HUMAN TISSUE

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A Neglected Experimental Resource
Introduction

The use of animals in medical research presents doctors with a serious problem: are the results valid for their human patients? The difficulties arise because people and animals are different in the way their bodies work and in their reaction to drugs. While experimenters search for the species that most closely mimics human responses, a more effective and humane approach would be to concentrate resources on methods of *direct relevance to people*. Such techniques include human population studies, clinical observation of patients, work with healthy volunteers and test tube experiments with human tissues. Test tube, or *in vitro* studies enable cells to be kept alive outside the body and in some cases cultured to allow continuous growth. At present, most *in vitro* experiments utilize tissues from animals killed for the purpose but with the constant risk of misleading predictions, more could be achieved using material of *human* origin. Tissue can be obtained from healthy volunteers, during therapeutic operations or from autopsy specimens, and can be kept in cold storage until required. As the following examples show, it could save many animals in medical science, drug research, toxicity testing and in the production of biological products.
Medical Research

One area where there is certainly no shortage of human tissue for study is cancer research. The differences between artificially induced cancers in laboratory animals and the naturally arising disorder in people are widely recognized and have led British cancer researchers Dendy and Meldrum to suggest that investigation of tumor cell properties "must concentrate more on the diverse nature of human tumor cells recently removed from patients and less on animal model systems."¹ A specific example reported by the Karolinska Institute in Stockholm describes how isolated tissue from human pituitary tumors continues to produce hormones just as it does in the living person. The tissue also responds in the same way when stimulated by chemicals found in the body.²

Even the spread of tumor cells (metastasis) can be studied without using animals: researchers at the US Food & Drug Administration have used human muscle tissue, normally discarded after routine surgery, as a test bed for studying the growth and spread of human cancers. The system successfully mimics the situation in the body where tumor cells proliferate, spread and invade the surrounding tissues, and also provides a means of testing new anticancer treatments.³

Animal ‘model' of cancer: "...while conflicting animal tests have often delayed and hampered advances in the war on cancer, they have never produced a single substantial advance either in the prevention or treatment of human cancer."
Dr Irwin Bross, Roswell Park Memorial Institute for Cancer Research, 1981.
The link between smoking and lung cancer was first revealed through human population studies but attempts to duplicate the effect by forcing laboratory animals to inhale the smoke have generally failed. In fact the harmful effects of individual chemicals present in tobacco smoke can be investigated without resort to animal experiments. In 1968 studies with human bronchial tissue led Britain's Strangeway Research Laboratory in Cambridge to conclude that, "hydrocarbons in cigarette smoke play an essential role in the development of human lung cancer." Today, the Karolinska Institute uses human bronchial cells to study lung toxicity and cancer-inducing properties of chemicals in tobacco smoke and car exhaust emissions.

Forcing animals to inhale tobacco smoke failed to induce lung cancer. This delayed health warnings, costing thousands of lives. Human tissue studies avoid the suffering as well as the misleading results.

Biopsy samples from patients with neuromuscular diseases like muscular dystrophy have been suggested as a means of studying the defects of neuromuscular transmission. Using the human tissue samples researchers at Britain's Newcastle General Hospital have obtained a working nerve-muscle preparation allowing studies of the chemical and physiological processes involved, and how they are disrupted in disease.

Osteoarthritis and low back pain are common conditions that have led to much research into the structure and function of articular cartilage and the intervertebral disc. Most investigations have relied on animals or their tissues but there are species differences which could invalidate results. A different approach has been taken by Professor Bayliss and his team at London's Kennedy Institute of Rheumatology. Using human articular cartilage and intervertebral disc from patients, Bayliss argues that, "such systems could be used to gather information about drug
action or to study biochemical factors in early stages of disease without resort to animal models." Nevertheless he notes that "very few attempts have been made to use human cartilage as an alternative to animals."

Epilepsy is another area of research that has relied heavily on animal experiments. While there are numerous "animal models" of epilepsy, none accurately reproduces the clinical disorder, and results vary depending on the model chosen. A more relevant approach is to supplement clinical observations of epileptic patients with studies on brain tissues obtained during therapeutic neurosurgery. For instance, researchers at the National Institutes of Health in Bethesda and the University of Tennessee Center for the Health Sciences, have studied the chemical basis of seizures in patients using tissue removed surgically during treatment for intractable epilepsy.

