

## **Ethical and effective acquisition of knowledge and skills in life science education**

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InterNICHE is the International Network for Humane Education. Formed in 1988 as EuroNICHE, we are based in England with a committee of over 30 national contacts stretching from Brazil to Belgium, Israel to India.

As both a network and an organisation, InterNICHE works with teachers to introduce alternatives to harmful animal use, and with students to support freedom of conscience. We aspire to work in a fully inclusive way, looking for common ground and win-win solutions, and we are committed to supporting the most ethical and effective ways of gaining knowledge and skills in life science education.

Within biological science, medical and veterinary medical education, animals often play a central role in laboratory practical classes. The relationship between the animals and the students, however, is usually one of harmful animal use. Tens, if not hundreds of millions of animals across the world are used in experiments or killed for dissection every year.

The InterNICHE vision is one of a fully humane education, where teaching objectives are met using humane alternative methods, and where compassion, respect for life and critical thinking skills are valued and developed. It is an education where students have freedom of conscience, and where the negative relationship with animals has been transformed to the positive through full replacement of harmful animal use.

I will show how full replacement is not an unrealistic vision but one that is reasonable and desirable, and in fact one that has already been achieved in a growing number of universities across the world.

Many of us are aware of the concept of the 3R's - the Reduction, Replacement and Refinement of animal use, as described by Russell and Burch (1959). But for education it is now possible to refine this conventional definition of an alternative. Developments in technology and in ethical thought, and the examples of replacement from within all the disciplines of the life sciences, mitigate for such a refinement.

Specifically, the definition of alternatives within education can be made more strict so as to comprise only replacement alternatives; and can be broadened to include approaches that involve neutral or beneficial work with individual animals. Such a definition goes beyond the 3R's of Russell and Burch. It is more appropriate to the nature of knowledge and skills acquisition within life science education, and reflects the present-day possibilities and opportunities for replacement.

Alternatives, therefore, are progressive learning tools and teaching approaches that can replace harmful animal use or complement existing humane education. But it is worth pointing out that for many people 'alternative' is not the right word, and indeed it has its limitations. Teachers who have replaced harmful animal use have done so usually because they are committed to better ways of teaching. And in some countries, humane approaches within certain fields are the tradition. 'Alternative' teaching approaches - by tradition or by modern choice - are therefore often the *norm*.

We also need to define harm. Harm comprises any action, deliberate or otherwise, that impinges on an animal's current or future well-being by denying or limiting any of the following freedoms:

- Freedom to live
- Freedom to express full natural behaviour
- Freedom to be part of a social structure and ecosystem
- Freedom from hunger and thirst
- Freedom from discomfort
- Freedom from pain, injury and disease
- Freedom from fear and distress

This is a very strict definition of harm, but harm is a serious matter and should not be trivialised. Moreover, it is perfectly possible to meet the standard teaching objectives of life science practical courses - and many more objectives - using humane alternatives that involve no harm or can actually benefit individual animals.

Alternatives comprise a range of different tools and approaches:

- **Film and video**

Film and video are used across the world to supplement practical work and to illustrate processes that need further explanation. They are also low-cost and easy to make. Professionally-performed dissections can often impart more knowledge than dissections performed by students themselves, or can better prepare students for real dissection using ethically-sourced animal cadavers. Digital video is very flexible and can be incorporated into multimedia alternatives and presentations.

- **Models, mannekins and simulators**

The model is the traditional anatomy learning tool, comprising a plastic or latex representation of an animal or organ, dissected or with removable parts. Life-like mannekins can support effective training of clinical skills such as animal handling, blood sampling and intubation. And basic surgery skills, from eye-hand co-ordination

to suturing and anastomosis, can be gained using simulators. Perfusion of ethically-sourced animal organs using dynamic simulators allows for realistic surgery practice, and advanced computer-assisted simulators of the human body can better prepare students for critical care scenarios. These alternatives help students gain confidence and competence through repeated practice before entering the real life clinical situation with animal or human patients.

