,48,50]

For example, the Human Anatomy and Physiology Society (HAPS) sums up the need as follows:

"Part of promoting excellent anatomy and physiology teaching is recognizing elements of instruction that provide meaningful support to developing and fostering an understanding of structure and function by our students. One such critical instructional element is the exploration and dissection of animal tissues, organs, and bodies. HAPS supports animal use as a cornerstone of anatomy and physiology instruction, provided that such animal use conforms with federal and state

Instructional videos

Computer simulations

Low-fidelity non-animal models
(e.g., surgery board to practice suturing techniques)

Cadavers

Plastinated models

Koken rat

Figure 2. Examples of nonanimal preparatory work prior to student use of live animals in higher education.

statutes governing such use, and fulfills clearly defined educational objectives. HAPS further believes that science educators should retain responsibility for making decisions regarding the educational use of animals for the betterment of their student's learning. *HAPS opposes any blanket restrictions on animal use as encroachments on the academic freedom and decision-making role of course directors in choosing how best to meet their educational objectives."*[36] (emphasis added)

The Wildlife Society, an international not-for-profit association dedicated to the responsible stewardship of wildlife, "endorses the principle that conservation education should emphasize experiential learning that fosters admiration and respect for nature and understanding of the interconnectedness among all living things."[65]

Curricula are often developed to allow students to develop and demonstrate proficiency in certain technical skills that are prerequisites for various certification programs (for example, American Fisheries Society,[3] The Wildlife Society[66]) and accredited schools (for example, AVMA Council on Education;[6] Figure 3). Many professions spell out the technical standards in which candidates must demonstrate proficiency before granting a degree, certificate, or license (Figure 4). In addition, faculty members and their departments are responsible for ensuring that their curriculum best serves the needs of students for foundational knowledge, animal handling experience, and readiness to enter a field of work. Thus, degree programs' and instructor expectations of knowledge and skills are equally important to those promulgated by certifying bodies. Such knowledge and skills are necessary to ensure graduates are competitive in the job market, both at the entry-level[32,35,45,46] and throughout their careers.[20,30,59,62] Societal expectations play a key role in what professionals, such as veterinarians, are expected to perform as "day one" competencies.[44]

The Needs of Students and Learners

For the students, the use of animals in teaching develops more than just an appreciation for the intricacies of the animals themselves. Studies show that not all students have the same learning styles (that is, visual, auditory, read–write, kinesthetic).[26,71] For example, with kinesthetic learners, the act of *doing* the procedure may allow for better understanding and retention of key concepts, compared with watching (for example, video, simulation) or reading about the procedure (for example, text assignment). Several authors have noted that hands-on physiology experiments increased student interaction and learning in the course laboratories.[17,54] In addition, laboratory exercises designed to teach dissection techniques led to better performance on laboratory tests[19] as well as improving the students' ability to design experiments and interpret data.[47] Although alternative methods may incorporate kinesthetic experiences, they often fail to capture the breadth and variability inherent in working with live animals. In many cases, both from a practical and learning standpoint, the observations and measurements on animals require intact biologic systems. An invaluable holistic component is added when animals are used in teaching. For example, when the procedure to be learned will have a systemic effect on the animal, the whole animal is necessary so that the student may develop proficiency at not disrupting multiple physiologic systems. In addition, live animals allow students to develop an understanding of how a procedure might affect multiple systems. Furthermore, many technical skills require repeated practice in which the student performs the actual activity on a live animal under the supervision of an experienced instructor; this repetition allows the student to develop the proficiency expected by employers from students graduating with these degrees.[42,73] For example, when veterinary technician students learn how to place intravenous catheters on dogs and cats, it is beneficial that they perform the procedure on multiple live animals. In this way, they simultaneously experience how veins can 'roll,' the appropriate amount of pressure to enter the skin, and the feel of the catheter entering the vein (the 'pop'). This experience is coupled with the real-world challenge of learning to successfully perform the procedure on an animal that may react in an unexpected manner.

