Rationale

The 2004 APS Position Statement on the Use of Animals in Teaching evolved following more than two years of discussions within the Council, the Animal Care and Experimentation Committee, the Education Committee, and the Editorial Board of the journal, Advances in Physiology Education. Position statements are, by definition, brief, and typically do not capture the detailed analysis and discussion of the complex issues that they summarize. Therefore, it is important to provide additional information to help orient the reader to the discussion that shaped the position statement. Toward that end, the APS is providing two background information pieces. The first is a historical perspectives review on the use of animals in teaching laboratories by APS Public Affairs Officer, Alice Ra’anan, available in the September 2005 issue of Advances in Physiology Education (8). The second is an educational rationale for the use of animal laboratories in the larger context of student laboratories.

Active learning approaches such as student laboratories are often costly in terms of time and resources. Educators must be able to explain clearly to administrators and to students the benefits obtained from laboratory experiences in the context of the educational goals for the course. The following rationale provides an overview of the benefits and considerations in selecting teaching laboratory activities (as distinct from activities in the lecture hall or in the research laboratory).

Selecting Pedagogy to Promote Learning

Learning is more than the acquisition of facts. Students, particularly in the sciences, need to be able to think critically, to analyze information, and to apply information and solve problems. These skills are characteristics of the higher cognitive domains in the taxonomy proposed by Bloom. Educational research shows clearly that active learning experiences such as student laboratories help develop higher cognitive skills (6). As one APS committee member observed during the development of the
position statement, “You think you understand something until you experience it.”

Instructional activities involving student-centered laboratories and lessons add important dimensions to the learning process. Laboratory activities allow the instructor to include a higher percentage of learning styles amongst students and thereby provide a much more meaningful and successful learning experience. A wealth of reports and research summaries over the past 20 years emphasize the importance of laboratory-based experiences in the development of both science content understanding and science process skills (6, 10, 9, 3. 8). The National Research Council’s Commission on Life Sciences pointed out that, in biology, laboratory investigations serve crucial functions, including:

- challenging students’ beliefs about the natural world and leading them to learn how to present scientific concepts accurately in their own words;
- enabling students to generate knowledge directly from natural phenomena and learning how such knowledge can become reliable knowledge;
- developing deep understanding of organisms and their environments through hands-on experience;
- helping students to learn about precision and accuracy in observations, measurement, record-keeping, and inferring as well as developing skills in problem-solving; and
- building student skills in using technology in the quest for new knowledge (5, p. 35).

Therefore, life science educators are well-justified in seeking to enrich the learning experiences of their students through laboratory exercises, despite the increased costs and preparation of laboratory-based lessons. As stated in “How People Learn,” “The expense of the laboratories is justified by the qualitatively different experience made possible when the boundaries of an idea can be tested or worked with in a laboratory or field-based setting” (1).

Diverse Lab Experiences Enrich the Curriculum

Effective science teaching requires a diversity of strategies and approaches (6). Diversifying the types of learning experiences and even the types of laboratory experiences in a course helps engage a larger number of students. Research has clearly shown that:

- students exhibit a variety of learning styles and characteristics;
- their preferences for learning styles can range from mild to strong;
- their cognitive preferences can affect their performance in different subject areas; and
- students whose learning style is complementary to the instructor’s teaching style often receive higher grades (12).

The three most common characterizations of learning styles are: 1) visual, auditory, read/write, and kinesthetic (VARK) (8) Carl Jung and Myers Briggs Type Indicator (BMTI) (2), and 3) Howard Gardner’s Multiple Intelligences (4). Despite their differences in measurement methods, each of these characterizations have demonstrated the importance of creating an environment rich with different types of learning experiences.
What types of laboratory-based experiences make positive contributions to student learning? The majority of life science laboratory-based experiences can be grouped into those not involving living tissue (simulations, physical models, preserved specimen tissue) and those that do involve living tissue (human subjects, animal subjects, and plants). As with all educational strategies, there are advantages and disadvantages associated with each approach. It is important to realize that this is not an “either-or” decision. Some educational goals are best accomplished by inanimate laboratories, others by the study of living systems. Some of the considerations that instructors may want to consider are listed below for a variety of laboratory options.

