ETHICS IN AGRICULTURE - AN AFRICAN PERSPECTIVE

Edited by
Alvin van Niekerk

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Preface

This book is intended for a wide audience. It is hoped that students, lecturers, advisors, policy-makers, politicians and the general lay-person will find the book useful, stimulating and above all, enlightening. Furthermore, it is hoped that many of the myths and misconceptions that abound in the various topics discussed in this book, will be removed, or at the very least, explained in simple terms. It is not surprising that the general lay-person is sceptical of biotechnology when much of the discussion and literature on this topic is shrouded in controversy. If this book provides simple, logical explanations to some of the areas of confusion, then it has been successful.

Acknowledgements

Firstly, I would like to thank all the contributing authors for their significant contributions without which this book would not have been possible. That they contributed their time, effort and ideas so willingly and without any financial reward is testimony to their dedication to the fields within which they operate.

Secondly, credit must go to Professor Ben Parker of the Ethics Centre at the University of KwaZulu-Natal who originally suggested that a book of this kind was necessary and that it could make an important contribution to agriculture and ethics.

Thirdly, I would like to thank Alison van Niekerk, who was forced to use all her editing skills in ensuring that the book is as free from grammatical errors as possible. She also made valuable suggestions towards making the book more readable for the general lay-person.

Introduction

AGRICULTURE AND ETHICS – PERCEPTIONS AND RESPONSIBILITIES

Alvin van Niekerk

Agriculture has been an integral part of the social and economic structures of African peoples for hundreds of years. In many African countries, agriculture is still the most important livelihood. For millions of people it is all that keeps them alive. It is therefore, one of Africa's saddest ironies that, on a continent where agriculture is as old as the oldest civilization, so many people still suffer from hunger. In the southern African region alone, approximately 13 million people face starvation every day. Africa is not unique. Of the approximately six billion people that inhabit the earth, 800 million people live on the starvation threshold and 1.3 billion live below the poverty line. What makes this figure even more tragic is that sufficient food to feed 9 billion people is produced worldwide annually. What is the problem? Why can we not achieve a fundamental human right – the right to sufficient and safe food? The objectives of this book are to explore some of the ethical issues that are intricately woven into agriculture and food production rather than to attempt to provide the answers to the logistical reasons for this worldwide tragedy. Ethical issues often do not command the same discussion priority as production issues when it comes to agriculture and food production and yet, in many instances, they lie at the very heart of the problems that mankind faces today. Even more importantly, ethical issues should be relatively easy to address; they merely require a mind-shift. Therein lies the problem.

Rural, poor people are particularly susceptible to the changing face of agriculture. According to the Food and Agriculture Organization (FAO), "Most societies were once structured so that, even though many people were

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poor, most had access to sufficient food to ensure their survival. Social, economic and technological changes have since eroded the traditional "safety nets", and ties to the land have been weakened or severed, making it difficult or impossible for the poor to grow their own food" (FAO, 2001). In many cases, the changing agricultural situation has resulted in limited access to land, water, fuelwood and other basic amenities. This scenario is common throughout Africa and indeed throughout many parts of the world. Inadequate nutritional diets facilitate and often increase the incidence of disease and sickness in rural populations by lowering immunity and reducing a person's ability to fight infections. Consequently, not only do many rural, poor people face starvation every day, but disease, sickness and premature death have become an inevitable and accepted part of their lives.

One of the most devastating diseases of modern times is HIV/AIDS. Whilst some politicians and scientists may debate the cause of HIV/AIDS, there is little doubt that rural, poor people are particularly susceptible and in areas where food security is tenuous the spread of HIV/AIDS is accelerated. When one considers that 54% of the global population, 67% of sub-Sahara's people and 72% of the south Asian population live in rural areas one begins to appreciate the potential size of the problem when these people live below the poverty line. The current estimate is that 42 million people are HIV infected throughout the world. Never in the history of mankind have we been faced with a pandemic of such magnitude. Whilst the suffering and death associated with HIV/AIDS is horrific, the perception of the syndrome amongst general laypeople is equally horrific. Myths about HIV/AIDS abound. For instance, for a long time the syndrome was regarded as being confined almost exclusively to homosexuals. It was also thought possible that one could contract HIV/AIDS merely by touching an infected person. One of the more horrific myths is the notion, within certain cultures, that HIV/AIDS can be cured by having intercourse with a virgin. This perception has resulted in babies often being molested with the most cruel results. Many more perceptions abound but the predominant consequence of all the myths is that HIV/AIDS sufferers are largely shunned by society. Whilst HIV/AIDS campaigners have sought to educate the general public, and in many cases have been successful, the truth is that many people still distance themselves from HIV/AIDS infected people wherever possible. Professor Coovadia in the Chapter on HIV/AIDS makes the point strongly that …"HIV/AIDS is a pervasive disease and that nothing that we do or live by, will remain unaffected by it". It is therefore everyone's responsibility to understand the syndrome, how it affects our lives and what role we can play in reducing its devastating effects on our society.

Another aspect that dominates the lives of people in Africa, and indeed in many other parts of the world, is the right to land. It could be argued that equitable access to land is, once again, a fundamental human right. What cannot be argued is that access to land is central to agricultural production. It is therefore not surprising that this has become a highly politicised, emotive topic, particularly in the southern African region. In South Africa, during the apartheid years, thousands of people were displaced and moved from land that had been their ancestral right for hundreds of years. This political blunder created hardships, resentment, turmoil and ultimately denied traditional people the right to ply their trade as agriculturalists. Today we are paying a heavy price for the apartheid land policies. The question of land redistribution and land restitution today dominate discussion in agricultural circles. In his discussion of the land-related issues in southern Africa, Dr Taljaard highlights the complexities of land redistribution and restitution. Policies are now in place to try and correct the mistakes of the past, but the road to providing adequate land to those who wish to return to their roots is a rocky one and fraught with many problems. The complexity of the problem is substantial and the economic cost to the country is staggering. All those involved in this process must however persist in a consistent and just manner with their efforts; failure to adequately address the land issues in South Africa could potentially result in increased conflict and eventually anarchy. The land issues and resulting turmoil in Zimbabwe, just north of South Africa's borders should, hopefully, serve as a reminder to all those involved in land-related issues of the need to proceed in these delicate matters in a just and orderly way.

The next issue discussed in this book relates to biodiversity conservation and also includes a section on medicinal plants. Professor Samways describes biodiversity as "the variety of life". Furthermore, he (Samways) makes the point that "It (biodiversity) is the natural, intrinsic, biotic capital of the earth. It is also the base for our food and is fundamental for all aspects of our welfare and survival". This viewpoint was echoed during discussions on the 5th of June 1992, at the Earth Summit in Rio de Janeiro, where more than 150 states signed the Convention on Biological Diversity. The most important consequence of the signing of this document was, not only the acknowledgement of the need to manage the world's living resources in an efficient and sustainable way, but the commitment of all the signatories to address the issues collectively. The treaty outlines an holistic approach to the conservation and sustainable use of the Earth's entire wealth of living organisms. Agriculture is often deemed to be the main culprit in reducing biodiversity in many parts of the world. It is against this background that the ethical issues associated with agriculture and biodiversity are examined.

There is general agreement that the signing of the Rio treaty was a milestone in the conservation of biodiversity, but the major victory will be putting policy into practice by all those concerned with environmental issues and sustainable development. Our grandchildren will one day testify to our success or failure in this regard.