- **Multimedia computer simulation**

Software alternatives are what many people think of when alternatives are discussed, but software is just one learning tool that can be employed to support effective learning and mastery of skills. Computer-assisted learning (CAL) has brought great benefits to life science learning, and high quality powerful software has been available since the mid-1990s with programs that can offer virtual dissections for anatomy lessons, and well-equipped virtual laboratories for experimentation. CAL can provide extra levels to the learning experience, as well as a degree of excitement due to its often innovative nature. Visualisation and understanding of structure and function can be enhanced through video clips, high-resolution graphics and images, the ability to highlight or dissolve away different organ systems, and options to magnify images or compare tissue between species. Virtual labs, typically simulating animal preparations and experiments in physiology and pharmacology, can support the development of enquiry skills and an understanding of the interplay between complex and related phenomena.

At the more expensive end of computer applications to learning there is true Virtual Reality (VR), currently used by only a few of the richer universities in some countries, and mostly within human medicine only. Specific clinical and surgical procedures can be practiced in an immersive, sensory environment, and even the sense of touch - haptics - can be simulated through the use of special 'data gloves'. This is a rapidly evolving use of computer potential that has applications particularly in endovascular and endoscopic procedures, and over time it will no doubt be available to a greater number of students as well as to professionals who need to re-train specific procedures or perform simulations of surgery in advance of the real thing.

Just as an airline pilot is expected to train using flight simulators in order to be fully versed with all likely scenarios, so must all students who will be working with patients have achieved the required mastery. The risks and ethical constraints of a pilot practicing in a real airline with real passengers are clear enough; we should be making sure that the future doctor or surgeon trains effectively with the best tools, and will be taking no risks nor violating any ethics in that training.

- **Ethically-sourced animal cadavers and tissue**

Although few students will actually use animals in their careers, many zoology students and all future veterinarians will require hands-on experience of animals and animal tissue. The use of ethically-sourced cadavers and tissue is an alternative to the killing of animals for dissection and surgery practice. The term 'ethically-sourced' in this context refers to cadavers or tissue obtained from animals that have died naturally or in accidents, or that have been euthanised secondary to natural terminal disease or

serious non-recoverable injury. Animals that have been harmed or killed to provide cadavers and tissue are not considered ethically-sourced, nor are those sourced from places where harming or killing is commonplace.

Body donation programs linked to veterinary teaching hospitals and independent practices can provide supplies of cadavers and tissue ethically. Tufts University School of Veterinary Medicine in the US has a 'client donation program' whereby companion animal guardians can consent to donating the cadaver of an animal for use in teaching. All the cadaver requirements for veterinary anatomy, clinical skills and surgery training are met through this program, which was initiated by an individual student. The animal guardians choose between the donation program and having the animal cremated or returned for burial, but they are aware that cadavers donated to education spare others being killed. Members of the public are therefore consciously involved in supporting replacement in life science education, and such links between the public and the university are very positive.

- **Clinical work with animal patients**

Experience with patients is the norm within medical education, and the growing use of problem-based learning approaches is providing further clinical experience to enhance the education. In veterinary medicine, clinical learning opportunities could be expanded considerably to replace animal experiments and to better prepare students for the professions. A progressive approach to learning veterinary surgery might involve the student mastering basic skills using non-animal alternatives, moving on to ethically-sourced cadavers for experience with real tissue, and finally performing a significant amount of supervised work with animal patients to gain skills such as wound management and basic surgery.

Shelter sterilisation programs are a huge potential resource for students, with castration and spays observed, assisted and then performed by students. This is realistic and relevant training for students who may graduate to perform many sterilisations in their careers. The clinic can also teach students many other skills that the lab cannot: experiencing and dealing with the clinical environment and its demands, appreciation of the diversity of patients and clinical situations, and communication skills with work colleagues and animal guardians. Crucially, the students will have been present and involved in the whole process of dealing with a patient, including diagnosis, the operation, and post-operative care.