**Inanimate Options**

Computer simulations, physical models, virtual reality, and other technological innovations are promising in terms of their ability to impart knowledge and provide skills training. Instructors should periodically review new developments in this rapidly changing area, and consider how these materials can be used to meet the educational goals of their course.

*Simulations*: Mathematical modeling of physiological systems provides a powerful tool for both teaching and for research. A very basic algorithm of the cardiovascular system allows students to interact and observe the consequences of changing variables such as peripheral resistance or circulating blood volume. Such a model can grow in complexity as our understanding of the interaction between physiological processes increases. Another advantage of simulations is their independence from time. These experiments can be reset and re-run, allowing multiple interventions in a limited period. Improvements in the graphical outputs of these models make them more attractive to learners, and evaluation of select learning outcomes confirms that simulations can provide a useful educational experience. Simulations and models, however, are by their nature approximations of a living system. The complexity and unpredictability of living systems is difficult to capture, even in the most complex simulation (video games vs. reality). Physical models: Physical models provide an opportunity for hands-on exploration. Models may be designed to allow learners to explore underlying principles, such as the relationships between flow, resistance and a pressure gradient. Often, experimental study of these relationships cannot be easily achieved in living systems. Models such as manikins are increasing in complexity, and are useful for skills training, such as cardiopulmonary resuscitation (CPR). The weakness of models is similar to that for simulations. At best, models are an approximation of a living system.

*Preserved specimen tissue*: Preserved tissues provide an opportunity for learners to explore structural relationships. Preserved specimens are anatomically correct, and if multiple samples are used, can be used to illustrate biological variation. For physiology, preserved tissues are static, and do not allow study of time-dependent events.

**Animate Options**

Instruction involving living organisms makes a unique contribution to life sciences education by providing students with a direct understanding of how living systems work. The use of animals gives students a direct understanding of how living systems work. This produces insights that are qualitatively different from those that
can be obtained by reading a textbook, watching a video, using a computer, or experimenting with inanimate models.

Students in the life sciences should be given appropriate opportunities to work directly with living systems, but educators in the life sciences should give careful consideration as to whether this mode of instruction is appropriate for their students. Issues that should be taken into account should include the educational objectives of a specific course within the broader program of study; the knowledge base, prior experience, and maturity of the students; and whether humane handling of the animals and an appropriate instructional environment for the students can be insured.

**Live tissue**: Laboratory experiments can utilize living tissue rather than an intact organism. For example, the chicken egg membrane and the red blood cell provide an excellent model mechanism for study of osmosis and membrane transport.

**Animal Laboratories–Humans**: Students in the life sciences often pursue careers in health and medical professions, and are most interested in human physiology. A number of commercial companies provide equipment and sample experiments where students serve as the laboratory subject. These non-invasive experiments use advances in technology to measure variables that previously were only available through invasive approaches. In addition to the regulations involving other animals, instructors must be sure that human subject laboratories comply with extensive regulatory guidelines, which in the USA now include HIPPA.

**Animal Laboratories–Other Mammals**: Animal laboratories allow students to perform both observational and/or invasive study of living systems. Animal laboratories provide experiential opportunities that cannot be obtained in other settings, such as observing cardiac contraction and ventricular fibrillation. Animal experiments involve a significant emotional experience that enhances learning. Such experiments illustrate intrinsic variability and unpredictability, and facilitate discussions of heterogeneity and functional variability. As with human experiments, instructors opting to use animal experiments must insure compliance with IACUC and other regulations.