The section on medicinal plants examines the ethical, economic and legal issues affecting traditional medicine, as practiced by many of Africa's people, and Western biomedicine. Particular attention is drawn to the fact that traditional medicine adopts an holistic approach where medical, psychological and cultural factors are all important in treating the patient. The role of medicinal plants has always been central to the treatment of people in traditional medicine. However, with the industry growing at a rapid pace and the need for sustainable harvesting of plants and other traditional ingredients, bioprospecting has become the preferred term. Bioprospecting is often linked to the conservation of biological diversity, but at present remains a controversial topic. The discussion highlights the economic value of harvesting medicinal plants and the vulnerability of certain plants due to overexploitation.

Animal rights and animal welfare are two topics that often draw vociferous debate, not only by agriculturalists, but also within certain sectors of the public. Many of the debates emanate more from an emotional involvement with animals and their welfare and less because of the importance of any symbiotic relationships that may have existed between animal and man for centuries. Animal experimentation conducted exclusively to satisfy the vanity of affluent segments of the world population has done nothing to allay the fears of people concerned with animal rights and animal welfare. Conversely, there can be little doubt that medical science in particular, has made significant strides in perfecting certain procedures and finding cures largely as a result of animal experimentation. The question is always posed: could these advances, which are beneficial to mankind, not have been secured by other means? It is this type of ethical question that needs to be uppermost in the minds of scientists and administrators involved with animal research. There is often a poor understanding of the difference between animal rights and animal welfare. The ethical views that often surround these two issues are discussed in the Chapter on Animal Rights and Animal Welfare by Professor Coetzer and Professor Goldring. Professors Coetzer and Goldring correctly raise the important ethical issue as to whether animals actually have rights. For many people there is no definitive answer to this question; responses are highly dependant on how one views animals and their role in a world dominated by

mankind. Situations vary between competition between man and animal to situations where there is a total reliance by one upon the other. However, certain key elements need to be appreciated in order for the debate to have some substance. For instance, animals are generally considered to be sentient beings, *i.e.* they are conscious and feeling creatures. Recognition of these two traits should ring ethical bells regarding the treatment of such animals. The aforementioned statement reflects a general western principle and outlook. Other cultures would not necessarily attach the same ethical value to animals. In fact, in many rural areas animals have a value only in terms of their value as a source of food or, alternatively, a monetary value.

The chapter on agricultural biotechnology by Professor Fossey is divided into two sections with plant biotechnology and animal biotechnology being discussed separately although the two topics share many common issues. Both aspects have controversial elements, as is the case with animal rights and welfare, that are hotly debated in agricultural, academic and political circles. The general public have also shown keen interest in, not only those aspects that directly affect their quality of life, such as genetically engineered food, but many of the ethical issues that have become highly emotive such as human and animal cloning. The objectives of this chapter are to present a balanced viewpoint regarding some of these highly emotive issues by outlining the scientific procedures involved, wherever possible, in a way that is simplistic and understandable for the layperson, whilst also discussing the ethical, legal and economic consequences of biotechnology.

Many of the highly emotive public debates spiral out of control primarily because the debate is based on poor or incorrect information. This is not always the fault of the debaters, but often due to the manufacturers or developers providing the public with insufficient information. Biotechnology is a classical example of such a debate. Negative perceptions about a particular aspect of biotechnology may retard the implementation of very useful technology simply because the layperson has been ill-informed. A good example regarding the positive use of biotechnology would be the fermentation processes involved in the making of bread, cheese, wine and beer. These processes have been in practice for hundreds of years; there is little doubt that in the minds of many people, their quality of life would be that much poorer if this technology had not been allowed to develop because it was deemed to be harmful to human health. The opposing viewpoint is however, that some developments in biotechnology **have** had questionable advantages, not only for the intended clientele, but also for the environment. For many people, certain genetically modified organisms (GMOs) fall into this category. Once again the general public is suspicious of many of these

developments simply because they have been so poorly informed and sometimes even misled by huge corporations and institutions that stand to make substantial financial gains from this form of biotechnology. The fact that much of the agricultural-related biotechnology is concentrated within the domains of a handful of huge corporations is of considerable concern for many people with an interest in agriculture and food production.

Probably the two most controversial aspects associated with agricultural biotechnology relate to food safety and the effects on the environment. Once again we find a polarization of situations that reflect the disparity between the poor and the affluent peoples of the world. Amongst the poorer people, just keeping hunger from the door is a major achievement; food safety is less of an issue when one is starving, susceptible to disease and generally living on the threshold of life. However, amongst the more affluent peoples of the world, with considerable buying power, food safety is a major issue. A healthy lifestyle has become highly desirable and in many instances such a life-style is regarded as a status symbol. Eating a nutritionally balanced diet, coupled with vigorous exercise programmes are regarded by many as a very important part of their well-being. It is with the poorer nations that potential dangers lie. Increasingly, the statement is made that hunger could be eradicated in poor rural areas by making use of new biotechnologies. Claims of increasing yields and reducing input costs are often purported to be a saviour for areas where food production cannot meet the population requirements. However, the statement is made once again; very often, people are starving not because there is a shortage of food to buy, but because of a shortage of money with which to buy food. It is therefore imperative that ethical considerations take precedence in assisting the poorer peoples of the world. If biotechnology can be used to produce food more cheaply and safely with no harm to the environment, then such biotechnology must be explored. However, this technology must be made available to the relevant governments **with no strings attached**. Some of the large corporations involved in biotechnology development have legally binding policies that significantly affect the way in which their products are used. For instance, farmers using genetically modified seed may not harvest seed generated from such plants and then use the seed for future plantings. Such a binding would be completely unacceptable to emerging farmers where the gathering of seed to generate the next crop is crucial in order for them to remain viable agriculturalists.

The last chapter deals with the effective practice of agricultural science. The discussion in this chapter by Professor Anderson is essential reading for scientists, students and the general lay-person who may be involved in

writing documents that opinions and information from a variety of sources. Too often these days people lay claim to ideas and opinions that are not their own. It is imperative that we as educators, inculcate in our students the importance or recognizing and acknowledging ideas and information that are not our own and to give the necessary credit where it is due. For many students, the difference between creating their own ideas and the use of other peoples' is sometimes blurred. Students need to be made constantly aware that far greater attention must be paid to this important aspect if they are to establish credibility in a world where the written word remains critically important.

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Chapter 1

ETHICS AND AGRICULTURE

Martin Prozesky

Just how important the world of agriculture is for all who care about strong ethical values was brought home to me very forcefully by a vivid experience some years ago. I was on sabbatical in the delightful university town of Claremont, California, undertaking research at the School of Theology. Soon after arriving I heard that the School had a Professor of Missions who had spent time as a missionary in Central Africa. This brought to my mind the usual stereotype of the zealous man of God venturing into some remote part of our continent to convert the local people to Christ. Imagine therefore my surprise and fascination when I met the Professor and found that he was by training a soil scientist and agriculturalist and not an evangelist trained in Scripture and theology. Puzzled, I asked him how he came to be a Professor of Missions.

His answer was one of those great moments of dramatic illumination that permanently change one's thinking and values. "The greatest missionary challenge today", he explained, "is not to save the soul but to save the soil and all that depends on it for survival and fulfilment. If we fail that challenge there won't be any souls around to save in the conventional sense".