- **Student self-experimentation**

For further experience of the living body, the consenting student is an excellent experimental animal. The intense involvement and self-reference of such experiments makes them highly memorable and supports effective learning. EEG, ECG, nerve conduction and many other tests can be performed using basic lab equipment or specially produced apparatus. Self-experimentation may also be useful for future veterinarians, who, like rats, dogs and cats are also mammals and who can perhaps better understand the nature of being a patient if they themselves have been consenting subjects of non-harmful experiments.

- ***In vitro* labs**

A number of recent published studies have shown that for some toxicity tests, *in vitro* technology is providing results that are more repeatable and more reliable. In other words, it is better science in comparison with animal-based tests - and certainly better value for money. The rapid development and uptake of *in vitro* technology in research and testing needs to be supported by student familiarity with the techniques, and *in vitro* practicals can provide this experience. Animal tissue and cells used for such work can be sourced ethically, and within some cell biology practicals, the use of animal tissue and cells can be replaced directly with plant material. For studying cell respiration and electron transport, for example, mitochondria can be sourced from turnips, potato or beet instead of rat liver. With ethically-sourced animal preparations, or with plant material, therefore, such *in vitro* practicals can then be considered as alternatives.

- **Field studies**

Students of biology, zoology, ethology and ecology may often find themselves in situations where animals are studied in a laboratory setting as a model for nature, or they will be faced with interaction with wild animals that is invasive or otherwise harmful to the animals or their habitat. But biology is not just experimentation, nor does its study require harm. Much of the knowledge gained about animals and nature has come from observation and other non-invasive field studies. This tradition of studying animals within their natural environment is a particularly rewarding alternative to harmful animal use which could be developed and explored in order to replace some lab animal practicals in the above disciplines.

The successful implementation of alternatives impacts on many spheres:

- **Pedagogics and quality of learning**

As well as the advantages of different types of alternatives as described above, over 35 published academic studies have shown that students using alternatives perform at least as well as those using animals in conventional, harmful ways. Combinations of alternatives applied to the educational process will clearly do even better: teachers committed to good curricular design will have audited their courses and chosen the best tools and approaches to meet the identified teaching objectives. The negative lessons of the hidden curriculum - that animals are disposable tools, for example - will no longer be learned, and many positive messages will have been given. Positive attitudes towards animals can be engendered, the need for conscientious objection is obviated, and the learning environment is further improved as a result.

- **Life science philosophy**

The roots of medicine and veterinary medicine are in healing, not harming. The imperative *Primum non nocere* is not an idle comment of no relevance, and the harmful use of animals is contrary to the fundamental tenets of these professions. While the physician may occasionally harm in order to heal, this is not the case when educating the future professional. Similarly within biology, harmful animal use is counter-intuitive. Biology often seems to be more necrology than the study of life.

Studying and affirming life can be achieved with alternatives, and such approaches help reconnect the life sciences to their positive roots.

Alternatives can also help support the practice of critical thinking. The scientific method itself is really just a formalisation of critical thinking, and essential scientific skills such as problem-solving and good experimental design are often treated as very important in many software products. And when students or teachers question the orthodoxy - which is often the orthodoxy of animal experimentation - and look for innovative, alternative ways of doing things, they are involved in critical thinking. This practice should be nurtured.

- **Emotional and ethical literacy**

Sensitivity, empathy and compassion all play essential roles in society, and reflect cultural values, practices and skills that are important to protect and develop. They are essential within science too, because it is people - thinking and feeling people - who are practicing science and who are engaging with other people and with animals.

There is significant evidence of the desensitisation of students through harmful animal use. This may be a result of the hidden curriculum, which teaches that life can be violated, or it may be a deliberate policy to 'harden' students, in the belief that this is a necessary part of moral development or the cost of scientific endeavour.

In fact, desensitisation and the denigration of the emotional realm help neither students nor science. Understanding and exploring the often complex emotions associated with challenging aspects of the life sciences is surely preferable to denial and ignorance. The mind and the emotions are always present and are never separable. It is not emotion that hinders objectivity, but a lack of critical thinking or of awareness of the whole picture.

