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Fundamental Criteria for Determining the Educational Value of Live Animal Experimentation in High School Science Fairs

David H. Neil

Colorado State University - Fort Collins

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Role of the Student's Supervisor/Advisor In Science Fair Projects

F.M. Loew

Students undertaking projects for science fair competitions are required to have an advisor. This is to increase the likelihood that a project is developed which is scientifically sound, a learning experience for the student, and within the capabilities of the student. In the case of projects involving the use of live animals, the advisor's role is of great importance not only in ensuring the above, but also in preventing painful or stressful experiences by the animal(s) involved. Too often, supervisors have failed to genuinely supervise such projects, and as a result, animal use in science fairs is being increasingly curtailed. True supervision should entail the proper use of a literature review, a plan (protocol), and expert knowledge of the biology and care of the animal species concerned.

The student's supervisor or advisor must really assume absolute responsibility for the appropriateness of the techniques selected and the acquisition, care, and disposition of any animals used. Most of the reported irregularities in animal use by science fair competitors could have been prevented by supervisors who really examined the plans and execution of experiments.

The science fair networks, so potentially useful in education, must create rigorous procedures for advising and supervising animal projects. If this cannot be done, then certain types of animal projects ought not to be carried out.

Fundamental Criteria for Determining the Educational Value of Live Animal Experimentation in High School Science Fairs

David H. Neil

Abstract

The author contends that great and very detailed attention to one minuscule facet of experimental animal biology, particularly if it requires the skilled and uniform alteration of a significant number of animals, is of no real educational value to a high school student. This type of work, the necessity for it, and the full understanding of its significance to the furtherance of human understanding must be the province only of those who are intellectually prepared. The suggestion is made that projects, which develop a more complete understanding of common and profoundly important elements in life (as we know it), should comprise the first steps for the aspiring bioscientist. Unfortunately, this is by no means a universal point of view, and educational programs still tend to be prematurely piecemeal and fragmented. The author concludes the presentation with examples of animal experimentation which might well serve as a catalyst to a sound understanding of biology where life is perceived as a fully integrated process.

Introduction

It might be contended by some that I ought to be in a torment of ambivalence on this issue, and when I glance over the last decade I can see why. During that period I have been happily involved in teaching people about animals. For three years in the early seventies I was a science fair judge in the Biology division of the Ottawa Regional Science Fair in Ontario, Canada, and I also served on the Animal Care Committee of the Canadian Youth Science Foundation. Last year I was invited onto the board of the Longs Peak Science Foundation in Colorado, which operates our local high school Science Fair. Throughout the last sixteen years, I have been a practicing laboratory animal veterinarian with ultimate responsibility for the care of countless numbers of laboratory animals in four major research institutions in three countries. In many instances I have been directly responsible for deliberately interfering with the health of these animals by the administration of noxious agents of one sort or another, or by surgical intervention.

My principal extracurricular pursuit since 1977 has been an active commitment to
Interventional Studies on Animals

From the outset let me say that I believe that research involving the use of laboratory animals is necessary for maintaining and improving the quality of life for man. To be more general, let me say that I believe that man’s “graspingness-of-mind,” as much as it gets him into trouble with the world in which he lives (sometimes to the point of mortal danger) is nevertheless part of his rason d’etre.

Man’s graspingness-of-mind is as necessary to his survival as speed is to the antelope, and tooth, claw and stealth are to the tiger. I firmly believe that man must now address not only his own new and unsolved problems, but those problems arising from some of his earlier crude and clearly imperfect solutions. We cannot go backwards. Attempting to attain a safer more manageable world by retrogression is an exercise in illusory nostalgia without historical support.

Medical research is an integral part of this “graspingness-of-mind,” and the use of animals in research is a necessary part of this at present. I am committed, therefore, to the use of animals in biomedical research when there is a significant chance of improving or safeguarding our quality of life. Nevertheless, I look forward to the day when we may achieve all that is needed in this regard for our continued success as a species, without having to violate the creatures with whom we share the earth. To me that era would symbolize the evolution of a greater intelligence in hominids, perhaps destined for a new Homo omnisapens.

