# VIRTUAL BIOLOGY: DO WE NEED THE REAL THING?

Sue Franklin, Mary Peat

ABSTRACT
One of the debates within biology teaching is the appropriate use of animals and plants to enhance the learning experience. In particular significant amounts of time are often set aside within curricula for relevant practical experiences, including dissections, drawings, microscopy, experimentation and discussions with peers and staff. For many reasons, an increasing number, albeit a minority of students these days are disinclined to handle biological materials, whilst financial cutbacks are making the provision of them more difficult. This makes teaching the discipline in a practical way increasingly difficult. This paper discusses how first year biology students at The University of Sydney use a variety of virtual resources to provide a stimulating learning environment in an atmosphere of dwindling resources. We will recommend a mix of teaching opportunities, virtual and real, that might best support student learning in the 21st century.

KEYWORDS
Biology, tertiary teaching, virtual, evaluation

## INTRODUCTION

Information technology (IT) in the form of computers, television, literature databases, and audiovisual materials have been available for teachers in all disciplines for many decades. So what is different about the high-tech learning environment of the 21st Century? Several factors have developed simultaneously to change the potential of IT as a learning tool. The most important is the ubiquity of computer networks, which has opened up the world of knowledge. Additionally, a convergence in digital technology has provided user-friendly multimedia instructional platforms, as well as the emergence of a cognitive learning theory which emphasises inquiry, and a marked change in the needs of society which has had an impact on the education process. Awbrey (1996) argues that educators need to encourage the work force of tomorrow to develop the skills of abstraction, system thinking, experimentation and collaboration. IT provides greater educational flexibility by creating learning environments that are accessible to individuals with a variety of learning styles at anytime and anyplace. Technology can assist in overcoming barriers faced by students of all descriptions such as the distant learner or physically impaired.

At an Australian National Teaching Workshop, Elaine Martin reflected on the use of computers in student learning (Martin, 1994) and proposed three main uses of computers in the educational setting today: as an information resource; to test and drill students in systematic and insistent ways; and as model makers allowing students to explore ideas and make connections.

The potential uses of IT in information storage, delivery and creating challenges in teaching biology are undeniably great. However, do we fill our biology curricula with meaningful IT experiences? How do we use computers to help our student learn? A recent review (Akpan, 2001) discusses issues associated with using virtual materials in biology education.

## REAL AND VIRTUAL FIRST YEAR BIOLOGY TEACHING AT THE UNIVERSITY OF SYDNEY

The delivery of a large (approximately 1300 students in 2002) first year biology course at The University of Sydney has undergone enormous change during the last decade, to cope with an increasing heterogeneity of students. At the same time the resources available to provide the curriculum have dwindled. A component of this change was the introduction of computer-based learning materials in 1992. To enhance delivery and ease of use of these resources we developed a Virtual Learning Environment (http://FYBio.bio.usyd.edu.au/VLE/L1/). The resources we have available online for the first year students include learning modules (tutorial-style programs), self-assessment modules (offering four levels of difficulty for self-assessment), lecture notes, course information and web links. As part of this initiative we have introduced many virtual learning experiences, which can be completed in the laboratory, from home or from the University computer access centres. These activities include virtual field trips, virtual microscopy, virtual dissections, virtual experiments and virtual communications designed to enhance the learning experience of students. We have developed several of these modules cognisant of the fact that many first year biology students do not need advanced technical skills in the discipline, such as microscopy and dissection, for their future career pathways.

During the last decade we have investigated use and usefulness to the student of a range of computer-based resources. Many of these investigations were to provide us feedback for the ongoing iterative development of our own materials and a better understanding of how the students use the resources. These have been reported elsewhere (Franklin and Peat, 2001; Peat, 2000; Peat and Franklin, 2002; Peat, Franklin and Mackay-Wood, 1997). Prominent in these investigations are studies on the value of the resources in student learning, including the use of computer-based dissections in enhancing learning. This paper will concentrate on the use of virtual material versus "real life" hands-on experiences, using examples from ecology, dissections and other lab-based activities. In particular, the paper will report on the status of dissections in the first year biology curriculum.