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For the applied ethicist this experience is a powerful reminder of just how ethically central the world of agriculture is, combining as it does a whole range of issues and practical challenges that are critically important for us all: the soil and all that depends on it, water, plant life, the production of food, animals - both wild and domesticated, human relationships, cultural diversity, scientific knowledge, technology, the economy, religious issues, environmental considerations, employment patterns, politics and the complex, highly contested issues of land ownership and redistribution, to mention just these, many of which receive detailed treatment in other chapters of this book.

In a single chapter it is of course impossible to deal in even modest detail with the ethical issues raised by the many facets of the total agricultural enterprise. What can however be attempted is to provide some guidance about the basic nature of ethics for those who work in and with these facets, who will in all probability constitute the majority of the readers of this book, and then provide an introductory discussion of some of the applied issues that can be grouped together under the broad heading of agricultural ethics. In so doing the main aim is to help foster a deeper appreciation of the importance of ethics for successful, sustainable agriculture for if we can't husband the earth in ways that are just, participatory and sustainable, we won't husband anything else on the planet for very long, except perhaps the graveyards of our own folly.

THE NATURE OF ETHICS

The *New Oxford Dictionary of English* (1998) tells us that ethics is about the "moral principles that govern a person's behaviour" and secondly it is "the branch of knowledge that deals with moral principles". These definitions won't help us much until we know what the word moral means. The same dictionary informs us that it means "standards of behaviour which are considered good or acceptable". This is more helpful. It takes us to one of the most important words that we use in ethics - the word good (and its opposite, bad or evil). In ethics another pair of words is often used to make moral judgements – the words right and wrong. In this chapter I use these two pairs of words – good and evil, right and wrong - interchangeably.

These definitions show that in current usage, the words ethics and morality mean much the same thing insofar as human behaviour is concerned. Notice that these dictionary definitions give us no guidance about

what sorts of actions are right and good. They don't identify the *content* of morality or ethical behaviour. All they do is point to the *form* in which moral or ethical judgments are made. Note also that ethical living or morality is a feature both of individual behaviour and of society, whose values play a big part in what individuals come to value. Bearing both the personal and social aspects of morality in mind, we can now define the *form* taken by ethics as follows:

> *Morality or ethics at a personal level takes the form of an ability to discern right and wrong, good and bad or evil, and to choose in an informed way to live by what is judged right and good. At the level of society, morality is the whole phenomenon of directing behaviour by means of the distinction between right and wrong, good and bad or evil.*

But what about the content of morality, and where does it come from? Most of us got our values from parents, families and teachers. But who or what guided them? Generally speaking, society guided them, involving the whole surrounding culture made up of our schools, politics, TV, the media, sports heroes, books, the law - and the faiths and philosophies present in any given society.

In South Africa, for example, people's beliefs about right and wrong have mostly come from our traditional African religions, from the Bible, the Christian churches and their leaders, from the Hindu faith, from the Holy Qu'ran, the sacred book of Islam, from the many smaller faiths in our society and from certain non-religious systems of belief and practice. These world-views, as they are often called, all contain influential teachings about what people should value or reject, and all of them influence their members' beliefs about what is right and good, often very powerfully.

To them we must therefore turn in the first place for the content of ethics. What do we find? We actually find a great many differences in what is regarded as right or wrong. Some regard meat-eating as morally acceptable while others see it as wrong. Some applaud the death penalty as morally justified, others find it repugnant. Some allow abortion, others don't. Some regard marriage as the sole moral basis for sex, others are more liberal. Ritual slaughter of animals is a moral duty in some, while others regard all life as sacred, including the lives of animals and even insects.

In a short introduction to ethical values it is quite impossible to catalogue these differences. What can and must be done is to be aware of them and be extremely careful not to jump to the conclusion that the values of our own tradition are necessarily best, and condemn those of others. We might be tempted to want our own tradition to count more than others when there is this kind of disagreement. That was certainly how most people thought in former times and many of us still do. But under democracy this is highly problematic. One of the cardinal principles of democracy is that we all have equal rights and must be accorded equal respect. In that case, what *ethical* grounds would any of us have for insisting that our values must count more than other people's, which quite clearly treats them unequally? At a purely personal level some of us may wish to regard our own culture as morally superior to others, but a democratic society cannot do that without fatally undermining its own foundations. Instead, the usual democratic response to cultural diversity is to show equal respect to the members of each culture.

Given our history in this country, it is vital to be ethical about ethics itself. That means becoming aware of and sensitive about values we may not ourselves hold but which are important to others. In short, we need to cultivate an ethic of respect for others and to take great care lest we arrogantly assume that we occupy a higher moral plane than the members of other traditions.

Differences of moral values are thus a reality with which we must come to terms. But there is something even more important about our various ethical traditions, namely a remarkable (if little known) consensus about the most important moral values of all. Given the fact that the various ethical traditions arose and developed independently, this convergence is even more remarkable. It gives us a way of building a shared ethic and of dealing with the problem of clashes of values. If we bring the core ethical teachings from the various traditions together in relation to the democratic realities of our own time, we get something like this: *moral goodness is at heart a free and informed commitment to active concern for inclusive well-being, and against selfishness, exclusion and harm*. Well-being refers to the total condition we experience, not just bodily health and fitness and all that goes with those conditions. It includes happiness, fulfilment, friendship, opportunities for growth, safety, peace, justice and - for many of us anyway - spiritual fulfilment, whether religious or secular. To both want and work for these things for others and not just for oneself is to be ethical, according to the great moral traditions. It is a matter of balancing our natural interest in a good, enjoyable life for ourselves with real concern that others too enjoy such a life.

Let us think of this core moral principle as a summary of a set of specific core values. They include those that follow. All of them are essential, and readers are encouraged to think of others that they would also regard as essential, and to list for themselves the opposite qualities of the list below as evils that we must strive to defeat:

- Generosity and compassion.
- Inclusiveness.
- Fairness and justice.
- Truthfulness and integrity.
- Freedom.
- Respect, including self-respect.
- Effort and perseverance.
- Responsibility.

Some important traditional moral principles are absent from this list, like the prohibitions against theft, murder and adultery. They are however fully covered by values like generosity, compassion, justice and respect. The list above operates at a different and more basic level. When put into practice, those core values logically mean that we must not harm or kill others, or steal what is theirs. Readers are urged to work this sequence (from basic values to specific moral guidelines and action rules) for themselves.

ETHICS IN AGRICULTURE

As I said at the start of this chapter, agriculture is a remarkably rich field for applied ethics. Where else do questions of animal rights, business ethics, food ethics, genetically modified organisms and foods, political ethics, land ethics, crime and violence, and environmental ethics come together as they do for the farmer, the agricultural officer and the scientist? In turning now to a discussion of some key aspects of agricultural ethics in this second part of the chapter, my main point is this: *for long-term success, everything today, including agriculture, needs ethics - and ethics for its part needs agriculture.*

To explain why everything today needs ethics I must now revert to the true story with which this chapter began, concerning the Professor of Christian Missions who told me his job was not to save souls but to save soil. Where he lectured, missionary work was seen as equipping students who would, as ministers of religion, be influential and thus able to spread the

word that the world's soils were in danger of being eternally lost, and with them, life as we know it on this planet.