I am one of many thousands of a like mind. The department of public affairs of Hoffman La Roche in No. 12 of a series on public issues, *Animal Experimentation in the Pharmaceutical Industry*, states “Scientists and lay persons alike look forward to the day when reliable alternatives can replace animal experimentation in medical research. That day, however, is still far in the future. Meanwhile, serious health problems continue to exist. Scientists must continue to rely on laboratory animals for much of the knowledge needed to solve these problems.” And so they do, but more and more and in the main they do so with great care.

This has been a memorable year in this regard. The National Institutes of Health adopted a new *Guide for the Care and Use of Laboratory Animals* prepared by the Institute for Laboratory Animal Resources (1978) of the National Research Council. They also introduced new contractual obligations for contractors and grantees at the individual institutional level. Unpublished in this Guide for Grants and Contracts Vol. 7, No. 17, Nov. 10, 1978.) Among the mandatory requirements was the need for a knowledgeable five person animal care committee (credentials of individual members being filed in Washington D.C. with the Office for the Protection from Research Risk, N.I.H.). These committees are charged to “maintain oversight of its (their) animal facilities and procedures.” In the same document are listed: “Principles for Use of Animals” which are also published again in Appendix V of The Guide. I feel that these are so important to the consideration of all interventional animal studies* that I should like to quote some of them here.

The Research

3. The research should be such as to yield fruitful results for the good of society and not random or unnecessary in nature.
4. The experiment should be based on knowledge of the disease or problem under study and so designed that the anticipated results will justify its performance.
5. Statistical analysis, mathematical models or in vitro biological systems should be used when appropriate to complement animal experiments and to reduce numbers of animals used.
6. The experiment should be conducted so as to avoid all unnecessary suffering and injury to the animals.
7. The scientist in charge of the experiment must be prepared to terminate it whenever he believes that its continuation may result in unnecessary injury or suffering to the animals.
8. If the experiment or procedure is likely to cause greater discomfort than that attending anesthetization, the animals must first be rendered incapable of perceiving pain and be maintained in that condition until the experiment or procedure is ended. The only exception to this guideline should be in those cases where the anesthetization would defeat the purpose of the experiment and data cannot be obtained by any other humane procedure. Such procedures must be carefully supervised by the principal investigator or other qualified senior scientist.
9. Post-experiment care of animals must be such as to minimize discomfort and the consequences of any disability resulting from the experiment in accordance with acceptable practices in veterinary medicine.
10. If it is necessary to kill an experimental animal, the animal must be killed in a humane manner; i.e., in such a way as to ensure immediate death in accordance with procedures approved by an institutional committee. No animal shall be discarded until after it is dead.

This is the statement of our contemporary ethics in the scientific community regarding the use of animals in research. Perhaps it did not use to be. Certainly Russell and Burch (1959) in urging their three “Rs,” “Replacement, Reduction and Refinement,” twenty years ago, were crystallizing the desires of many, but certainly not the mainstream of opinion in the bioscience community at that time. But it is apparent to me that ethics change as society changes, and many societal changes have occurred in the last two decades. Some of those changes have had high and wide visibility, such as the achievement of the moral and well as the constitutional rights of black Americans, and the revolution of sexual mores. Both the foregoing examples are very dramatic, and yet

*By interventional animal studies I mean those in which an attempt is made to induce a change in the animal such that its physical and/or mental wellbeing would be compromised, and as a result it can no longer be regarded as within the range of a normal state of health (e.g., those things resulting from surgical alteration, aversive stimuli leading to abnormal behavior, the feeding of nutritionally deficient diets and the administration of toxins or toxicologic agents of disease).
I would contend that although the use of animals in research is largely a concern of specialist groups in more discrete numbers, the changes in attitude of experimental animal users and the degree of attention given to laboratory animal usage and care which have occurred in the same period of time are equally dramatic. Clearly the mainstream of moral thinking in the biomedical sciences in 1979 is not ambivalent in regard to the use of experimental animals. There is a dynamic equilibrium between the desire of man to live well and the concomitant use of animals for research on the one hand and the respect for life and the proper care of these animals on the other side of the equation.