> ***Note on computer and Internet access at home.*** *In Australia today approximately 33% of households (an increase since 1999) have an Internet connection. An estimated 6.5 million people accessed the Internet in 2000, which included 75% of 18-24 year olds (Australian Bureau of Statistics, 2002). At the University of Sydney 100% of biology students have access to a computer, 84% of them have access to the Internet from home and 100% access to the Internet from the University Student Computer Access Centres (Peat, Franklin, Lewis and Sims, 2002). In comparison, in the UK 40% of households have Internet access (but with signs of this percentage beginning to decline) (ZDNet UK, 2002).*

### Hands-on versus virtual biology experiences – advantages and disadvantages

The advantages of hands-on biology experiences are many and varied. With real materials students are obviously provided with a more realistic and arguably more exciting appreciation of the biology. The real material is three-dimensional, it can often be handled and used to stimulate group discussions and is the best way to develop the manipulative skills of the discipline such as dissections, microscopy and use of scientific equipment. The disadvantages of using real materials are often managerial and cost-related. The materials themselves may be expensive to buy or collect, the laboratories have to be maintained and teaching staff must be provided. Other disadvantages are associated with the limited flexibility of the modern student. They are often not able to attend on-campus, for a variety of reasons and there may be ethnic or cultural considerations when working with biological materials.

The use of virtual biology experiences poses a different set of advantages and disadvantages. Virtual experiences can be obtained anytime/anyplace, and in this mode they are usually obtained on one's own. They may be "quicker" than traditional activities, such as field trips and experiments, which may suit many students. They may be less expensive to sustain as an activity, once the initial costs of production have been met. They may be used in a classroom situation by groups of students to help stimulate

discussion and to develop communication skills and critical thinking skills. They may be available in the classroom as pre-hands-on "training" or as an alternative (opt-out) for hands-on experiences such as dissections for students who have cultural objections to this. A virtual biology learning experience may in fact be better for some aspects of learning biology than the real experience, and vice versa. Ultimately, in some situations, virtual biology learning experiences may be better than the hands on learning experience.

At The University of Sydney, in First Year Biology, we have integrated virtual field trips, virtual microscopy, virtual experiments and virtual dissections into the curriculum of nine courses taken by a total of 1300 students.

**Virtual field trips**

To recreate a field experience electronically allows students to take part in a time honoured biological learning experience in a more time and cost effective manner. Learners take part in authentic activities in realistic and relevant fields. Students are provided with experience and appreciation of multiple perspectives, by allowing them to access and collect information and construct their own understanding of the basic topic covered. With declining teaching budgets and increasingly busy curricula, we have found virtual field trips to be powerful aides in the teaching of biology. Our experience is supported by Bitner *et al*., (1999) who found that the use of virtual field trips increases students' abilities to solve real world problems.

We use the commercially available CD-ROM, *Investigating Lake Illuka* for about 300 students in non-biology major courses and in our bridging course (from secondary school to university). In this program students can work in four ecosystems associated with a fictitious lake. The program allows them to investigate the diversity of species present in each ecosystem and to gather information about the physical and biological parameters of these ecosystems. The data collected by the students are then used as the basis of a discussion on some aspect of ecology. Evaluation of the use of this program indicated that the students were comfortable with the active learning scenarios and felt they had developed ideas and skills that would enable them to make better use of a real visit to a lake ecosystem. The students were exposed to issues of lake management and their responses indicated a transfer of ideas to real-life issues.

**Virtual microscopy**

It takes time and practise to develop the skills of microscopy to the level that the microscope does not impede the material being studied. More and more these days students are being shown the "equipment", in this case a microscope, but they are not being given the time to develop the appropriate technical skills to make the most effective use of it. At The University of Sydney, in a general biology course there are potentially hundreds of microscope slides of specimens that could be used by students. We have taken some of the conceptually more difficult microscopy materials and produced a virtual tour of them. For example, "Meiosis: A Visual Reminder" (http://FYBio.bio.usyd.edu.au/VLE/L1/ResourceCentre/CAL/Meiosis-VR/MeiosisVR.html) consists of a series of photomicrographs of meiosis, the process of cell division which produces gametes, each with a companion drawing and with the provision to add the labels to either the micrograph or the drawing (see Figure 1). A small amount of descriptive text is available and the menu design takes the students through the material in a logical sequence.