Many of today's students have limited experience in handling animals prior to coming to an institution of higher learning.[43,53,61] In a survey involving undergraduate animal science students, 86% of the respondents self-identified as having minimal or no experience with large domestic animals.[53] In another course survey, most of student respondents surveyed (> 61%) indicated that they had enrolled in the specific animal science course precisely to gain experience of working with beef cattle, whereas 39% wanted to "enhance their application" to veterinary school.[43] Student inexperience can express itself in ways that are detrimental to the wellbeing of the animals and negatively affect the learning experience. For example, inexperienced students may exhibit increased levels of anxiety when faced with the requirement to use animals.[16,41] In our experience, exposures to multiple animals further increases students' comfort level over time. These considerations cannot be replicated adequately by using nonanimal methods. Supervised animal use in the context of a controlled teaching environment can overcome these anxieties and ultimately provide the professional competencies needed to succeed in the workforce. In addition, increased comfort in a particular species may open a student to working with a species that they would not have considered previously.[21,73]

Existing Regulatory Guidance on Protocols Using Animals in Teaching

Currently, no federal laws, regulations, or policies clearly and specifically address ACUP involving the use of animals in teaching. The Animal Welfare Act Regulations[70] (AWAR) only tangentially touch on the content and review of teaching ACUP. The AWAR explicitly excludes animals used in K–12 education but applies to animals used "for research, tests, experiments, or teaching" in higher education (AWAR §1.1).[70]

The AWAR states that "unnecessary duplication of research involving animals" should be avoided (AWAR §2.32 (a)[5](iii).[70] To that end, the AWAR makes clear that it is the institution's responsibility to ensure the training of personnel to use databases

Field	Certifying body	Guiding document or certification program
Animal sciences	American Registry of Professional Animal Scientists (ARPAS)	Professional Certification Program and Board Certification (Diplomate): http://www.arpas.org/Portals/0/Documents/Professional_Certification.pdf https://www.aaalac.org/about/Ag_Guide_3rd_ed.pdf
Fisheries	American Fisheries Society (AFS)	Professional Certification Program: http://fisheries.org/docs/cert_pcp.pdf
Veterinary medicine	American Veterinary Medical Association's Council on Education (AVMA-COE)	COE Accreditation Policies and Procedures: Section 7 (Outcomes assessment) https://www.avma.org/ProfessionalDevelopment/Education/Accreditation/Colleges/Pages/coe-pp-requirements-of-accredited-college.aspx
Veterinary technician/technology	American Veterinary Medical Association's Committee on Veterinary Technician Education and Activities (AVMA-CVTEA)	CVTEA Accreditation Policies and Procedures: Appendix I: Veterinary Technology Student Essential and Recommended Skills List https://www.avma.org/ProfessionalDevelopment/Education/Accreditation/Programs/Pages/cvtea-pp-appendix-i.aspx
Wildlife biology	The Wildlife Society: Professional Certification Program	Tasks—http://wildlife.org/next-generation/career-development/where-to-get-your-degree/ Code of ethics—http://wildlife.org/governance/code-of-ethics/

Figure 3. Selected fields of study, responsible certifying bodies, and the guiding documents used for setting forth essential and recommended skills.

and other information services (for example, National Library of Medicine, National Agriculture Library) to ensure that such unnecessary duplication does not occur. The AWAR, however, is silent on what would constitute unnecessary duplication in teaching protocols.

For teaching protocols supported through Public Health Service (PHS) funds, adherence to the PHS Policy,[49] *Guide for the Care and Use of Laboratory Animals*[38], and *US Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training*[49] is required also. In addition, many institutions state on their PHS Assurance Statement that all ACUP will be treated as though they were supported by using PHS funds, regardless of the actual funding source. Thus, all protocols would be expected to adhere to the PHS-related regulatory guidance at those institutions. Although exceptions can be made to the *US Government Principles*, they "should not be made solely for the purposes of teaching or demonstration."[49]

The procedures in teaching protocols may be subject to additional regulatory oversight, such as special permits, depending on the animal species used and the procedures performed. For example, state fish and wildlife departments may require educators to obtain educational or scientific collection permits.[37,64,72] In addition, wildlife classes that teach field procedures, such as safe trapping, handling, and release techniques, may require the issuance of a federal permit by the US Fish and Wildlife Service.[69] At AAALAC-accredited institutions, teaching ACUP involving agriculture animals needs to adhere to the *Guide for the Care and Use of Agricultural Animals in Research and Teaching*.[25]