In concluding my first point I will pose the following questions, and leave them for you to answer. If the biomedical and bioscience researchers are striving to minimize the use of animals, and if they have established safeguards for the use and care of animals in research situations, and if they have indicated that the ultimate goal would be not to have to use animals in this way, then how can we not apply the same standards or criteria to the citizens and scientists of tomorrow? If we condone interventional experiments or technical demonstrations on laboratory animals in high school science fairs, are we not establishing a double standard? What justification for performing interventional experiments at this stage of young people's biology education can there be? Even if one could justify interventional experiments, could one guarantee the same standards of care, from personnel highly trained in this work at all levels?

Could there be adequate peer review of project proposals? I believe that the advocates of interventional experiments in high school science fair projects might be a little less adamant after making a serious attempt to answer these questions honestly.

In my experience with university students with high school still fresh in their minds, I find that year by year they are increasingly more aware of the need to think very carefully about such issues. We are experiencing a shift from amorality to moral concern. A number of these young people have referred with disdain to their traumatic and insensitive introduction to vertebrate biology in school laboratory situations.

There is no doubt that using animals in teaching is a more delicate issue than using them in research, because it is compounded by the effect upon the student's own sense of the animals themselves. Desensitizing and inuring students to procedures likely to produce distress in animals does not serve them well and quite clearly this has occurred in the past, particularly in science fair situations. More important though, because they are probably far more common and insidiously subtle, are those procedures which cause little or no distress to the subjects, but alarm and brutalize the neophyte, such as the more physically violent (albeit controlled) methods of causing sudden death or insensitivity, such as stunning, cervical dislocation, decapitation and pithing.

Thus far, therefore, we may postulate that interventional animal experimentation in high school science fairs might strike the bright and informed student of the 1980's as follows:

A. A double standard exists concerning the use of animals in science. One stringent and moral set of standards for the fully fledged, bona fide bioscientist, and another amoral set of standards for animal use in high school science fairs.

B. Because science fair regulations and NIH guidelines are wholly incompatible with one another, and the continuance of interventional animal experimentation in science fair projects is permitted by officialdom, then our elders are posturing, and their concerns are not sincere, but more motivated by politics. This has shades of the sixties cast all over it; another lever in the credibility gap.

C. In order to be a good biomedical scientist, or practising professional such as a doctor or a veterinarian, one must become inured to distress and be able to inflict pain and suffering without emotion.

D. Generally speaking morality is an adult thing, being a carefully argued facade of academic interest only but with considerable political utility for the skillful pragmatist of the future.

We might consider at this point whether we would wish our children to be as we were, and to some extent still are, or would we rather they become what we would wish ourselves to be? Is education the process of maintaining the status quo, or is it part of the movement to a better future for mankind?

Educational Value of Intervenotional Experiments

If we assume hypothetically that equivalent standards of environment and ethics for the care and use of animals in research institutions could be applied in high school situations, then this would overcome many of the objections I have raised so far. The question of the educational value of interventional experiments with animals in high school science fairs remains to be addressed, however, and I have some thoughts on this subject.

Although I am sure all of us agree that it is very unlikely, though not impossible, that a high school biology student is going to bring about a major conceptual change, or even a significant advancement in the "puzzle solving" of the "tradition bound activity of normal science" as Kuhn (1970) referred to it, I nevertheless think that a high school biology project in a science fair can demonstrate an established fact or principle with elegance and clarity.

There is even one area in which the diligent neophyte observer of life can perhaps make an original observation. I refer to the study of normal animal behavior. The patient and tutored observer can make original observations, and I encountered such a happy instance in Ontario, Canada in the early nineteen seventies where a young man had conducted an ethological field study of the fisher (Martes pennanti) in winter. It is not the possibility of originality, however, that makes the study of normal animal behavior so exciting to me but rather the idea of studying the entire animal and its environmental relationships initially rather than starting with a mammalian cell and then approaching the whole animal through a variety or organs and systems, in a morass of data which to the majority may seem to be fragmented and not immediately relevant to an understanding of the entire organism. Perhaps the biology student is expected to commit all the fragments of information to memory for subsequent recall when animal ethology is finally broached. This in my own case occurred many years later.