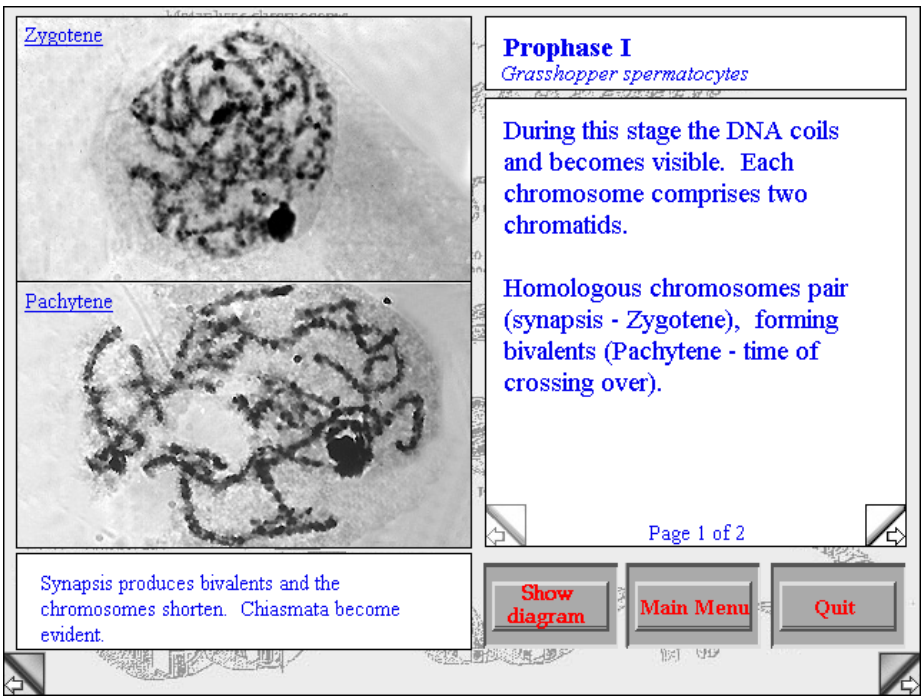


Figure 1. Screen shot from "Meiosis: A Visual Reminder"

This program and others are integrated into the curriculum and the laboratory sessions but they can also be done anytime/anyplace. The advantages for the students are that they: have a consistent interpretation for each slide; can choose to do them at home; and view the sequence of cell division in a logical way. The advantages for the department are that these slides, which requiring oil immersion are liable to breakage and take considerable staff time to set up, are not required in the student lab classes. There is a saving in the replacement cost of the slides and in the setting up of the sequence in multiple sets which needs constant attention from staff during a practical session. In addition, the development of a set of templates for producing a Visual Reminder has reduced the production time.

**Virtual experiments**

Virtual experiments, like virtual field trips, can offer students activities and exposure to content in ways that are not always possible in the classroom. Virtual experiments have been shown to provide a learning experience which is considered to be as effective as "wet" practicals for knowledge and understanding (Hughes, 2001). We have designed experiments that are integrated into the curriculum and can be used both by groups of students together in class or alone (at home) for revision. Experiments can be designed to generate data that is collected by a group of students for discussion or for writing a report. The advantages of virtual experiments include the time factor (often the real experiment takes too long to generate sufficient data for a useful discussion to take place), their relative low cost in terms of materials, rapid data collection and potential to instigate group discussions in the limited time of the class.

One of our experiments is "Simulation of the effect of light on photosynthesis" (http://FYBio.bio.usyd.edu.au/VLE/L1/ResourceCentre/CALModsRC.html), which simulates experiments that investigate the effect of light intensity and wavelength of light on the rate of photosynthesis of a plant. The students collect data from the simulations and then plot these data in their workbook (see Figure 2). The experiments are simple in concept but would require multiple sets of expensive equipment to do in the classroom for such large numbers of students.