**Low back pain:**
Research into this common and disabling problem promises much through work with human tissues.

Not surprisingly, artificially-induced epilepsy in animals does not accurately mimic the human condition. Helping these patients demands the sophistication of human-based approaches.
Tissues from the same source are also being used to investigate how chemicals in the brain transmit signals between nerve cells and thereby control their function. Tissue from rodents has traditionally been used for the purpose and it was assumed that results would be similar in the human brain. However, marked species differences have now come to light, prompting some researchers to explore the use of human brain tissue. Thin slices of tissue are used to investigate the electrophysiological and pharmacological properties of human cerebral cortical neurons, and according to David McCormick of Yale University’s School of Medicine, the advantages are many:

"... it overcomes potential species differences; it allows direct study of the cellular basis of numerous neurological disorders; and it decreases the number of animals required."

Research with human brain tissue.

The use of human brain tissue in the study of neurological disease is likely to yield many new insights and was the method by which the chemical imbalance in Parkinson’s Disease was discovered. In 1960 Ehringer and Hornykiewicz found that patients with Parkinson’s Disease had depleted levels of a chemical called dopamine in those regions of the brain most affected by the illness. This led to the successful use of L-dopa, a drug converted to dopamine in the brain, thereby making up the deficiency.
Drug Research

A major change in the strategy by which the National Cancer Institute (NCI) searches for new anticancer drugs was recently announced. The NCI traditionally relied on mice, in which leukemia had been induced, to screen around 10,000 chemical substances a year. But it has been admitted that such an approach has not identified new drug candidates with particularly promising activity against any of the major cancers, including lung, colorectal, breast and prostate. In the new system, the animals have been replaced by test tube studies with human cancer cells, at least in preliminary tests: drugs successful at this stage still proceed to further animal experiments. Other researchers argue this could be misleading and believe only human cancer tissue should be used to test the effectiveness of new drugs. Dr Sydney Salmon of the University of Arizona argues that the best means of assessing drugs successful in human tissue tests is not to carry out potentially misleading experiments on animals ("... inactivity in the mouse would not mean that a drug would be inactive in man") but to submit them for clinical trial in cancer patients. Although the NCI's initiative is to be welcomed, it was over 30 years ago, in 1956, that Eagle and Foley first showed that human cancer cells could be used to test new anticancer drugs.

Apart from searching for new drugs, human cancer tissue can also be used to identify which combination of existing remedies is most effective for individual patients. To do this, cancer cells are taken from patients and their sensitivity to drugs and radiation tested in vitro. The technique ensures that patients are less likely to be exposed to treatments that do not work.

Because AIDS is a uniquely human disease, scientists have been forced to rely on human cell tests to identify new treatments. Clinical observation of AIDS patients has shown how the HIV virus works, enabling a simple in vitro test to be developed.
The AIDS virus disrupts growth of the T4 lymphocyte, a cell crucial in regulating the body’s defense mechanism. The beneficial effects of new drugs are therefore easily assessed by adding them to test tube cultures of the T-cells to see if they prevent damage caused by the virus.\textsuperscript{16}

Researchers argue that sufficient \textit{in vitro} techniques exist so that almost any useful drug effect can be predicted without using living animals.\textsuperscript{17} Such tests utilize cells, tissues and enzymes from the body and while in many cases these originate from animals, the potential exists for human material to be used instead. For instance, a variety of \textit{in vitro} tests can be used to detect new immunosuppressive drugs to prevent rejection of transplanted organs. But while some of these tests do indeed employ human cells (human blood lymphocytes in this case), others still rely on tissue from animals.\textsuperscript{18}

A further aspect of drug research is pharmacology where scientists study exactly how drugs and naturally occurring body substances exert their effects on the tissues. An understanding of the chemical processes involved can be valuable in providing a more rational basis for the design of new drug treatments. Traditionally, pharmacologists have relied mainly on animals despite numerous contradictory results. Acetylcholine, a chemical released by nerve endings, produces entirely the opposite effect in animals: according to experiments with dogs, acetylcholine was widely believed to dilate coronary arteries, but in human coronary tissue it actually caused a narrowing of the vessels which is thought to result in heart spasm in a living person.\textsuperscript{19}
Considerable species differences also exist in the action of naturally occurring body chemicals on blood vessels in the brain: noradrenaline contracts human cerebral vessels but has no such effect on similar vessels from cows while human cerebral basilar arteries are relaxed by bradykinin whereas dog basilar arteries are contracted. Further species variations have been reported with natural substances called leukotrienes (LT). LTC4 and LTD4 constrict guinea pig skin blood vessels but dilate human and pig skin blood vessels. And the prostaglandins (PG), a family of substances discovered over 50 years ago in human seminal fluid, show considerable differences in cardiovascular responses between the species: in heart tissue from cats and rabbits, PGE1 has no effect on contractile force or in heart rate but increases them in rats, guinea pigs and chickens.