IACUC Evaluation of Teaching Protocols

Teaching protocols have very different objectives and outcome criteria than research protocols. Therefore, the evaluation of teaching protocols requires a different approach. Several areas of teaching protocol review require unique consideration. Adherence to the 3Rs means, in part, adhering to the principle of eliminating the unnecessary duplication of animal use. To avoid unnecessary duplication, the protocol reviewer may find it helpful for the primary investigator to give information specific to the teaching approach in their discipline (Figure 3). Teaching protocols often require the duplication of the same types of animal use over the course of multiple class sections, semesters, and even years. In those circumstances, providing the context of learning objectives will be invaluable for both those writing and reviewing protocols. For example, the placement of a particular animal-related activity (for example, early during a lower-level course) and how such work prepares students for higher-level working and critical-thinking skills is important to understand, not only in terms of the individual course but also within the broader goals of the curriculum. Whereas in research protocols, animal numbers and group sizes can most often be justified by using statistical power analysis, this same principle cannot be applied to teaching protocols. Therefore, other criteria must be used in evaluating the animal use, and these should be linked to the number of repetitions and interval of exposure to the learning activity (Figure 5).

One set of criteria that can be used to evaluate a teaching ACUP relates to the learning objectives of the course. For example, in an upper-level wildlife course, it may be critical to a student's education to become proficient in the safe trapping and handling of live wildlife in the field by using techniques that minimize stress to the animal. Students wishing to pursue a career in, for example, beef cattle management should be able to safely and efficiently work a herd of cattle through chutes and a head gate to provide preventive care, such as checking hoof health, giving anthelmintics, and performing pregnancy checks. The rationale that these skills should be taught to students in a controlled environment with sufficient oversight by professionals (for example, the instructor) is a valid one.

Meeting professional standards promulgated by accrediting bodies, such as the AVMA's Council on Education and Committee on Veterinary Technician Education and Activities, is another valid justification by educators seeking IACUC approval of specific activities on a teaching ACUP. The Committee on Veterinary Technician Education and Activities requires competencies are perhaps the most task-oriented as compared with other certifying bodies.[4] Many of these are hands-on techniques involving animals. For example, prior to graduation, a veterinary technician student must be able to demonstrate the ability to safely and efficiently apply a bovine halter, position horses for radiographs, and use a balling gun or dose syringe in

Certifying body	Selected competencies (not a comprehensive list)
AVMA Committee on Veterinary Technician Education and Activities (CVTEA)	Required: • Appropriately restrain dogs and cats for procedures • Auscultate heart and lungs (dog, cat, horse, cow) • Perform jugular venipuncture (dog, cat, horse, ruminant) • Safely and effectively administer drugs by common parenteral and enteral routes • Maintain and operate anesthetic machines, including rebreathing systems, non-rebreathing systems, and masks • Participate in ovariohysterectomy surgeries (dog, cat) • Safely and effectively handle common laboratory animals used in animal research, including restraint (mouse, rat, rabbit) • Perform nail trim (dog, cat, bird) Recommended: • Appropriately restrain sheep and pigs • Perform blood typing • Anesthetize mouse, rat, and rabbit • Wing clipping (bird)
American Veterinary Medical Association's Council on Education (AVMA-COE)	Required: • Comprehensive patient diagnosis (problem-solving skills), appropriate use of diagnostic testing, and record management • Comprehensive treatment planning including patient referral when indicated • Anesthesia and pain management, patient welfare • Basic surgery skills and case management • Basic medicine skills and case management • Emergency and intensive care case management
American Fisheries Society (AFS)	Required: • Specifies coursework but does not list specific tasks (full membership available for those who have held applicable degree for more than 3 years)
American Registry of Professional Animal Scientists (ARPAS)	Required: • Specifies coursework but does not list specific tasks • 1–4 years of full-time experience, depending on the candidate's level of education
The Wildlife Society: Professional Certification Program	Required: • Specifies coursework but does not list specific tasks • Coursework or curriculum which includes work with live animals • A minimum of 5 years of full-time professional-level wildlife experience, obtained within the last ten years of applying for certification • Professional experience must demonstrate the application of current biological knowledge to problems and programs dealing directly with the wildlife resource (administration, education, research, or management) as a significant portion of job responsibilities • Provides a detailed description of duties and responsibilities performed in fulfilling the experience requirements and list the percentage of time spent on these activities