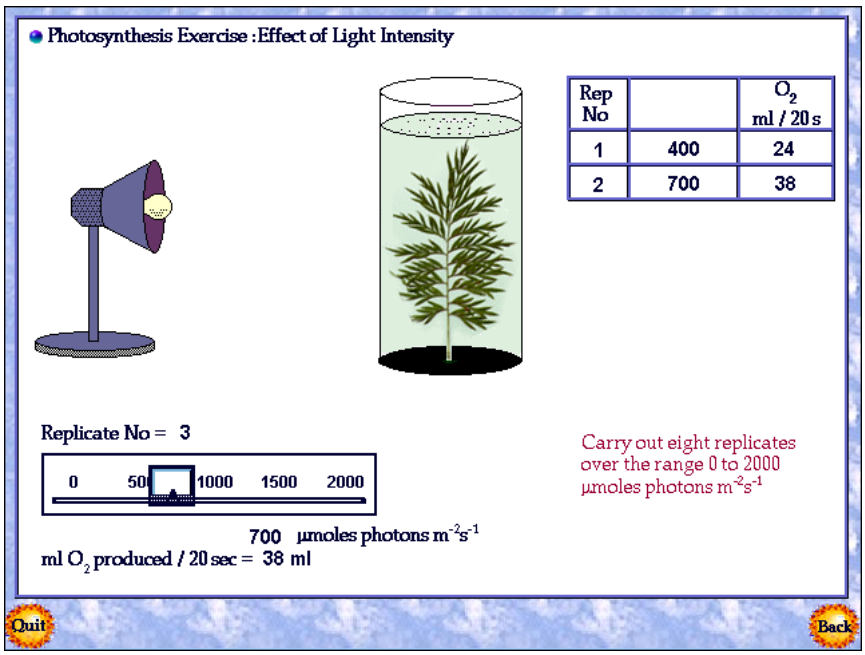


Figure 2. Screen shot from "Simulation of the effect of light on photosynthesis"

An extension of virtual experiments is the use of pre-lab modules as introductions to laboratory equipment. Students are able to gain an understanding about how the equipment works before handling it in the laboratory session. We use two modules to allow students to practice using a spectrophotometer and an ultra-violet light source prior to using them in a laboratory session. It has been shown that this is an effective way to help students learn to use equipment and one that is now used extensively in Chemistry classes in the higher education sector (Wilson, 1996; Wilson and Cavallari, 1995).

**Virtual dissections**

The use of dissections, especially of mammals, is becoming more controversial, leading teachers and students to reconsider the value of these procedures in the classroom. In some institutions dissections have been abandoned, partially in response to 'animal rights' issues (Heron, 1992). Alternative to using animals for dissection are 3D models, slide-tapes, videotapes, videodiscs and computer simulations (Kinzie, Strauss and Foss, 1993; Langley, 1991; Quentin-Baxter and Dewhurst, 1992; Strauss and Kinzie, 1991). Also it has been shown that when students are offered an alternative to a rat dissection (like models and charts), their performance in examinations is no different from those students who completed the dissection (Downie and Meadows, 1995).

In 2001, we investigated the use of real dissections and virtual dissections by 800 first year biology students. The virtual dissections are computer-based cat cadaver materials (http://FYBio.bio.usyd.edu.au/VLE/L1/ResourceCentre/CAL/CardioCat/Cardio.htm). They were introduced in 2000 to be used for new learning, revision or as an instructional alternative for those students who had animal rights issues and ethnic/cultural sensitivities to animal dissections. The computer-based materials (see Figures 3 and 4) are accompanied by paper-based instructions, and they are fully integrated into the curriculum. A full description of the design of these materials and their use has previously been reported (Franklin, Peat and Lewis, 2002).