This story illustrates some of today's most urgent ethical challenges. Firstly, we must stop confining ethical concerns to the micro-world of individuals and extend it to the global world of macro-ethics, which includes matters like food production and distribution, land ownership, use of growth hormones in cattle and governments' agricultural policies. Next, this Professor of Missions encourages us to focus ethical effort on the needs of *this* world and *this* life because that is where the need for ethical power is now greatest. In the light of this incident, it takes no great feat of the imagination to see how important ethics is in agriculture. As an outsider to that world I am in no position to judge its moral health. This is something for insiders to do. But I can mention some of the questions insiders might ask, based on the core ethical values that were explained above: Where is there potential for creating greater benefit for humanity, and whose responsibility is it to do so? What resources do they need? Where, if anywhere, is harm being done? Whose responsibility is it to intervene appropriately - and what resources do they need?

Seen through that Professor's eyes, souls are not a sort of mysterious, gassy presence somewhere inside us that escape when we die. Soul is another name for conscience - the moral energy that drives us to climb the heights, stretch the horizons and take up the great journey that can make us noble and add true value to life on this planet. It is a journey that can begin anywhere. It is a journey we can all make. It is a journey we **must** all make.

Why must we make it? This brings me to my second story. It was told to me and others by Dr Rushworth Kidder, who directs the Institute for Global Ethics in the USA. His account is based on investigations he did into what really happened at the Chernobyl nuclear power station in the Ukraine some years ago. We all know that there was a catastrophic meltdown of a nuclear reactor, which leaked vast amounts of deadly radiation into the air, caused tragic loss of life in humans and animals, made large tracts of fertile farmland into radioactive no-go zones for generations, and caused environmental damage in other countries thousands of kilometres away.

Chernobyl is seen as the worst man-made environmental disaster in history. All this we know. But why did that reactor fail? The usual view is because of poor Soviet technology. Kidder's investigations reveal a much more disturbing real reason. In his own words, before there was a technological meltdown, there was a moral meltdown. Senior engineers at

Chernobyl - and remember that Soviet standards in physics and related forms of engineering were top-class - wanted to do an experiment of their own. It involved great and well-known dangers but they went ahead anyway, overriding several layers of safety precaution, until finally the reactor in question had been flogged to breaking-point to satisfy a few men's self-centredness.

For this, people paid with their lives. Whole towns remain abandoned. Some people are still dying. And once-productive farmland may never again yield a single mouthful of food in a world where half the total population is poor and one sixth - yes, one sixth - is utterly destitute.

The bottom line, says Kidder, is that ethics has now become a matter of human *survival*, because only the power of a strong conscience could have prevented the Chernobyl disaster and other potentially catastrophic events. Not more science, more technology, more politics - but *more conscience*, is what is needed. We therefore must equip ourselves and the younger generation with the one thing that can go with us anywhere, cross any political and religious boundary, and be there for us when the moment of fateful decision comes - and that one thing is conscience - a deep commitment to ethical living - saying no to the pull of selfishness and harm, and yes to the opportunity to extend our concern actively to others.

These two stories teach us a lesson in survival tactics. At Chernobyl, the failure of ethics has doomed the soil because the Soviets (like others even in our own country) thought that all you need to succeed is knowledge and intelligence. But on the positive side, my experience with that Professor in California shows what could happen when conscience enables us to transcend our ignoble side - and, in the agricultural sector, take up the cause of the soil and all that depends on it - and everything else that exists because if we destroy the soil we destroy everything.

This is why agriculture is so ethically important. Here we humans interact directly with the world of nature - the soil, the streams and rivers, the plant cover, the insects and animals. Scientific knowledge and agricultural practice are forms of power - highly potent forms - and power can be used for good as well as evil. It needs ethics to give good the edge over evil. In agriculture we also, obviously, interact with other people - other agriculturalists, labourers and their families. We interact with the economy - with bankers and creditors and the like; we interact with land-hungry people and with the whole complex and painful question of land rights. These are crucial matters, affecting many people very directly and very deeply. If we

want them to treat us fairly and helpfully, then we must treat them fairly and helpfully - in short, ethically.

So my argument is that agriculture needs ethics. But ethics needs agriculture - successful, sustainable agriculture - just as much. Why so? Because ethics is not just a sense of deep regret at the misfortunate of others, like injury and hunger, or at damage to the environment. It is much more than that - it is a matter of *successfully doing* something to help. Ethics must never become a losing struggle. It must win. That means that we have to make a real, practical difference to people's lives, putting food into hungry mouths, shoes on to bare feet, shirts on to backs, sustainability into nature. These things take money, time, effort and knowledge, and all of these require wealth. But all the monetary wealth in the world will fail to save us from global meltdown if we have no food, or if we beggar the soil and poison the waters, or turn life into an endless war between the haves and the have-nots.

It is thus no exaggeration to say that the quest for ethical victory - for the good life for all - begins on the soil and with the soil, and thus with those most directly connected with it.

But why should we not just be selfish and satisfy our own personal needs and wants, and those of the small number of people we really care about? The reason is this: life is a network. To exist is to exist with essential connections with other people and nature. Everything we do impacts on that surrounding reality - and everything it does impacts on us. The success and happiness we all want cannot therefore be had if we behave as if others don't matter. Like it or not, they matter. We need them and they need us.

There are, suggests Australian business leader and ethical writer Ted Scott, just two basic ways to manage this reality of our interdependence with others and theirs with us. If we are strong in some way , uncaring, or just very unwise, we can try to dominate and even bully them into giving up what we want from them. This is management by fear. It can work in the short-term - that is why we see so much of it. But it cannot ever be maximally productive and it does not work in the long term, because it makes people around us work for our downfall. It makes them pretend to like and respect us when in fact they do not and should not. It never gets their best effort because they know they are being exploited and harmed. Above all, it gives their creative intelligence every reason to find a way to defeat us. Hitler tried this path. So did Stalin. It is clear why they failed and

had to fail. Their whole approach runs against people's grain and sooner or later the exploited people hit back and topple the selfish bully.

The other option is to work with other people's well-being in mind. This approach to the world does not exclude competition. In fact it thrives on it, provided the rules are fair and we play by them. Here we look for projects where everybody can win. We work with people's freedom, respect, dignity and creativity, not against them. Is that not why democracy, which works this way, is far more stable than dictatorships?

This second option is of course the ethical one. And once we understand its logic and the way it works with human nature and with external nature all around us and not against them, we can see that ethics is in fact the passport to what we all want most - lasting well-being in stable conditions.

Let me end this part of the chapter by offering five suggestions about how to mobilize ethical power, or mobilize it better. Firstly, let us believe in ourselves as centres of creative moral power. The days are over when we could leave ethics to the saints and gurus of the world. Democracy means that power moves downward, sideways and above all inward. We all have the potential to use the powers at our disposal - powers of mind, education, land ownership, farming skill, money, time and muscle for good or for ill. There is no magic wand that will fix our ethical problems in a trice. Instead, there is the opportunity we all have to enter every day with the determination to live it generously and truthfully, rather than selfishly. When we live that way, positive influence flows from us to all whom we encounter, adding value to their lives. That makes it possible for them to return the value to those whom they meet, rather than to return greed, harm or lies.