These examples highlight the dangers of animal-based research but as Else Muller-Schweinitzer of the pharmaceutical company Sandoz has explained, "Despite the limited relevance for human pharmacology of most of the animal tissues, the use of human material in pharmacological studies is still the exception rather than the rule."
Fortunately, some researchers are beginning to recognize that animal experiments have serious limitations. In 1987 the scientific journal *Trends in Pharmacological Sciences* stated that "direct extrapolation from animals to humans is frequently invalid" and noted that "recently much interest has focused on use of human autopsy or biopsy tissue as a means of overcoming these limitations." An example is the use of diseased human heart muscle preparations from patients who have died. Researchers at Hamburg's Universitat-Krankenhaus Eppendorf and the Universitat Munchen argue that such tissue is useful in evaluating certain heart drugs and may also provide new insights into the nature of heart disease. The preference for human cardiac tissue is shared by scientists at Stanford University and the School of Medicine at the University of Utah who have studied the chemical changes that occur in cardiac tissue during heart failure. Only human material can provide accurate results because of species differences in the type and proportion of the all-important tissue chemicals known as receptors.

It has even proved possible to study beating human heart cells. Researchers from the Children's Hospital of Winnipeg and the Department of Pediatrics at the University of Manitoba state that "although numerous in vitro studies have been done on beating cardiac tissue and cells from experimental animals, there has been a surprising paucity of similar work with human material." During chromosome studies with tissue from early human spontaneous abortions, they found isolated heart cells maintaining a rhythmic beat in tissue culture. Pulsation continued for up to 88 days allowing heart drugs and body chemicals to be tested for their effects. As expected from their action in a living person, adrenaline increased pulsation rate while addition of the heart drug propranolol slowed the rate.

Pharmacologists have used many other human tissues for their research. Professor Schror of the University of Dusseldorf and Raphaela Verheggen at the University of Gottingen argue that human cerebral blood vessels, obtained within 24 hours of death, provide a valuable means of studying cerebral vasospasm, a condition in which blood
vessels in the brain constrict, with fatal results for patients with subarachnoid hemorrhage. Little is known about how to treat cerebral vasospasm because the underlying chemical processes are poorly understood. The German researchers refer to considerable species variations in animal models and conclude that much needed improvements in treatment can be expected from human tissue studies. Another example is the use of lung tissue to investigate asthma and related conditions. The tissue is obtained from patients undergoing surgery for lung disease. When treated with the bronchodilator drugs used to treat asthma, the tissue is "relaxed" as would be expected in patients receiving treatment. On the other hand, bronchoconstrictor drugs make the tissue constrict.

**Toxicity Tests**

A former Director of the Wellcome Research Laboratories has stated that "the unsatisfactoriness of predicting adverse effects in humans from animal experiments has been known for a long time" while the *Lancet* medical journal acknowledges that "animal tests are very imperfect indicators of human toxicity." Most drug side-effects occurring in people undergoing treatment cannot be correctly predicted by animal experiments so it is not surprising that the great majority of drugs found safe and effective on the basis of animal tests fail during clinical trials with volunteers and patients. While such trials are the most reliable test of a new medicine, some preliminary testing is essential to identify and reject the most toxic substances. It is here that *in vitro* studies with human cell promise better protection than experiments on animals.

The idea that a combination of *in vitro* tests would allow the general toxicity of chemicals to be correctly predicted, is a basic assumption behind a multicenter trial initiated during 1987 by the Scandinavian Society for Cell Toxicology. The research aims to find exactly which combination of *in vitro* cell systems best predicts lethal doses of chemicals in human beings. Although many of the cell systems derive from animals, a human-oriented approach is possible. Indeed, while introducing a workshop
Medical research using human tissues: Many approaches could be utilized to benefit human medicine and save many animals from needless suffering and death.