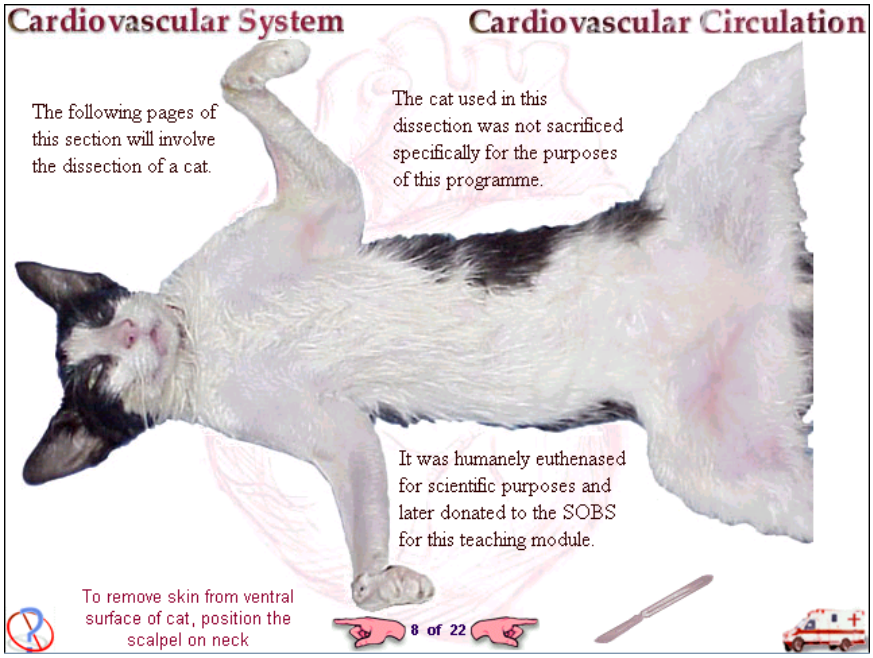


Figure 3. The cat cadaver prior to dissection by the student (user). Students dissect the cat using the scalpel. Help is available by clicking on the ambulance

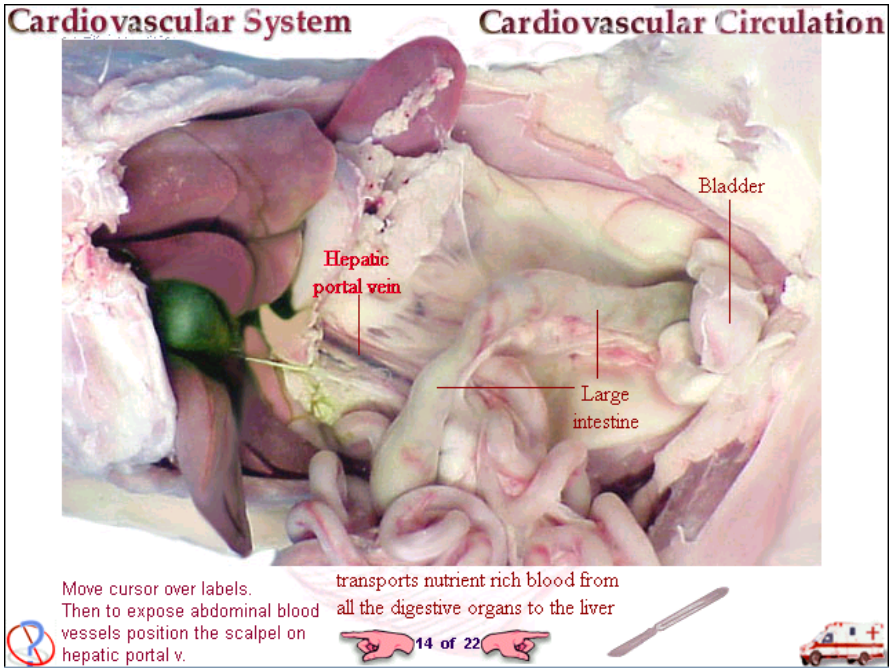


Figure 4. Cat cadaver dissected to show abdominal organs and blood vessels. As the cursor moves over the labels a "pop up" appears (above the "hands") giving information about the structure indicated

Student use of the real cat cadaver dissection and the virtual alternative are shown in Table 1. In this study we found that 80% of the students surveyed used the real dissection materials and 36% of students used both the real dissection materials and the virtual materials. The data also indicate that the provision of opt-out materials is welcomed by a proportion of the students (15%), who, for a variety of reasons, find the real dissection material not to their liking. This suggests that tertiary biology education, opt-out

schemes are viable and that the continued development and provision of these types of materials is warranted.