Figure 4. Selected tasks recommended or required by a certifying body.

large animal species.[4] Required tasks involving small animals such as dogs and cats include cephalic venipuncture, performing the Schirmer tear test, collecting and evaluating skin scrapings, and administering gas anesthesia to patients.[4] Although preliminary instruction in the proof-of-concept of these methods may have an applicable nonanimal alternative, at some point during their training, students are expected to perform these skills competently on live animals. However, the use of live animals in teaching increasingly has come under question by the public.

The educational requirements set by the AVMA's Council on Education for students pursuing a Doctor of Veterinary Medicine degree tend to be more performance-based than task-specific.[6] However, this emphasis does not mean that all animal work can be substituted with nonanimal alternatives. Although substituting a portion of students' curriculum using such nonanimal alternatives as surgery boards[68] to learning surgical knot tying or surgical simulators,[27,28,33,52,63] some schools use whole-body cadavers[9,14] in the laboratory to teach critical concepts in surgical technique. Even today, live animal survival surgery is used to help students develop the necessary skills of hemostasis, appropriate tissue handling, anesthesia, and postoperative care. Many schools are moving away from terminal surgeries that result in the euthanasia of the animal prior to anesthetic recovery. Terminal surgeries have been found to cause distress and a psychologic toll on some students.[7,13] Some schools, such as Purdue's College of Veterinary Medicine, are teaching surgery by using rescue or shelter animals in survival spay and neuter surgeries, both within the school and through mobile units.[11,29] These services not only benefit the students' education but also increase the possibility of animal adoption.[18] Thus, these activities serve to reduce and refine animal use because additional animals are not needed for training—a

Based on stressors to the animal and recognizes the effects of any cumulative use on an individual animal?
Number of students that can use available animal-related equipment simultaneously?
Based on variability of student prior experience?
Based on student enrollment?
Based on the necessary repetition of the procedure(s) over time?
Number of procedures? (How much repetition is necessary to achieve the reinforcement of concepts and/or mastery?)

Figure 5. Examples of criteria used to evaluate animal numbers used in a teaching animal care and use protocol.

single surgery serves to provide multiple benefits (for example, training, adoption). Even though the institutions do not own these animals, schools that have used this option most often still require the formal inclusion of the learning experience on a teaching ACUP.

Although not all certification programs are as prescriptive as the AVMA in the list of required tasks, many deem the use of live animals a necessary part of a student's education. The Wildlife Society's certification program does not list specific hands-on tasks. Yet according to Keith Norris, Director of Government Affairs and Partnerships for The Wildlife Society, "it is implicit that live animal 'use' is a common element of being a professional wildlife biologist, and I think it is safe to say that many career paths within the wildlife profession require an understanding and ability to safely capture and handle live animals. Lack of that experience could curtail or otherwise limit an individual's career options."

The preceding discussion does not mean that the use of non-animal alternatives should not be encouraged or even expected by today's IACUC. Indeed, the IACUC should be encouraged to ask that instructors provide information regarding the non-animal alternatives that exist in their discipline, what (if any) alternatives an instructor will be using prior to the animal work listed on the ACUP, and the pros and cons of the alternative methods considered with regard to meeting the course learning objectives. Finally, the instructor should be asked to provide a rationale as to why the inclusion of animals in teaching is necessary to meeting course objectives.