1. Cerebral blood vessels
2. Brain tissue
3. Bronchus
4. Lung
5. Intervertebral discs
6. Spleen
7. Kidney
8. Skin
9. Lymph nodes, found throughout the body
10. Placenta after childbirth
11. Blood
12. Nerve cells
13. Human muscle tissue
14. Varicose veins
15. Bone marrow
16. Articular cartilage
17. Intestines
18. Liver
19. Coronary tissue Heart muscles
20. Breast & mammary cells
21. Tonsils
22. Pituitary gland
23. Eyes
24. Human cancer cells throughout the body
on the application of tissue culture in toxicology, Dr. Zucco of Italy's National Council of Research explained how the problem of extrapolating data from animals to people could be bypassed with the use of human cell cultures, in effect allowing us "to carry out studies on our species directly." For instance, in tests carried out at Denmark's Roskilde University Center, the lethal concentration of chemicals to cultures of human blood lymphocytes showed "very good correlation" with their reported lethal doses in people. The lymphocytes were obtained from a volunteer's blood sample.

Such in vitro studies are valuable in assessing overall toxicity but a more sophisticated approach would be to carry out additional tests with tissues from organs most commonly damaged during drug treatment, such as the liver, kidney, blood and skin. For instance, some drugs damage the bone marrow producing fatal blood diseases; but scientists at Britain's Lister Hospital in Hertfordshire have recommended the use of human bone marrow cultures to detect hazardous products before they reach clinical trials. They conclude that,

"any in vitro method using human tissue gives a degree of reassurance not provided ... by animal experiments".

The technique can detect chloramphenicol, an antibiotic known from clinical experience to cause the fatal blood disorder aplastic anaemia. Chloramphenicol was thought to be safe after experiments on animals.

In another example, researchers have proposed the use of human kidney tissue to study the damaging effects of aminoglycoside antibiotics. These drugs are known to cause kidney problems in a substantial number of patients and tests with human tissue correctly identified the antibiotics that were most toxic in clinical practice. The results give confidence that human kidney tissue could accurately predict the harmful effects of entirely new drugs. Other scientists have suggested human cell tests to identify drugs which damage the fetus, while human blood lymphocytes have been recommended as one way of detecting mutagens and cancer-causing chemicals.
A recent initiative by Organogenesis Inc. of Cambridge Massachusetts, is the production of living organ equivalents from human cells. Known as TESTORGANS, they are intended to promote extended organ-like function in vitro for use in studying the effects of pharmaceuticals, pesticides, cosmetics, detergents and other substances on human organ systems. By 1989 TESTORGANS included TESTSKIN, TESTLUNG, TESTINTESTINE and a living artery equivalent test system. Organogenesis believes that its test organ systems will have applications not only in toxicity testing but in other areas such as investigating how drugs can be delivered through the skin, wound healing research and the study of specific diseases like psoriasis and atherosclerosis. The company's most developed product is TESTSKIN, a full-thickness skin replacement consisting of two layers - a living dermal layer and a multi-layered epidermis. Unfortunately, part of the skin model is currently built up on collagen of bovine origin. TESTSKIN is already being used by some cosmetic companies.

Another company, the La Jolla-based Marrow Tech Inc. in California, has recently developed complete culture systems for human bone marrow, liver, oral mucosa and skin for in vitro safety tests. In the case of the human skin model, the different layers of cells which form normal skin are placed in layers on a nylon mesh producing a full-thickness skin equivalent. Unlike the Organogenesis product, no collagen extracted from another species is used to form Marrow Tech's simulated skin product.
The company feels that its skin equivalent will be useful in detecting potential skin irritants. This would be a considerable advance over the traditional use of animals who are widely acknowledged as poor models for human skin tests.

With their obvious advantage in overcoming species variations, the potential of human tissue tests should have been appreciated long ago. Yet only a handful of researchers appear to have recognized their importance: for instance, in 1952 Britain's Industrial Medicine and Burns Research Unit at Birmingham's Accident Hospital was using cultures of human skin to assess the relative toxicity of antibiotics; in 1962 researchers using human bone marrow cells predicted that griseofulvin, an antibiotic, might damage the blood, a finding subsequently confirmed by clinical experience; in 1966 scientists were comparing the toxic effects of various anaesthetics on human liver cells and three years later they reported similar studies with kidney tissue; and in 1971 Lash and Saxen showed how human cells could be used to investigate the harmful effects of thalidomide.

Today, the overwhelming emphasis is still on animal experiments and even those using in vitro techniques rely on laboratory rats: intelligent, sensitive, relatively cheap, and known to metabolize most substances quite differently than humans.
heavily on animal cells rather than human tissues: at the 7th Scandinavian Society for Cell Toxicology Congress held in Denmark in 1989, only three of the 18 papers studying the toxicity of chemicals to people actually employed human cells. Most of the remainder used tissues from rats and mice.