Secondly, we must never give up. Very few of us are saints who always do the right thing. We will falter. We will even falter badly. I remember with deep admiration the strength of character of the people I have known from the agricultural and farming communities. Getting the milking done by dawn on an icy Free State morning in July when the thermometer has sunk to -15 degrees is not for the faint-hearted. It needs that kind of determination and staying power.

Thirdly, we need to share the ethical adventure with those nearest us - those we can trust. As I have tried to explain, the whole point of ethics is to help us get the better of the pull of selfishness that we all feel, and add value to whatever and whoever we encounter. Ethical power is stronger when it

involves partnerships - when there are people around with whom we can discuss our dilemmas, our occasional failures and our successes.

Fourthly, we need to remember that ethical living is an investment in the future - our own, our children's and the world's. Wise people know better than to live just for today. They know that sometimes we must put ourselves second, and that this can be hard. But they also know that ethical power brings with it a depth of enjoyment, a deep happiness that nobody can take away, and the best kind of lasting success in life. What price can we put on the feeling we get when we look in the mirror and see a person with moral backbone, a pillar of strength who isn't the slave of his or her appetites?

Lastly, we must never underestimate the power of small beginnings. Surrounded by violence, corruption and other moral evils, it is natural to ask what the individual can do to stem the tide. But while this may be natural, it is also quite wrong. One of the most important and fascinating things about ethical capital is the way it gathers energy and grows. It is one of those things that increases the more it gets spent, unlike money.

What happens is this. Suppose somebody does me a small kindness - like providing me with a cup of tea while I am writing this chapter. This doesn't just refresh me for the task in hand, it also enriches me inwardly by giving me evidence that there is goodness around me on which I can count. I then write a better chapter, capable of giving something useful to my audience. They go home and remember the point about the power of even small things. And so moral power gathers momentum, picking up the appreciation of others, encouraging them, adding extra value and spreading further, who knows where.

Is this just wishful thinking? No it is not. One winter morning, in the small hours, a completely unknown young lawyer was deeply insulted and humiliated on Pietermaritzburg station. In the privacy of his own mind he resolved not to fall victim to the evil he had experienced but to turn it to good by seeking another way of living in which nobody would be humiliated. What could be more modest than one young man's decision? Yet look where it led. It has changed large parts of the world. That young lawyer is known to us and to world history as Mahatma Gandhi.

Within us all there is a little Hitler and a little Gandhi. Our families, our communities, our country and our world need people on our farms and managing our agriculture in whom the Gandhi element will win. It can win. It must win.

Chapter 2

ETHICS, HIV/AIDS AND AGRICULTURE

Hoosen Coovadia

INTRODUCTION

At first glance there is at most a very tenuous connection between the ethics of HIV/AIDS and the field of agriculture. Ethical issues in HIV/AIDS have been extensively addressed nationally and globally, on a range of subjects such as mother-to-child transmission of HIV, introduction of HIV vaccines, informed consent and confidentiality, and access to anti-retroviral drugs by the poor in developing countries. In addition, the impact of HIV/AIDS on virtually every sector of organised human activity and all facets of individual life, has also been documented in considerable detail. The damaging consequences of the pandemic on agriculture and food security are widely recognised. However to take these two apparently divergent facets of the subject (*i.e.* HIV ethics and agriculture) and attempt to relate one to the other may appear artificial and strained. But there are links, important ones, and there are matters of relevance to both subjects arising from these connections. It is the purpose of this paper to make these links explicit. The main point to be made, and then which needs to be repeated, is that HIV/AIDS is a pervasive disease, a wholesale onslaught on our communities, and nothing that we do or live by, will remain unaffected by it.

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AGRICULTURE: A SPECIAL CASE

HIV very often affects the impoverished of the world, fuelled by their social and economic vulnerabilities, and the disease increases the burdens of the poor by exacerbating poverty. Among the many millions who farm land and live by husbandry, who are already crippled by financial hardships, and who exist on the fringes of the formal economic life of nations, AIDS can deal a deadly blow. More than one billion people (of the global 6 billion) cannot satisfy their basic needs such as food, water, sanitation, health care, housing and education (Anon., 2002). Among these, 1.1 billion have inadequate food and frequent infections leading to malnutrition and 1.2 billion live on < $1 per day. In more than 30 of the poorest countries (mostly in sub-Saharan Africa), the real per capita income has been declining for the past 20 years.

When HIV/AIDS is added to these cumulative burdens of the poor, the fine balance between survival and death is upset, triggering an inexorable slide towards an early end. At the close of 2002 there were 42 million people living with HIV in the world, 3.2 million being children (< 15 years); 5 million had been newly infected in 2002, 800 000 being children; and 3.1 million had died in the same year, 610 000 being children (Anon., 2002). Since 1981 more than 20 million have died from AIDS, and between 2000 and 2020, 68 million will succumb earlier than they would because of AIDS. Life expectancy has been falling precipitously so that the average figure for sub Saharan Africa is 47 years, whereas it should have been 62 years without the epidemic (Anon., 2002).Young childrens' deaths (< 5 years) have increased by 20%-40% because of AIDS in seven sub-Saharan countries.

The centrality of agriculture in the lives of people in all parts of the globe is forcefully made by Barnett and Whiteside in a recent publication (Barnett & Whiteside, 2002). They rightly emphasize the obvious: that we all have to eat to survive. Organized activities in providing food have been at the core of our lives for tens of thousands of years; producing seeds, breeding plants, providing food, processing and marketing, are part of our natural heritage. Agriculture is, they note, the cornerstone of human life. The majority of people in the world live in rural areas: 54% globally, 67% in sub-Saharan Africa and 72% in South Asia. Civil unrest in Africa worsens food insecurity and accelerates the spread of HIV/AIDS. Farming not only feeds rural populations but also underpins the nutrition and development of urban communities. Although agriculture comprises only 4% of the value of the global domestic product, it remains the bedrock of modern existence. Without it, there would be no industry, no services and no urban areas.

Indeed, throughout history the progress in urban regions has been continually advanced and replenished by food and by migrations of people from rural areas.

The viability of the agricultural sector in Africa had already been undermined by existing problems when HIV/AIDS appeared to deal a further blow. These pre-existing problems included Structural Adjustment Policies, long term food insecurity, environmental degradation and climatic change, absence of the `Green Revolution` and crises of state legitimacy.

More than 1 billion people (of the global 6 billion) cannot satisfy their basic needs such as food, water, sanitation, health care and education.

1.1 billion people have inadequate food and frequent infections leading to malnutrition.

1.2 billion people live on less than 1 US dollar a day.

ETHICAL ISSUES

The HIV/AIDS epidemic is an unprecedented catastrophe and may well be the most devastating plague in all of recorded human history. The infection and disease threaten the enormous gains in social, economic and political progress made over the past half a century; indeed the social fabric of a few high prevalence countries is unlikely to survive intact. Changed social forms and new dangers to these nation states may emerge.

The HIV/AIDS epidemic is an unprecedented catastrophe and may well be the most devastating plague in all of recorded human history.

Although the impact of the epidemic is experienced in virtually each and every aspect of society, I have tried to argue that the effects on agriculture and food security deserve our special attention.