In addition to the question of when to give approval for the use of animals in teaching, the IACUC may struggle with the number of animals used on a teaching ACUP. Although the avoidance of 'unnecessary duplication' is mandated, exactly what falls under this umbrella statement is unclear. In an effort to adhere to the reduction of animal numbers, some instructors may choose to reuse a set of animals for multiple course sections or courses over the entire semester. Although this practice does decrease total animal numbers, care must be taken to avoid the overuse of any individual animal. Posing certain questions to the instructor may help the IACUC in determining the total number of animals used in teaching, and even more importantly, the rate of reuse of animals in teaching (Figure 6). For example, an instructor may be teaching animal science or veterinary medical students how to perform pregnancy examinations through rectal palpation in a colony herd of teaching cows. To reduce the total number of cows palpated in any one laboratory, an instructor might allow 2 or more students to palpate the same cow. A reasonable question for the IACUC to ask is how the number of cows requested was determined. Example questions to pose to the instructor(s) include:

- Are animal numbers in the protocol based on the available number of cows in the teaching herd? The total student enrollment in the course?
- In cases where cows will be palpated by more than one person, what is the maximum allowable number of palpation events per cow per class session?
- What are the risks associated with repeat palpations on the health of the cow? How will the instructor manage these risks?

For example, a known risk of rectal palpation is rectal tearing. It would be important for the instructor to explain how this, and other risks, will be managed in the course's laboratory.

Occupational Health and Safety Considerations for Teaching ACUP

Part of the evaluation of any ACUP is to determine that all animal users are aware of and can take the appropriate steps to ameliorate any associated risks related to animal work. Such an evaluation often requires input from and coordination with other related institutional committees (for example, the institutional biosafety committee). Most often, the institution's biosafety officer performs this review, which should include performing a risk assessment. Occupational risks associated with animal use include the development of animal allergies, physical hazards (for example, bites, scratches), and zoonoses.[39] Once a risk assessment is performed, the IACUC, in consultation with the institution's biosafety officer, may require the use of various control and prevention strategies. These include engineering controls, process controls, and the use of appropriate personal protective equipment.[38]

One of the potentially higher risk animal experiences is the field setting. The health status of an individual wild-caught animal typically is unknown, and therefore the likelihood of any individual animal acting as a reservoir for zoonoses is based on current epidemiologic data. A risk analysis of the zoonoses that the field students are most likely to encounter should be performed. In the risk analysis, special significance should be placed on the zoonoses that have high morbidity and mortality in humans. Appropriate control measures that prevent or minimize exposure to the health hazards that are the most likely and highest risk should then be put in place. For example, the overall probability of developing hantavirus pulmonary syndrome, an uncommon but severe respiratory disease, when working with wild rodents was reported to be extremely low (about 1 in 1400 persons).[40] In that report, the field biologists surveyed experienced high occupational exposure to wild rodents across their careers;[40] thus, transmission risk is likely significantly lower for the exposure events more typical for students. However, development of hantavirus pulmonary syndrome has an overall fatality rate of approximately 30%, making this pathogen important to protect against.[12] Therefore, it is often recommended that field personnel, including students, wear an N95 mask or similar respiratory protection when working with permissive species of wild rodents (for example, *Peromyscus*). The use of such personal protective equipment often requires that occupational health care staff obtain an individual's respiratory health history and perform fit testing. The entire institution benefits when the IACUC and the instructor work together to communicate clearly to the students the requirements regarding personal protective equipment, including any necessary paperwork, to facilitate compliance. This paperwork can constitute a high regulatory burden on instructors when one considers the

How are the learning objectives of the course related to animal use?

Why do students need to learn the procedure on a live animal?

Why do students need to learn the procedure on a cadaver? (i.e., Why is a nonanimal model or simulation not sufficient?)

Does the course build on animal experiences covered in previous courses? If so, please explain and list the courses.

Does this course prepare students for animal use in future (higher level) courses or post-graduate careers? If yes, please explain and list the courses.

Will professional standards (e.g., AVMA, VTNE exam, Wildlife Society) be met by the animal use in this course? If yes, please list which one(s).

Does the instructor give a rationale for using these animals that recognizes the effects of any cumulative use on an individual animal? What has been done previously in the course to limit painful iterations? (see also Table 2)

Figure 6. Examples of questions to elucidate the justification and rationale for the use of animals in teaching in a particular teaching setting.

number of students involved. The IACUC and occupational health and safety department within the institution should be encouraged to work together to find innovative ways in which to streamline this process and concurrently optimize the safety of the students.