**Animal Laboratories–Other Vertebrates**: The educational goal of the laboratory is sometimes best accomplished by selecting non-mammalian, experimental subjects such as frogs or fish. The diversity of biological systems provides opportunities for students to gain an appreciation of the comparative anatomy and physiology of a variety of living systems while allowing the instructor to select from animal models that fit the lesson objectives, available equipment and lesson time, and costs. As above, instructors must insure compliance with IACUC and other regulations, where applicable.

**Animal Laboratories–Invertebrates**: Invertebrates exhibit a huge diversity in physiological processes that should be considered when designing student laboratories. Invertebrates provide excellent opportunities for student laboratories examining, for example, thermoregulation or the transmission of genetic traits. Although invertebrates are not covered by USDA or IACUC, use of any living system must follow ethical guidelines.

**Animal Use Ethics**
The use of animals in student laboratories provides an opportunity to open a
discussion of the ethics of animal use in our society. It is important to provide the
opportunity for students to consider their attitudes toward the use of animals in
research, for clothing, for food, and as pets. These are important ethical issues. This
discussion also provides an opportunity to draw a clear distinction between animal
welfare groups and the animal rights groups.

Summary

The study of living systems is an essential component of physiology instruction. The
American Physiological Society is committed to the continuing development of
resources that enhance the student laboratory learning experience. Teaching
laboratories provide unique opportunities for active participation, discovery learning,
and development of team skills.

Physiology educators have a long tradition of developing and evaluating the
effectiveness of novel educational tools. The APS publishes a journal with that
specific focus, Advances in Physiology Education. The evaluation of the learning
process is essential to good teaching, and insures that the focus remains on
providing educational experiences that enhance student learning. To assist in the
evaluation and selection process, the APS has developed a listing of resources on the

When selecting laboratories that do and do not use living organisms, instructors
must bear in mind that students may differ in their educational preferences; that is,
some students may be uncomfortable with instructional activities involving animals
while others find these activities inspiring and particularly beneficial. The same
students also differ in their educational needs; diverse student learning styles call for
diversity of learning experiences. In many cases, hands-on experience with living
systems may be the ideal learning experience for a student and, in an educational
setting that is becoming increasingly dependent upon print and multi-media images,
may become a critical experience for students who need tactile experiences to
enhance their learning.

These advantages significantly outweigh the drawbacks of limited curricular time,
limited facilities, costs, and the need for regulatory compliance for laboratories
involving human or animal subjects. In the final analysis, the only way to truly
understand living systems is to experience living systems.

APS Position Statement on the Use of Animals in
Teaching
Adopted by the APS Council, November 2004

The study of living systems is an essential component of physiology
instruction. Teaching laboratories that actively engage students in
observation of and interaction with living systems enhance student
understanding of physiology, providing experiences that are qualitatively
and quantitatively different from those gained through lecture, small group
discussion, or multimedia presentations. In addition, the active
participation and discovery learning opportunities provided by teaching
laboratories allow students to hone independent and life-long learning.
skills such as analytical and problem solving skills. The hands-on approach used in laboratories offers active learning opportunities for all students, whether they are strong visual, auditory, or kinesthetic learners. These advantages significantly outweigh the drawbacks of limited curricular time and facilities as well as potentially greater costs and increased resources required for regulatory compliance for laboratories involving human or animal subjects. Whether working individually or in groups, well-designed animal laboratories provide vivid, exciting opportunities for the direct study of how living systems work. Not only do these lessons foster active learning and the development of critical thinking skills in students, but they provide a unique opportunity for students to develop a lasting appreciation of the complexity of living systems and an abiding respect for living organisms. Animal laboratories should be offered for valid educational reasons, where the use of the laboratory builds important knowledge, skills, and/or attitudes. Instructors who incorporate animal laboratories into their course or curriculum must insure that the students are appropriately prepared for the experience and that the laboratory is conducted humanely. The American Physiological Society is committed to the continuing development of resources that enhance the student laboratory experience for all types of learners. A description of various laboratory options is included in the rationale document supporting this position statement.

References

2. Center for Applications of Psychological Type (http://www.capt.org/The_MBTI_Instrument/Home.cfm).