The unique characteristics of HIV/AIDS and the colossal harm it can produce, lead me to the conclusion that no sentient human being on this planet can escape engagement, either peripheral or in serious commitment, with this epidemic. One may be tempted to describe such involvement as an essential and undisputed moral imperative of this twenty-first century. This engagement is founded on a singular belief of human destiny; a belief which recognizes a global responsibility, beyond ideology, complementary to religious convictions, and outside of national and political loyalties. Acceptance of individual responsibility and belief is the first step towards acknowledgement of a collective responsibility. This leads naturally towards the organization of personal moral positions into a code for general behaviour. Therefore, the response of moral men and women to the epidemic, of engagement, involvement and commitment, becomes a universal ethical code.

The nature of these ethical responsibilities across the range of individuals, families, communities, societies, governments, and the `globalised` world, is an indispensable exploration. However, these issues have been adequately dealt with in numerous publications during recent years, in relation to ethical concerns which have been raised about HIV research in developing countries. I will not repeat these discussions as they apply to the consequences of HIV/AIDS in general; I will restrict my comments to the points which are relevant for HIV ethical issues and agriculture. I discuss some of the responsibilities of different groups, which appear important to me in this regard, in a later section which deals with Approaches to Solutions.

I now present an approach to ethics which allows and justifies the application of what I referred to as `an universal ethical code` to all units of society-individuals and collectives.

Ethical behaviour has been expected of medical professionals by well-defined codes. They are sworn to treat patients according to the Hippocratic Oath and by modernized versions of this code.

This is a widely used code and although out-dated in many parts, the principles which have been embodied in the newer versions, still have validity. A more recently developed area for the codification of professional responsibility is that of Good Clinical Practice (GCP). As the name implies, this is a code, which attempts to improve the relationship between clinical practice and patient needs. It is organized into an active body with the European Union.

These two codes are relevant to the subject of this chapter with regard to the following:

- The personnel arm of agricultural production. The prevention of HIV, treatment, care and rehabilitation of farm workers, their dependants and families, are covered by these codes of professional conduct.
- Food security. Addressing hunger and malnutrition in terms of prevention, management, care and convalescence, are within the scope of these two codes.

The Ethics of Research, which are based on beneficence, non-malfeasance, subject autonomy and equity, would apply to any studies on agriculture, AIDS and ethics. There is an enormous amount of work which has gone into attempting to safeguard the poor in developing countries from exploitation for research. There would be numerous points in the process and performance of research at which farm workers and their families, and the rural poor who face hunger, starvation and occasionally famine, would be vulnerable to a denial of their rights to autonomy and an abuse of their human rights. Yet appropriate research is a global good and essential for the advancement of civilization and the alleviation of poverty. It is outside the scope of this presentation to summarize the breadth and depth of these dilemmas. The Ethics of Research are governed primarily by the Helsinki Declaration and the CIOMS Guidelines, although other national guidelines also prevail.

Beyrer & Kass (2002) have recently introduced ideas on the effects of political factors (mainly in developing countries) and the violation of human rights on Research Ethics. They deal with human rights violations, increased risk to research staff, risks of violence to subjects and validity of the study findings. These factors would be especially evident among the rural poor and are worth remembering.

Within the world of work on HIV/AIDS there is an unresolved debate on whether the approach to interventions should be based on human rights and/or on the principles of public health. These have been cogently argued by De Cock, Mbori-Ngacha & Marum (2002) and deal with the questions of attaining social justice through public health measures rather than an over reliance on Human Rights. Agricultural workers, the impoverished and the hungry, exposed to HIV, are likely to be among the poorest of society, and therefore would benefit by both an enforcement of their Human Rights (as

shown by the struggles for drug access in the South African courts) as well as implementation of appropriate public health programmes.

I have had my own thoughts clarified by an excellent account of the ethics of public health published by Robert & Reich (2002). The authors identify three main streams of philosophical theory influencing public health: Utilitarianism, Liberalism and Communitarianism. My view is that all three streams apply in different ways to the issue of AIDS, Ethics and Agriculture. Utilitarianism (after Bentham) is concerned with `outcomes - the greatest good for the greatest number`. Liberalism emphasizes Human Rights (as in the UN Declarations and in the South African Constitution: individual rights, social and economic rights). Communitarianism reflects the resolution of diverse ethical approaches through community decision-making. None of these are mutually exclusive and indeed in many cases a mixture of approaches is utilized. Amartya Sen has an attractive and sensible philosophy which draws attention to the importance of `capabilities` (made possible through education, good health, social support *etc.*) in the realization of those things which are considered of value to human beings.

ECONOMIC ISSUES

Economic consequences of HIV/AIDS on agriculture and food security

AIDS is devastating Africa's agricultural base. The UN states that in Africa's 25 worst affected countries 7 million agricultural workers have died from AIDS since 1985 and a further 16 million could die by 2020 (Anon., 2003).

In Africa's 25 worst affected countries, 7 million agricultural workers have died from AIDS since 1985 and a further 16 million could die by 2020.

Households in affected regions cannot cope (Anon., 2002; Barnett & Whiteside, 2002). In Zambia, where the mothers had died, 65% of households dissolved soon after; where the father died, the monthly family income dropped by >80% in two-thirds of such families. In Cote d'Ivoire the income in affected households was half that of the average household, and health expenses rocketed by 400% when a family member had AIDS. Income has decreased by 13% in Botswana in affected households. In Burkina Faso, extreme poverty will increase from 45% currently to 51% in

2005 due to the effects of AIDS; and 20% of rural families have either reduced their quantum of agricultural work or abandoned their farms due to the disease. In Ethiopia households affected by AIDS have had to reduce by >50% the number of hours of agricultural work compared to households in which there are no AIDS cases. Moreover, nutritional requirements are increased in the presence of HIV/AIDS.

The personal and social processes which extract such an heavy toll on human life and livelihood are multi- dimensional (Barnett & Whiteside, 2002). Parents die, the family unit dissolves, food access becomes restricted, health care costs go up and the ripple effects from one family with HIV/AIDS lead to many families in the community becoming affected. In Africa, where linkages and social and family obligations are intricate and wide, the ramifications of a single family with HIV/AIDS can be sweeping and cause the breakdown of social solidarity and social capital. A Thai study showed that AIDS related stress in households impacted on agricultural practices, local knowledge and systems.

The impact of AIDS on agriculture results in smaller plots, loss of farm labour, falling production, uncultivated areas, loss and sale of land, sale of equipment, loss of savings, sale of other assets, increasing debt and serious damage to the entire farming system (crops, livestock, soil, fertilizers). Husbandry of livestock falls, a smaller range of crops is grown, yields drop, marketing fails and rural infrastructure decays. All this leads to a major change in the life of the rural poor.

James Morris, Executive Director of the UN World Food Programme (WFP) believes that HIV/AIDS will have a bigger impact than drought on food supplies in Africa. AIDS has depleted the public health infrastructure in many of the countries. It has had a real impact on the agriculture infrastructure (Anon., 2003).

The effects of HIV/AIDS on both Commercial and Subsistence Agriculture have been documented in a series of briefs prepared for planners by the Health Economics and HIV/AIDS Research Division, at the University of KwaZulu-Natal (Parry, 2002; Barnett, 2002). In brief, the personnel effects include illnesses, absenteeism, malnutrition, overtime by healthy workers, time-off for funerals and loss of skills. The operational problems are related to impaired planning, shifting deadlines, poaching of skilled labour, loss of motivation and falling morale, demands for credit and leave, and costs of absenteeism and death as well as recruitment, training, and hiring of additional staff.