I do not believe that the high school biology student has the degree of knowledge or understanding necessary to benefit from interventional animal experiments because this type of work inevitably is focussing on one small facet of the animal's biology, and frequently is associated with resultant abnormality. The student cannot know normality well enough to appreciate the abnormal, nor can detailed and fragmented study assist at this stage in a full appreciation of the healthy animal in one piece.
Since it is clear by now that I have developed a great sensitivity to man's use of animals, I would like to give an inanimate and unemotional example of what I mean by "fragmentation" in science education.

If one wished to develop a concept in a student's mind of the physics and engineering of flight and our contemporary use of these principles, how would one go about it? By studying the engine pylons of a DC10; by studying the metallurgical properties of magnesium/aluminum alloys; or by disassembling an RB200 jet engine? They are all part and parcel of modern flight but are all special technologies. When one has finished, one may run home and tell Mom and Dad what fun one has had, but the basic concept of human flight and how it is achieved has eluded one completely. Such isolated exposures would be little more than seemingly unrelated technic in vacuo. How many biology projects are like this, however?

A trip in a Lockheed Tristar and observation of take-off and landing at once embrace the principles of flight, and to the inquiring mind are inspiring of awe and motivating to the acquisition of more knowledge. What appears to be a simple up and down procedure on a grand scale, clearly relies on many complex systems within and outside the aircraft, and the questions will tumble out of the young observer's mind. The answers (where they exist) will be used to fill in the myriad of gaps, but they will always be relevant to the whole aircraft, and the joy of enlightenment can have its motivating effect, because it is in answer to the questions which the young mind feels are relevant to an understanding of how a Tristar goes up and down.

We must remember that human flight to the aeronautical engineer is not quite the phenomenon that it is to each person contemplating it specifically. The first bright young mind may be triggered into asking questions which men have tried to answer since Leonardo da Vinci and before, the basic difference being that many of the questions now have readily available answers. Therefore, I will pose another question for you to consider. Why not lead young aspiring scientists along the historical pathways of human inquiry, rather than down the narrow tunnels of technic?

So many of our science fair projects in the past have been isolated examples of technical aspects of science. Merely imitating the techniques used by scientists in their pursuit of knowledge may result in the student developing a very incomplete and unbalanced view of science and scientists. There is no doubt that scientists have fun in pursuit of knowledge, but the fun is intellectual and not mechanical. The mechanics or technic of investigation serves the search for knowledge and is an integral part of the scientific method. It is not, however, the whole thing nor is it necessarily the lion's share.

If science fairs are to have any real meaning, the motivation to enter must be for the right reasons, it must be to know what science is and to understand the scientific method in pursuit of a concept.

I do not believe that it was a burning desire to grow peas that consumed Gregor Johann Mendel. It was the question of what determined the characteristics of progeny in sexual reproduction. The concept on which he based his experiments is thought by Bronowski (1973) to have been the inheritance of sex (after all, one either ends up with a male or a female and not an hermaphrodite). It was human genius, elegant simplicity so obvious everyone overlooked it. The motivation was "the question;" the excitement was the concept; the anticipation was the experiment; and the ecstasy was the knowledge. The motivation was not a trowel and a packet or two of seeds!

We must not debase science in the minds of the public, the citizens of tomorrow, or ourselves by allowing mindless technic to pass as science in itself. Such a popular attitude does exist today to some extent and has served science and therefore all of us rather badly in recent years. If we are to have high school science fairs then let them be about science in the biology division also. But if the fairs are to include an amateur surgeon's division, then names either the division or the fair and do not burden science with such absurdity.