There is another area of toxicity testing where scientists have been equally reluctant to use human cells. Sometimes chemicals only become hazardous when metabolized, or broken down, in the liver, so researchers often include liver cells in their in vitro tests to mimic the body's main metabolic reactions. The Ames bacterial test, which is designed to identify mutagens and cancer-causing chemicals, routinely includes cells from the rat's liver. Yet common sense would demand the use of human liver cells since differences in metabolism between rats and people are known to be the rule rather than the exception. Differences even occur between different rodent species as discovered during an investigation of 74 chemicals by the Edinburgh-based contract laboratory Inveresk Research International. Each substance was assessed for mutagenicity by in vitro bacterial tests incorporating liver cells from either rats, mice or hamsters. "Marked differences" in metabolism between the species were found, suggesting that reliance on animal tissues might fail to identify some mutagens.

As long ago as 1982, Britain's Guidelines for the Testing of Chemicals for Toxicity stated that,

".. in the assessment of risk to man there are obvious theoretical advantages in the use of [a liver cell mixture] prepared from human tissues, which may differ from tissues prepared from rats . . . in their ability to activate or detoxify chemicals."

Nevertheless, a survey of papers published by the scientific journal Mutagenesis during 1989 showed that in nearly every in vitro test where liver cells had been added to metabolize test chemicals, the tissue had originated from rats or hamsters.

Production of Biological Products

1) Antibodies and Monoclonal Antibodies.
A healthy body deals with the threat of invading bacteria,
viruses and other foreign substances by producing antibodies. These essential body chemicals seek out and form a close bond with the invading organisms as a prerequisite to their ultimate elimination. Apart from defending the body against attack, antibodies have been much used for basic research into the immune system and as a means of measuring the concentration of small amounts of substances. For such analytical purposes antibodies have traditionally been produced by injecting animals with the substance under investigation. Blood samples are later taken and contain antibodies that can be used to identify and measure the substance originally injected. But occasional scientific reports show that antibodies can be produced in vitro. In 1974, researchers at Japan's Osaka University Medical School described how human tonsil tissue could be used to produce antibodies in response to foreign substances. The tissue is obtained from therapeutic tonsillectomy:

"Since it is very easy to obtain large numbers of human lymphocytes from tonsils and they contain complete sets of cells necessary for antibody formation in vitro, tonsil lymphocytes could be very useful for the investigation of the immunologic phenomena in humans."

Recently there has been great interest in monoclonal antibodies. It is in the nature of cancer cells to reproduce themselves indefinitely but this can be turned to advantage by combining them with other cells which produce antibodies. The combined cell system is called a hybridoma and continues to produce antibodies indefinitely. Since the antibodies are of the same type and come from the same original cell, they are called monoclonal antibodies.

Although the two cell types that form the hybridoma often originate from animals, there are advantages in using human tissues. This is because monoclonal antibodies may have therapeutic applications in addition to their more familiar diagnostic role. Used therapeutically, monoclonal antibodies are administered to people, and if derived from animals, present a high risk of allergic reactions. Symptoms include fever, rashes, vomiting, rapid heart beat and difficulty breathing. Furthermore the human body sees
them as "invaders" and acts to reduce their effectiveness. The solution is to develop monoclonal antibodies entirely of human origin: in other words human cancer cells would be linked to human antibody forming cells.

The requirement for human antibody forming cells has given scientists the incentive to produce antibodies in vitro because the traditional method of antibody production - the deliberate injection of foreign substances into a living being - would be regarded as unethical in people. Tonsils, spleens and lymph nodes, obtained surgically, are valuable sources of lymphocytes which can be used to produce human antibodies in vitro. But by far the most convenient source of lymphocytes is human blood.48

A possible therapeutic application of monoclonal antibodies is in cancer research where they may have value as a less toxic form of treatment. Researchers at Japan's Kyushu University and the National Kyushu Cancer Center Hospital have produced human monoclonal antibodies that lock onto breast cancer cells in sick patients. In this case the hybridoma was made up of lymphocytes from the lymph nodes of breast cancer patients and from human cancer cells.49