APPROACHES TO SOLUTIONS

James Morris notes that `...food is the most important drug in the fight against HIV/AIDS` (Roberts & Reich, 2002). Therefore productive agriculture and food security are solid foundations for an anti-HIV/AIDS programme.

The central point of my thesis on the ethical concerns in addressing the devastation of AIDS, and preventing further damage caused by HIV/AIDS on agriculture, is that the responsibilities are to be borne by all of us. It is as much a personal moral issue as it is a national duty and an international obligation. Faced by a ferocious modern plague of such immense destructiveness, unequalled by any similar pandemic in all of human history, and which threatens the very existence of some of our communities and fellow nations, how could we offer any less than the utmost we can do? Individual engagement, government commitment, workplace programmes, donor assistance and socio-economic upliftment, are the foundations for success. Individual action is necessary - individual behaviour changes where there is risky behaviour, and a personal contribution to the common good within the work, recreational and residential spaces of ones life. Communities have a central role in the struggle against this epidemic. In all parts of the world, some more than others, shame and discrimination are key elements in forcing the infection below the surface of social acknowledgement and acceptance. Much can be done by communities to overcome these prejudices and dispel the myths surrounding the disease. It goes without saying that government commitment, action and programmes are critical for prevention and care. The call to the global community must be equally persuasive - here the industrialized world has a special obligation.

The UN has identified 5 broad areas of action for this purpose (Anon., 2002):

- International cooperation.
- Accountability and transparency of international institutions.
- Replenishment of national capabilities to safeguard right to health.
- Redressing global poverty.
- Equity in distribution of the fruits of globalisation.

The WFP had begun a scheme of food donation to families affected by AIDS in four Asian countries in 2002; this has to be extended to Africa and vulnerable groups in other countries. In this respect the capabilities of developing countries to feed themselves are continually undermined by

restrictive global policies affecting agriculture. Subsidies to farmers in wealthy countries act as a barrier to the export and foreign-exchange earnings of developing countries. For example, high-income countries spent >$300 billion in 2001 on agricultural subsidies; this is roughly equal to the combined GDP of all the countries in sub-Saharan Africa (Anon., 2002).

We know, whether we are individuals, politicians, corporate executives, communities or faith-based institutions, what has to be done. Prevention and Care measures are effective and well known (Stover, Walker, Garnett, Salamon, Stanecki, Ghys, Grassly, Anderson & Schartländer, 2002).

PREVENTION	CARE
AIDS Education (schools, out-of schools, mass media campaigns).	Opportunistic Infections (treatment, prophylaxis).
Workplace Programmes.	HAART (treatment, laboratory monitoring).
Condoms (public sector, social marketing).	Orphans (community support, school fees, orphanages
Outreach Programmes (commercial sex workers, homosexual men).	HIV Testing.
Voluntary Counselling and Testing.	Palliative Care.
Mother-to-child Transmission.	
Sexually Transmitted Diseases.	
Harm Reduction.	

Sustainable Development is central to health and human progress. This is especially important for protecting agriculture and promoting food security. Von Schirnding (2002) discusses three essential requirements for health: economic development, social development and environmental development.

Investments in women are known to reap maximum benefits (Von Schirnding, 2002). For the purposes of this paper it is important to bear in mind that women contribute more than 50% of food production in Asia and sub-Saharan Africa, they do the most labour-intensive work in farming, and also prepare the food (Anon., 2002). Microcredits for rural women, for example, are likely to be highly effective if carefully implemented.

Government commitment is a solid bulwark against one of humankinds worst enemies. At the OAU Special Summit on AIDS in 2001, African governments endorsed the Abuja Declaration which requires them to spend at least 15% of their national budgets on Health (Anon., 2002). In 1998, only a handful of countries had achieved this target; the number of countries has gone up since then, but much more needs to be done to cope with the detrimental effects of AIDS. In many countries the poor are often expected to pay for their HIV/AIDS treatments - payments which are very often unaffordable. In Rwanda 93% of expenditure for HIV/AIDS in 1998-1999 came from out-of-pocket money, and 7% from government and donors.

Global Fund spending is key to addressing the problems in the agricultural sector identified above. This Fund has to reach about $9.2 billion by 2005.By mid-2002, aggregate spending on HIV/AIDS in low- and middle-income countries was $3 billion, much of it from international sources. In the same year international donors gave about 66% of HIV/AIDS budgeted spending in low- and middle-income countries. However, the burden of AIDS is often too heavy to bear in poor countries, and about 80% of total resources needed in sub-Saharan Africa, South Asia, and South-East Asia, will have to come from international sources.

Debt Relief is a hoary issue, but very important nonetheless. This debt averages four times the annual export earnings in 38 HIPCs (Highly Indebted Poor Country). In 16 African countries in 2001, the servicing of debt exceeded the funds spent on Health. The international campaigns against these crippling burdens can be considered indirect support for the fight against AIDS and for food and for a secure agricultural system.

The ODA (Official Development Assistance) is also a perennial focus of criticism and a source of shame for the industrialized countries. The agreed proportion is 0.7% of GNP; for most of the wealthiest countries the current figure is <0.3%, and for some it is as low as 0.1%. For the 28 recipient countries most affected by the AIDS epidemic, the ODA has decreased by a third between 1992 and 2000.

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Chapter 3

LAND REFORM

Michel Taljaard

INTRODUCTION

Legislation and policies are generally applicable to a particular and specific situation or country. South Africa is no different; because of the political history of South Africa, current legislation is designed to deal with specific situations which may or may not be similar to land-related problems experienced in other countries throughout the world. It is hoped that the dialogue that follows in this chapter, whilst being specific to the South African situation, will provide interesting reading and also offer direction for countries with similar land-related problems.

The inclusion of the subject of land reform in a post-modern publication of applied ethics in South Africa is important for a number of reasons. Firstly, land holding and the change thereof is a critical issue in modern African politics. Secondly, the National Government of South Africa views land reform as an important mechanism through which transformation of the national society can and will take place. Thirdly, land reform in South Africa offers an excellent opportunity for students of Ethics to study it in an applied environment.

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This chapter on land reform can only serve to stimulate discourse in the discipline of ethics within a specific and defined context. It is not the purpose of this chapter to discuss land reform in detail, or to attack the practice of land reform in general. Careful reading of the chapter will reveal appreciation for a national strategy that is well defined and structured.

An introduction to land reform, by means of a summary of the different pieces of land reform legislation that is applicable in South Africa, is discussed in order to provide the reader with a perspective on the legislative issues involved. Similarly, the policy accompanying the legislation is also presented to the reader. Policy is the application of the legislation.

Furthermore, the chapter identifies a number of ethical issues that are important in the field of land reform in South Africa. These issues relate to the distinction between redistribution and restitution, the need for land reform in an economically viable environment and the complex nature of land reform praxis.

Lastly, the chapter attempts to address economic issues such as the cost of land reform and the economic viability of the national strategy for South Africa.

LEGISLATION AND POLICIES

The Land Reform Programme has three primary aims:

1. To promote social and economic development by improving access to land;
2. To provide households with an opportunity to engage in productive land use; and,
3. To increase employment opportunities through encouraging greater investment.