Selection of Animals and Projects for Science Fairs

I would now like to discuss the sort of animals I would like to see used in science fairs and the type of studies involved. Why the mammal (rat, mouse, gerbil) etc. is ripe for interventional experiments for boys and girls intrigues me. It must have something to do with their availability, but I think it also has been associated with their "complexity" and "closeness" to us, at least compared with arthropods, for example. Obviously, the reasons are many, and it is also quite likely that a clear rationale for preference that can be substantiated has yet to be developed. Life in all its forms is amazing, and it is in some of the "lower forms" such as the arthropods that we now begin to realize, with some degree of awe, the complexity of the organism and the precise sensitivity of that organism to the many facets of its environment. In addition, such knowledge makes one realize the impossibility of manufacturing an "order" of sentence. While we boom out our lofty thoughts in spoken words, the earth beneath us, the water around, and the air about us is alive with orientating organisms, sensitively communicating with their kind and striving to cope and compete within their part of the biosphere without, one might add, threatening to destroy the whole shebang!

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How can we encourage man's awareness of himself as an integral part of the equilibrium of the biosphere, with the unique capability of a species, to be a responsible steward and thrive himself, like a latter day Noah? We must become more aware of the role we may now play in the continuable life of earth as we know it. This is not only the province of a handful of concerned scientists, or even aspiring biologists, the many puzzle solvers of tomorrow's "traditional science" in its broadest sense, but it is also of profound importance to future politicians and industrialists. Therefore, above all else our teachers must now, if never before, speak of life and living and our role of stewardship.

The first encounter with a species surely must be with the live health organism in its fullest sense. The frog is often the first terrestrial vertebrate encountered in biology and unfortunately a good analogy to my earlier example of the fragmented study of an aircraft. The first encounter a city student might have with a frog is either in dissection or even with a live heart preparation. I have sought and received feedback from both arts and science majors on their perception of these experiences. The general feeling is one of failing to see the point of it and being "freaked out" by the procedures. To me the greatest indictment of this type of teaching is that the students at the end of their course of instruction still know nothing about frogs, even though some of them will know something about the sino-atrial node.

Quite clearly, we need to reevaluate the way in which we organize the exposure...
of the young mind to the study of life. It has already been suggested that the relatively new science of ethology is probably the prime candidate to greatly enhance good education in biology, and I must definitely concur, for not only does it give a true understanding of a species in dynamic equilibrium with the environment but it also emphasizes the complexity and sensitivity involved in this in the alleged "lower forms" of life.

Donald R. Griffin (1976), in his book The Question of Animal Awareness, starts out by stating that the book should not have been necessary because our increasing knowledge of animal behavior should have had a more profound effect on our thinking than it has. He discusses animal behavior with emphasis on evolutionary adaptation to the natural world; for example: social organization and communication; individual recognition; altruistic behavior; rhythm and biological clocks; and orientation and navigation. He states that:

... ethologists now feel confident in making statements that differ qualitatively from anything that was scientifically thinkable forty or fifty years ago... (and) it is especially appropriate to pose some new questions and to relate the general issue of our evolutionary kinship to other species of animals, with special reference to the more complex cognitive functions that appear to regulate the behavior of animals and men... Ethologists and comparative psychologists have discovered increasing complexities in animal behavior during the past few decades....

When I read this book, I found it difficult to stop. The part that aroused me the most was not the excitement over sign language in nonhuman primates but rather the complexity of communication and orientation in bees observed by Karl Von Frisch between 1923 and 1974. I heard the 'musie' of the whirling, wiggling swarmet-tanz, and I have never been the same since; it is the bees' dance language or tanzsprache in which communication was not enough. The accuracy of this dance language was truly amazing. As if my previous and long ignorance of this complex communication was not enough, I was incredulous at the description of the observation of several bees each, making their report, with an ultimate decision being made based on quantity and distance. The accuracy with which an experienced man can interpret tanzsprache is extraordinary, being 10 per cent plus or minus the real distance and 10° either side in direction. For the first time, I realized the incredible complexity and awareness of these "lower forms," and I was filled with wonder.