A commitment to ethical science and to open ethical discussion in the classroom will help the future professional to be more able in ethical decision-making and can encourage a strong sense of personal and social responsibility. Emotional and ethical literacy will always benefit science, but they may demand the use of alternatives rather than the killing or harming of animals.

- **Accessibility and civil liberties**

A leading Jain academic advised adherents of Jainism that they should not enter medicine because of the required dissection and vivisection. Should life science education discriminate according to religion and ethical commitment? Recognition and validation of such commitment through the use of alternatives will ensure that all students who would not have entered the life sciences because of harmful animal use can now participate and contribute. This increased accessibility is relevant for all students, but in many countries this will also have a significant positive impact on increasing the number of women in the life sciences.

For those who are already students, the threat of academic or psychological penalty when conscientiously objecting is a form of discrimination, and the lack of opportunities to use alternatives is limiting students' experience with best practice

learning tools and approaches. Compulsory harmful animal use is unacceptable coercion, and can cause psychological trauma for students. It also risks costly court cases - one university was ordered to pay US\$95,000 to a student for denying her freedom of conscience. Animal use in education is clearly an ethical issue, and by dealing with it through discussion and action teachers will demonstrate that science and ethics can be compatible and that problems can be faced rather than denied. This is a good lesson for future scientists for learn.

- **Practical impact**

*Environmental and animal welfare*

Animals caught from the wild, animals bred, caged, killed or experimented on do suffer harm, and the scale of the suffering is as great as it is unnecessary. Conventional animal use is not acceptable from the perspective of animal ethics. Taking animals from the wild can seriously disturb local ecosystems, and has contributed to the decline of some species, such as leopard frogs. Threatened or endangered species, including dogfish, are also caught for educational use in some countries. Moreover, the toxic chemicals used for preparing the millions of animals killed each year have a damaging environmental and health and safety impact. If high quality alternatives can replace such use, then from the animal welfare and environmental perspectives alone the logical conclusion is replacement.

*Economic benefits*

Several studies have shown that the use of alternatives provides significant economic benefits to universities. The direct and indirect costs associated with the use of animals are removed, and after purchase or development most alternatives can be used for several years. While the initial outlay of computer hardware may be high, many universities already have such equipment, and the costs are anyway recovered over time. Software with hundreds of high quality anatomy images or a well-equipped virtual laboratory is inexpensive compared to the cost of the real laboratory with similar equipment and textbooks. Moreover, some alternative approaches just make good use of existing untapped resources. Teachers can also make their own learning tools, using their own experience and according to their specific course requirements. For most teachers who have developed alternatives, it is usually the economic and pedagogic advantages that have motivated them.

*Personal and institutional reputation*

Many producers of alternatives have found their personal and institutional reputations enhanced by their work, and some high quality software has won awards for multimedia design or teaching innovation and success. Many academic papers have been published by teachers who have developed and implemented alternatives. The enhanced reputation of teachers amongst students has also been a positive result of efforts to improve teaching and to respect students' ethical concerns. Reputations can also be seriously damaged by negative media publicity or legal challenges occasioned by communication breakdown and student-teacher conflict. Resolution of ethical problems in the classroom in advance of such action is clearly preferable, especially as co-operative solutions can usually be found.

### *Legislative requirements*

Personal and collective responsibility for curricular change is always preferable to that forced by diktat. Until such responsibility is widely taken, however, legislation is a useful tool for implementing alternatives and for modernising education. The use of alternatives accords with the letter and spirit of many national laws and international conventions and directives which state that alternatives should be used wherever possible. As there are examples of alternatives being successfully used for practical course in all disciplines, it could be asked whether harmful animal use is in fact illegal.