2) Vaccine Production
Vaccines against diseases caused by viruses have traditionally been made from animals or their tissues but this can be dangerous as contaminants from animal tissues have produced fatal results in people.50 Furthermore, cancer-causing viruses have been found in cells from primates, dogs, chicks and ducks which are used in the preparation of vaccines. The cancer-causing viruses such as SV40 which contaminate tissue from primates only become dangerous when they cross the species barrier,50 so the use of human cells to make human viral vaccines would seem the safest approach. Today, vaccines for many viral diseases such as polio, rubella, measles, mumps, smallpox, rabies and diseases caused by arboviruses such as yellow fever, can all be produced from test tube cultures of human cells.
Indeed, scientists suspect that monkeys may be the origin of the human epidemic of AIDS. Writing in the science journal *Nature*, Drs. Sergio Giunta and Giuseppe Groppa of the INRCA Clinical Laboratory in Ancena, Italy, ask whether the transfer of a monkey virus to humans could be linked with the beginning in the 1950s of a massive trade in primates from Africa to Western countries for virus research and studies into the production and control of polio vaccines. In their view, such events inevitably involved more contact between the human population and the monkeys they captured and transported.52

In Britain, polio vaccine is made from human diploid cells by the Wellcome Research Laboratories yet despite the risks of contamination, primates are still widely used for the purpose in other countries.53

**Source of Human Tissue**

While most human tissues for research and testing can be obtained from volunteers, biopsies, surgical operations and post mortem samples, a much neglected source is the
normally discarded human placenta. Many studies of placental structure and function continue to use animals but as Joseph Dancis of the New York University School of Medicine has explained, "of all mammalian organs, the placenta shows the greatest variation in structure among the species ... One cannot be confident that an observation made with animal placenta is pertinent to the human, unless it is tested in the human." The placenta may have other important applications. Since it comes from the same single fertilized human egg as the baby, it can almost be seen as a scaled-down human being. Testing the action of drugs on placental biochemistry could therefore eliminate many tests currently performed on animals. Soli Contractor of London's Charing Cross and Westminster Medical School argues that:

"The human placenta has enormous potential for studying metabolic processes without recourse to animal experimentation. Its greatest advantage lies in eliminating the necessity for extrapolating results from animal experiments and trying to interpret them in terms of the human situation."55

The placenta contains tiny vessels and has been suggested by surgeons at Britain's Frenchay Hospital in Bristol as an alternative to animals for practicing microsurgery.56

In many cases it is advantageous for human cells to be cultured to allow their continuous growth. Such "tissue cultures" allow researchers to increase the number of cells available for study. It also enables the effect of drugs on

Placenta: Not only valuable as a source of tissue for research, but a viable alternative to animals for practicing microsurgery.
cell growth to be monitored, providing scientists with a measure of toxicity. To enable cells to grow effectively, they are kept in a nutrient medium usually derived from fetal calf serum. But there may often be advantages in using synthetic growth media where the exact composition of nutrients is known, or indeed human sera. Researchers at the University of British Columbia compared the growth of human breast cancer cells incubated with either human or fetal calf sera. As might be anticipated, they found that use of human serum most closely resembled the clinical situation not only in the growth of cancer cells but also their sensitivity to chemotherapeutic drugs. The results have important implications for the development of anticancer drugs.

Why is human tissue so little used?

Despite anticipated savings in the cost of animals and their housing, the use of human tissue is very much a neglected experimental resource. The reason usually cited is difficulty in obtaining regular supplies of human material. Furthermore some tissues must be used quickly if they are to produce useful results. An example is cerebral blood vessels which must be used with 24 hours of death. Placenta also need to be collected quickly after childbirth and Soli Contractor of the Charing Cross and Westminster Medical School notes that "one needs to establish a considerable rapport with the midwives and the clinical staff, without whose help and interest the work would not be possible." Taking the time to develop good working contacts with surgeons and other hospital staff is surely worthwhile, bearing in mind the greater relevance of human tissue studies. By sacrificing accuracy for the greater "convenience" of animal experiments, scientists do medicine a disservice. In any case many human tissues can be successfully preserved by storage at very low temperatures.

A greater willingness to leave parts of our bodies for medical research and a well organized system of tissue storage would leave experimenters little excuse for continued reliance on animals. Prof. Corwin Hansch, an expert in drug design, has stated,
"No laboratory animal will ever be a completely satisfactory substitute for the human system and the time will come when we shall stop wasting the enormously valuable enzymes and organelles of the dead and instead put these to use to understand the living human being better." 

Conclusion

The astonishing neglect of human tissue for research and testing reflects poorly on the scientific community and illustrates a widespread disregard for the suffering and death inseparable from animal research. The overwhelming advantage of human tissue studies is their relevance: compared to this, the continued use of animals must be regarded as bad science. As human tissue researcher Maurice Panigel of the University of Paris has pointed out,

"Whenever human material becomes available for research in satisfactory condition and without danger to the patient, it should be preferred to any animal living material."
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