Perhaps the emphasis on the animal cell as the unit of animal life is unsound. Surely the unit of animal life is the animal itself. Surely the study of its life, its biology is the study of how that animal survives in its environment. Perhaps we should know what food an animal eats and how it acquires that food before we know how it digests it, and what happens when it cannot.

My friend and colleague, Dr. Bernard Rollin at Colorado State University, has adopted Aristotle's term "telos" in a book soon to be published. This is the expression of character that makes a field wak a field wak; it is the expression of the animal's individual and sometimes unique characteristics which can be clearly identified as typical of that species. The study of the organism and its telos is to all intents and purposes ethology. Griffin (1976) addresses the nature of ethology and shows it to be the expression of the animal which can nevertheless be broken down to basic components in the empirical sciences. He writes:

... the patterns of structural and functional coordination by which thousands of cells produce bird flight, for example, are not easily derived from data on the endoplasmic reticulum or sliding filaments of actomyosin.

Again, in referring to the immense complexity of bird flight, he says:

... this does not delude us into postulating vitalistic essences of flight independently of physics, chemistry, or cell biology.

Nevertheless, he argues that these disciplines only help us to understand the multitude of coordinated components of, say, locomotion in man. The telos of all of these is a creature behaving in its environment in a way characteristic of its kind, like its fellow organisms now, then, and in the future. The creature's telos is very real and is vital to its success or failure, but the components can be broken down many times under the electron microscope and in the chromatograph etc. etc.

At this point, we have come full circle, back to the example of the Lockheed Tristar aircraft used earlier in this presentation and in my opinion the same principle of scientific education applies. Thus, the appreciation of bird flight in its totality leads to many questions, and some answers. At no point is knowledge isolated in various disciplines, contrary, it constantly enriches the overall understanding. Where gaps in our current knowledge are found by the student, he or she may then encounter current endeavors in scientific investigation, the puzzles of traditional science.

Conclusion

I do not believe that we can justify on moral or educational grounds the use of interventional experiments at the high school science fair level. Examples of interventional experiments encountered by some in the past and referred to at this meeting only serve to emphasize my point. I do believe, however, that biology education without live animals is largely a waste of time and effort.

The use of existing facilities such as zoological parks, particularly in the more highly populated areas, has already been discussed by others at this meeting. Animals in their association with the human form a fascinating study. The urban dog or cat, whether happily domiciled or roaming ownerless, are an excellent focus for detailed observation. I believe family pets in general are much underrated as subjects for high school ethology. The value and the needs of pets in society could certainly stand the scrutiny of the citizens of tomorrow.

The rural high school student has a wealth of material ranging from the wild but less common creatures such as ground hogs and prairie dogs, to the fully domesticated animals such as the horse and ox (Bos taurus and Bos indicus) family. If animals are to be kept in captivity in schools for whatever educational purposes, I would like to see them in vivaria, where their natural environment is simulated in units built by the students themselves under instruction. These projects may be more expensive and time consuming, but the cost-benefit ratio must be eloquent in support of this sort of endeavor. Thus, we could envision classroom beehives which have been available for
years with the lucite observation panels; aquaria which are excellent ecological models; and vivaria for gerbils, field voles and deer mice. Vivaria for amphibia and for harmless reptiles might also be considered.

It has taken me thirty years to reach my present state of awareness and I feel that I have only just begun. It is sad to have to admit that one's perception of the living world of which we are an integral part has been limited and impeded by a lack of knowledge unrelieved by a fairly extensive science education. I must reiterate that I believe that man's "graspingness-of-mind" is a major part of his raison d'etre. Whether he continues to evolve or perish depends to a great extent on the concept he has of life on this planet, including his own. High school biology education is the starting point of our human understanding of the integration of life as a whole and our place within it. We must ensure that it speaks of the oneness of all life first and its amazing complexity second.

References


DISCUSSION

The papers presented in this section were invited following the conference discussion and address state education legislation, educational practices, and the philosophies of animal rights.

CHAIRMAN: ANDREW N. ROWAN