How does InterNICHE help realise the vision of full replacement of harmful animal use? The network offers a range of information and other resources to teachers and students to empower them to facilitate change. These resources include:

- ***from Guinea Pig to Computer Mouse***

Published in 2003, *from Guinea Pig to Computer Mouse* is a 520-page book in 4 parts. Part A provides the background to animal use in education, describing alternatives and their pedagogical advantages, and looking at their broader impact. Dr Jonathan Balcombe reviews published papers that assess alternatives in terms of student performance, and Dr Lara Rasmussen addresses the concept of curricular design and the best ways to meet teaching objectives. Part A also looks at the role of conscientious objection in curricular transformation, and gives a review of the philosophy and practice of InterNICHE.

Part B comprises case studies written by university heads of department who have implemented alternatives and replaced harmful animal use. They share their experiences of the process of change and the advantages of using alternatives. The authors include:

*Dr Hans Braun* from the Institute of Physiology at Marburg University in Germany. Braun co-developed the award-winning Virtual Physiology series of virtual laboratories, such as SimNerv, which have fully replaced the animal experiments in his institute for students. Although he was initially very much in favour of continuing the conventional animal experiments in the face of student protest, Braun found that the students were much more active in practical classes with the simulations, and were learning successfully how to experiment and to make use of their knowledge.

*Dr Henk van Wilgenburg*, pharmacologist from the University of Amsterdam in the Netherlands. Van Wilgenburg developed the 'Microlabs' collection of computer simulations, and in his chapter questions the relevance of conventional animal experiments when obtaining and interpreting data can be achieved so effectively with advanced computer software. Van Wilgenburg also advises on the process of implementation of alternatives, particularly preparation of the environment and staff, and cost allocation between hardware, software and support.

*Dr Mykola Makarchuk* from Kyiv State University in the Ukraine. Makarchuk is a biologist who has successfully replaced animal practicals with student self-experimentation and computer simulation for the teaching of human and animal physiology. He explains the challenges facing replacement in former Soviet countries,

especially in terms of cost, availability and opportunities to trial alternatives, and also draws a comparison between broader social changes in the Ukraine and improved attitudes towards animals.

*Prof Garry Scroop*, physiologist from the University of Adelaide in Australia. Scroop has implemented 'research project practicals' for students, which comprise semester-long self-experimentation practicals based on research methodologies to support learning of problem-solving strategies. Instead of students producing contrived results from brief, poorly-supervised animal experiments - which Scroop sees as typical of many practical classes - the alternative approach is specifically designed to encourage critical thinking. It also provides opportunities for teamwork, and fully replaces the animal use. The approach has been recognised nationally as an example of best practice, and has now been emulated at other departments and universities.

*Dr Amarendhra Kumar* from Tufts University in Boston, USA. Tufts University School of Veterinary Medicine runs the sustainable client donation program for ethically-sourced cadavers. In a survey, 97.5% of students questioned preferred to use donor - ie ethically-sourced - animals. 0% wanted to use animals that had been killed for the purpose, and 2.5% didn't care either way. The School's reputation for using just ethically-sourced cadavers is part of the attraction for new students.

*Dr Daniel Smeak* from Ohio State University, USA. Smeak has developed a range of portable skin / suture pattern and hollow organ simulators for use with training videos for highly effective manual skills acquisition. Students can practice again and again, both in the lab and at home, and then progress on to ethically-sourced animal cadavers before their clinical rotations. Over 5000 animals from shelters have been sterilised by students working under supervision, increasing student exposure to clinical experience as well as increasing the rate of adoption of animals to nearly 100%. The experience of Smeak is that mastery of surgery skills can best be achieved through application of such alternative tools and approaches.

*Dr Lara Rasmussen* and colleagues from Western University of Health Sciences, USA. The country's newest veterinary college is zero animal consumptive and has a 'reverence for life' philosophy. A skills-oriented curriculum which optimises the use of progressive, humane learning tools and has a strong focus on clinical work and strategic alliances will ensure only beneficial or neutral interaction with animals for veterinary students. And if this can be done within veterinary medicine, then it can certainly be done in human medicine, where the focus should be on the human body rather than animal experiments.