Table 1. Use of dissection resources

| Resource | Use of resource (n=200) |
|---|---|
| Real cat dissection | 80% |
| Virtual cat dissection as opt-out | 15% |
| Neither | 5% |
| Both real and virtual cat dissection | 36% |

Students who had used both the real dissection materials and the virtual dissections indicated that both real and computer-based dissections were useful for their studies, illustrating the value of offering a diverse range of materials to provide students with a rich learning environment. Indicating how different media can be used for different inputs/outcomes, many students remarked, in open-ended responses, that cadaver-based dissection was probably more useful for understanding structure and interrelationships, and computer-based dissection was probably more useful for function. These results are shown in Figure 5 and confirm the findings of Lord (1990) who suggested that wet specimen dissection labs where students handle, rotate and manipulate objects contribute greatly to the development of visual-spatial perception. In addition, he indicated that text, workbook and computer-based activities rarely stimulate visual-spatial thinking in the student (Lord, 1990). Interestingly the majority of our students recognised the advantage of the use of the real dissection, in particular its 3D nature, even though some found it distasteful.

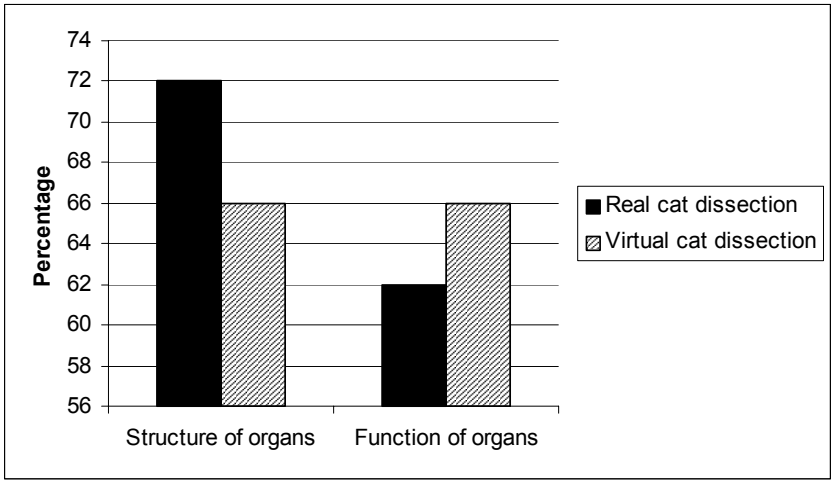


Figure 5. Usefulness of real dissection versus virtual dissection material in understanding structure and function of organs

A proportion of students (8%), however, found both methods of dissection "of no use" to their learning, which reinforces the requirement for academic departments to continually review their resources to ensure they meet student needs and learning styles. In addition, the data showing that some students found the computer-based dissections of no use indicate that the development of such resources, which are often costly, must be objectively justified and comprehensively integrated into the course of study.

While the majority of students reported that they obtained value from both the real and virtual dissection resources, a number of critical factors emerged. Given that neither form of instruction, real of virtual dissection, was clearly favoured by students to be superior to the other it is difficult to support

the provision of one rather than the other. Our results suggest the use of both might be the ideal, as they appear to complement each other in the case of many students. However, the provision of both real and virtual dissections has real cost implications, which might not be sustainable or justifiable in the case of a biology unit considering the introduction of a virtual dissection module. The trend for removing animal cadavers from laboratory classes is likely to continue with added pressure from both increasing student numbers and community objections to animal dissections (Wheeler, 1993). It is our intention at The University of Sydney to continue to offer the real dissection materials and continue the development of computer-based materials to be used by students as a complement to real dissection, an opt-out option and a tool for preparation and revision.

## CONCLUSION

In answer to the question "Virtual Biology: do we need the real thing?" the students are telling us that the answer is a resounding "yes", but that there is also an important place for virtual biology in its various guises. Virtual experiences are valued for their flexibility of use, availability for revision and provision of additional information, whereas real experiences are valued for the hands-on, 3D nature but also for their "reality". If we wish to excite students about biology we consider that it is essential that they experience as much real material as possible within the constraints of time and budgets.

In large group of students, which are often culturally and ethically diverse we recommend, based on our experiences, the provision of virtual dissection materials as an opt-out even though real materials are provided for the majority. Virtual dissection materials are also recommended as a complement to real dissections, where we believe they may be superior in teaching the students functional biology as opposed to structural biology.

Mindful of diversity of learning styles and levels of prior knowledge of students, we consider that the provision of the widest possible range of learning opportunities will best stimulate students to achieve the best possible learning outcomes.

## ACKNOWLEDGMENT

The authors wish to thank Michael Loxton for his careful and critical review of this paper.