Work with teaching animals in a relatively more structured setting, such as a farm, still requires a risk assessment. Working with farm animals carries an inherent risk of personal injury by excitable livestock (for example, kicks, bites, crushing injuries) or by use of equipment such as cattle restraint chutes. Therefore, an IACUC may wish to know what type of restraint will be used (for example, physical, chemical, or combination) and what safety training the students will receive prior to working with livestock. In addition, information should be obtained regarding the degree of instructional oversight used to ensure that safe conditions exist during the learning experience (for example, instructor-to-student ratio).

Elimination of injuries sustained from animals may be impossible, given the unpredictability of how any one particular animal or group of animals will react to the teaching setting. Likewise, a student's reaction to a species it is unfamiliar with or potentially fearful of handling may exacerbate this. However, consideration of the risks just mentioned can help to reduce the incidence of personal injury or illness.

Recommendations for the Review of Teaching ACUP

The targeted use of animals in teaching is fundamental to ensuring that students are adequately prepared for various careers in the biologic sciences. However, institutions of higher education have come under increased pressure from society to limit or even eliminate the use of cadavers and live animals in teaching. Teaching with animals can provide a kinesthetic approach to learning that may help students more actively connect with the concepts being taught. In addition, several certifying bodies have either explicit or implicit expectations regarding the student's ability to work appropriately and safely with animals. Although some certifying bodies have very specific task-oriented objectives, others (for example, American Fisheries Society) have more overarching animal care and use objectives.

In the current protocol review system of many colleges and universities, the questions asked on an ACUP are geared toward the use of animals for research. Often these questions are not wholly appropriate in evaluating a teaching protocol; some questions are not applicable, whereas other important questions may be missing. Animal numbers cannot be calculated using the traditional power analysis. Instead, learning objectives and number of needed iterations for mastery are some of the criteria which should be considered when requesting a specific number of animals for teaching. Replacement of animals should be highly encouraged, yet in some situations the use of live animals is critical, especially when students must integrate and use information in a multisystems approach. Some institutions are already reducing and refining the use of animals through service learning opportunities, such as mobile spay teaching clinics.[29] Many institutions of higher learning require the IACUC to review a large number and wide variety of protocols over time. An IACUC member who is reviewing a teaching ACUP may not understand how that particular ACUP fits into the overall teaching goals of a particular college, major, or career path. A protocol that may appear to promote unnecessary duplication may be entirely appropriate in the context of animal use for teaching. Therefore, the IACUC should develop a framework that supports the appropriate and critical evaluation of how these protocols advance learning yet adhere to the 3Rs. In summary, we believe that the following measures may help investigators and ACUP reviewers increase their understanding of the review process and serve as a 'best practices' for both groups. These recommendations include:

- Create a questionnaire or supplementary set of questions specific to teaching protocols
- Include a question to identify if the protocol is meeting a professional standard
- Include questions to identify (if applicable) the sequence of coursework required and how the current protocol fits into this sequence and meets the course or course series objectives.

The exact questions posed to instructors will vary from institution-to-institution depending on the specific educational needs of their students and the program objectives of the institution. Examples of questions that the task force felt were important to include on a Purdue ACUP are:

- What is the sequence of coursework required in the degree program within which this class is situated? How does the current protocol fit into this sequence and how does the animal work meet the course or course series objectives? Will the animal use on the current protocol serve as foundational knowledge for higher-level coursework?
- Is the proposed animal use designed to help students meet a professional standard or certificate program? If so, please identify that standard or program (Figure 4).

• Why must a live animal be used? Does the proposed animal use build on knowledge and skills gained from a student's previous use of nonanimal models or simulations (Figure 2)? If so, how?

• What is the basis for the total number of animal requested? How do the total numbers requested consider stress to the animal and the potential effects of cumulative use on an individual animal? If so, please explain (Figure 5).

• Will multiple or repeated procedures be performed on the same animal(s)? (for example, canine intubation lab) How many students will use the same animal? What are the risks associated with repeat procedures on the animal? How will the instructor manage these risks? What will be the minimum recovery time between repeat procedures/uses?

These recommendations likely will aid the IACUC in balancing the costs and benefits of using animals in teaching as we provide strong foundational knowledge and prepare students for careers in science.

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