Part C of the book is the Alternatives File, which comprises the majority of the publication. This is a database of over 500 alternative products, detailing for each their application, specifications, and source. The section is divided according to discipline, such as anatomy, anaesthesia and critical care, physiology and pharmacology. Each discipline is then subdivided according to medium - software, video, models, mannekins and simulators, and finally web-based alternatives. The Alternatives File comprises up-to-date and original research, and includes some alternatives that have never before been marketed or shared.

Part D comprises over 1000 further resources such as on-line curricular material, printed resources, recommended reading, details of alternatives loan systems and organisations worldwide, as well as full contact details of producers.

The Appendix presents the comprehensive 10-part InterNICHE Policy on the Use of Animals and Alternatives in Education. Over 10 language translations of the book are under production, and a CD-ROM, DVD and web version with searchable database will also be produced.

- ***Alternatives in Education***

This 33-minute video, produced in 1999 and available in nearly 20 languages, is an exploration of alternatives within anatomy, physiology, pharmacology, clinical skills and surgery. Interviews with university teachers who have developed and implemented alternatives are complemented by visual demonstrations of a range of tools and approaches. The multiple benefits and pedagogical superiority of alternatives compared to conventional lab animal use are explained using specific examples.

- **Alternatives Loan System**

This is an evolving library of over 100 of the best alternatives, including multimedia software, videos, models, mannekins and simulators from a variety of disciplines. Teachers and students can borrow items from the Loan System, paying only the return postage, and can trial them to assess their relevance to their own specific curricula. The Loan System gives borrowers the opportunity to familiarise themselves with some of the best products available.

This resource is being used across the world, and some loans have already brought about replacement by presenting examples of high-quality learning tools. Products are also taken to conferences and have been used on outreach tours by InterNICHE contacts. Four small-scale micro-Loan Systems are currently being established in Brazil, Russia, India and Japan.

- **Humane Education Award**

This annual Award of 20,000 Euro is targeted at teachers and others who can bring about replacement through the production of new alternatives or the purchase and implementation of existing products. In 2002 the Award was focused on former Yugoslavia and Romania, and in 2003 on India, with over 10 projects supported to date.

One project comprised the production in Romania of veterinary physiology software and the establishment of a computer simulation laboratory using reconditioned computers. Together these have replaced the annual use of nearly 1000 animals, and with the alternative being freeware, it is available for free worldwide distribution and use. A second project comprised a compilation of pharmacology freeware. This has been distributed free to over 3000 pharmacology and pharmacy teachers across India, and is also available worldwide.

- **Website:** *www.interniche.org*

The InterNICHE website is the largest existing website on alternatives in education. It provides a wide range of information and resources on-line, including comprehensive background to the issues, news, student testimonies, and links to producers, product reviews and external resources. Currently available also in Russian and Greek, a number of other language versions are under production, and new resources are continually being added.

- **InterNICHE Conference**

InterNICHE holds a major international conference every 2-3 years, offering leading international and local speakers, challenging workshops, an alternatives centre with some of the latest teaching products, and room for discussion and networking. Delegates include teachers, product developers, students, legislators and animal protection campaigners.

- **Other conference visits and outreach tours**

Both the InterNICHE Co-ordinator and national contacts have co-organised and spoken at a wide range of international and national events on alternatives. Larger outreach tours have also taken place, including visits to Russia, the Ukraine, and India. These visits allow the presentation of the InterNICHE vision, demonstrations of alternatives, distribution of resources, and support for local humane education initiatives. A 7-week nationwide speaking tour of India in early 2003 also allowed the distribution of 1200 copies of *from Guinea Pig to Computer Mouse* to teachers and students of dozens of institutes from cities across the country. In the same year, two Japanese veterinary students visited all of Japan's veterinary universities to speak and present a range of products from the InterNICHE Alternatives Loan System, exposing most of the country's veterinary teachers to alternatives, many for the first time.

In summary, the replacement of harmful animal use has been gaining momentum across the world, supported by developments in technology and the evolution of ethical thought. The multiple positive impact of alternatives means that this replacement is to the benefit of students, teachers, animals and the life sciences. It is a win-win situation. InterNICHE is happy to support those who are committed to a high quality and ethical life science education.