## REFERENCES

Akpan, J. P. (2001) Issues Associated with Inserting Computer Simulations into Biology Instruction: A Review of the Literature Electronic Journal of Science Education 5(3), March 2001 http://unr.edu/homepage/crowther/ejse/akpan.html (verified 3 December 2002).

Australian Bureau of Statistics (2002) Year Book Australia 2002 http://www.abs.gov.au/Ausstats/ (verified 29 November 2002).

Awbrey, S. M. (1996) Successfully Integrating New Technologies into the Higher Education Curriculum Educational Technology Review 5.

Bitner, N., Wadlington, E., Austin, S., Partridge, E. and Bitner, J. (1999) the Virtual Trip Learning and Leading with Technology 26(6), 6-9.

Downie, R. and Meadows, J. (1995). Experience with a dissection opt-out scheme in university level biology Journal of Biological Education 29, 187-193.

Franklin, S. and Peat, M. (2001) Managing Change: The Use of Mixed Delivery Modes to Increase Learning Opportunities Australian Journal of Education Technology 17(1), 37-49.

Franklin, S., Peat, M. and Lewis, A. (2002) Traditional versus computer-based dissections in enhancing learning in a tertiary setting: a student perspective Journal of Biological Education 36(3), 124-129.

Heron, L. (1992) Cutting out the cutting up The Independent December 17th, p.16.

Hughes, I. E. (2001) Alternatives to laboratory practical – do they meet the needs? Innovations in Education and Training International 38(1), 3-7.

Kinzie, M. B., Strauss, R. and Foss, J. (1993) The Effects of an Interactive Dissection Simulation on the Performance and Achievement of High School Biology Students Journal of Research in Science Teaching 30, 989-1000.

Langley, G. R. (1991) Animals in science education – ethics and alternatives Journal of Biological Education 25, 274-279.

Lord, T. (1990) The importance of animal dissection Journal of college Science Teaching 14(6), 330-333.

Martin, E. (1994) Reflections on teaching with electronic technology. CAUT National Teaching Workshop, 1994.

Peat, M. (2000) On-line self-assessment materials: do these make a difference to student learning? Association for Learning Technology Journal, Issue 8.2 51-57.

Peat, M. and Franklin, S. (2002) Supporting student learning: the use of computer-based formative assessment modules British Journal of Educational Technology 33(5) 515-523.

Peat, M., Franklin, S., Lewis, A. and Sims, R. (2002) Learning human biology: student views on the usefulness of IT materials in an integrated curriculum. Australian Journal of Educational Technology 18(2), 255-274.

Peat, M., Franklin, S. and Mackay-Wood, R. (1997) The development of self-assessment modules: Use of tailor-made templates. In Virtual Conference on Computers in University Biology Education 1997 (CUBE97) http://www.liv.ac.uk/ctibiol/vCUBE97/html/rob_mackay-wood (verified 29 November 2002 at http://science.uniserve.edu.au/mirror/vCUBE97/html/rob_mackay-wood.html).

Quentin-Baxter, M. and Dewhurst, D. (1992) An interactive computer-based alternative to performing a rat dissection in the classroom Journal of Biological Education 26, 27-33.

Strauss, R. T. and Kinzie, M. B. (1991) Hi-Tech Alternatives to Dissection American Biology Teacher 53, 154-158.

Wilson, A. (1996) Multimedia Maclabs Education in Chemistry 33(5), 134-136.

Wilson, A. and Cavallari, B. (1995) Ozchem: an Australian Chemistry Laboratory Simulation Active Learning 3, 45-50.

Wheeler, A. G. (1993) Justifying the dissection of animals in biology teaching Australian Science Teachers Journal 39, 30-35.

ZDNet UK (2002) UK home Internet usage levels off http://news.zdnet.co.uk/story/ (verified 29 November 2002).

Dr Sue Franklin,
School of Biological Sciences, F07,
The University of Sydney,
NSW 2006,
AUSTRALIA.
Email : sue@bio.usyd.edu.au

Associate Professor Mary Peat,
School of Biological Sciences, F07,
The University of Sydney,
NSW 2006,
AUSTRALIA.
Email : maryp@bio.usyd.edu.au