In the current context, land reform seeks to affect a rural landscape that reflects a variety of land ownership systems and numerous farming enterprises ranging from subsistence to large-scale commercial farming. The White Paper on South African Land Policy (1997) outlines the strategic objectives of the Land Reform Programme as follows:

- To correct the injustices of racially based land dispossession of the past.

- To achieve an equitable distribution of land ownership.
- To ensure security of tenure for all.
- To establish a system of land management that will support sustainable land use patterns and rapid land release for development.

The government seeks to achieve these objectives by means of the three elements of the Land Reform Programme, namely: redistribution, restitution and tenure reform. A number of Acts have been promulgated to facilitate and provide the legal framework for the implementation of the Land Reform Programme. The important legislation is summarised in the following block.

SOME NATIONAL LEGISLATION APPLICABLE TO THE LAND REFORM PROGRAMME

- *The Restitution of Land Rights Act, 22 of 1994*, provides for the restitution of rights to land lost as a result of racially based and apartheid legislation.
- *The Provision of Certain Land for Settlement Act, 126 of 1993,* provides for the designation of land for settlement purposes and financial assistance to people acquiring land and for settlement support.
- *The Development Facilitation Act, 67 of 1995*, introduces measures to speed up land development.
- *The Upgrading of Land Tenure Rights Act, 112 of 1993,* provides for the upgrading of various forms of tenure.
- *The Land Administration Act, 2 of 1995,* makes provision for the assignment and delegation of authority to the appropriate authorities.
- *The Land Reform (Labour Tenants) Act, 3 of 1996*, provides for the purchase of land by labour tenants and the provision of subsidies to this end.
- *The Extension of Security of Tenure Act, 62 of 1997*, establishes security of tenure by giving occupiers the right of residence to live on land on which they currently occupy.
- *The Communal Properties Association Act, 28 of 1996,* makes provision for groups of communities to acquire, hold and manage property as a group under a written constitution.

LAND REFORM PROGRAMMES

Land Redistribution Programme

In terms of the White Paper on South African Land Policy (1997), the Land Redistribution Programme is intended to provide the poor with land for residential and production purposes and thereby (hopefully) improve their living and socio-economic conditions. Furthermore, it will contribute to the alleviation of poverty and reduce the current levels of environmental degradation associated with overcrowded areas. It is a flexible program designed to embrace and respond to a wide variety of land needs including landless communities, labour tenants, farm workers and emerging farmers. It enables eligible individuals to obtain a Settlement/Land Acquisition Grant to a maximum of R16 000 for the purchase and development of land. Target areas and groups include:

- Marginalized groups and landless communities.
- Local government commonage.
- Farm workers.
- Labour tenants.

The Redistribution Programme is based on a "willing-buyer willing-seller" principle, and beneficiaries are encouraged to purchase and hold land under a formal title. The state will make grants available but will not be the buyer or owner. Opportunities are also offered for individuals to access the grants for land acquisition.

Marginalized Groups and Landless Communities

The Land Redistribution Programme is intended to provide the marginalized and landless sectors of the population with land for both residential and production purposes. It is a gender sensitive programme that acknowledges gender inequalities and attempts to address the plight of women. It is intended that this will be achieved through the removal of all the legal restrictions and changing of social perceptions thereby encouraging women to participate in land-related matters, including ownership of land.

Local Government Commonage

The White Paper on South African Land Policy (1997) makes provision for small towns and settlements to establish conditions that will enable needy communities to gain access to existing commonages currently used for other purposes. Commonages can be used as grazing land and garden areas to supplement incomes and to enhance household food security. The

Department of Land Affairs has also allocated funds to assist under-resourced Municipalities to acquire additional land for this purpose.

Farm Workers

Farm workers, as defined by the Department of Land Affairs, constitute one of the poorest and most insecure sections of the South African population. In the past, government subsidies were channelled to the farm owners for farm worker housing, and this resulted in housing being tied to employment. The White Paper encourages the provision of subsidies to the farm workers in a manner that leads to security of tenure, contributes to equitable ownership of land and harmonized relations between the affected parties. There are two ways in which this can be achieved:

1. Off-farm settlement whereby land closer to the existing farm employment is purchased and developed for permanent occupation by farm workers and their families. Agri-villages are one of the mechanisms in which off-farm settlement can be realized; and
2. On-farm settlement can be achieved by means of equity share schemes of a contractual agreement between the state, farm workers and the farm owner in which the farm worker together with his/her family use the grant to enhance their occupancy rights.

Labour Tenants

Like farm workers, labour tenants are among the most vulnerable groups in terms of land tenure in South Africa. The Land Reform (Labour Tenants) Act, 3 of 1996, is a retrospective Act, which protects labour tenants' rights as of 2 June 1995. It also makes provision for the acquisition of land for the existing labour tenants using Settlement and Land Acquisition Grants. It applies to labour tenants as described in the Act, and therefore excludes rural land dwellers, farm workers, tenants on farms and persons who would have qualified as labour tenants were it not for the fact that they personally ended their labour contract with the farm owner.

LAND RESTITUTION PROGRAMME

The Land Restitution Programme is based on the provisions of the Constitution and the Restitution of Land Rights Act, 22 of 1994. Its primary aim is to facilitate the restoration of land rights (in both urban and rural areas) and provide alternative measures to people who lost their rights to land on the basis of racially discriminatory legislation and in furtherance of the apartheid policies. It is a reconciliatory programme based on the

principles of justice, equity and fairness, and it seeks to promote nation building, reconstruction and development. Land Restitution can be implemented in the following ways:

- Restoration of land from which claimants were dispossessed.
- Provision of alternative land.
- Payment of compensation.
- Alternative relief comprising the combination of the above.
- Priority access to government housing and land development programmes.

Compensation will be just and equitable, and will only be considered where other remedies are not appropriate. The Act and the Constitution also make provision for the payment of compensation to the landowners.

The Restitution Programme is implemented through the Land Claims Commission and the Land Claims Court, and it recognizes rights that were established by long-term occupation, and lost after 19 June 1913. It is not limited to registered or ownership rights and/or interests, but also covers long term tenancy and occupational rights. To this effect, it recognizes the fact that some individuals or groups of people may have been prevented from obtaining legal rights to land on account of their race. Cases that do not fall within the ambit of this program may be dealt with through the Land Redistribution Programme. This includes claims that occurred before 1913.

Tenure Reform

Tenure Reform is a complex and intricate process. It addresses a multitude of land ownership problems created by apartheid policies and practices. It seeks to replace permit-based land rights with a new system of land holding and establish tenure rights in terms of ownership. The following are some of the ways in which this programme delivers security of tenure:

- Upgrading of *de facto* vested interests in land into legally enforceable rights through the Upgrading of Land Tenure Rights Act, 112 of 1993.
- Protection against eviction of occupants of privately owned land through the Extension of Security of Tenure Act, 62 of 1997.
- Membership of group based ownership through the Communal Properties Association Act, 28 of 1996.
- Family-based ownership which arises in the context of ex-SADT land and township houses which were allocated to families.

The Land Tenure Reform Programme is premised on the fact that the rights of the long-term holders of the land should be treated as ownership rights. It recognizes that there are areas where customary land tenure systems are preferred. While it will be unnecessary and even dangerous to interfere with such systems, a legal framework is being created to enable the establishment of various forms of tenure arrangement in traditional authority areas.

ETHICAL ISSUES

The preceding discussion attempts to outline how government and its policy-formulating mechanisms have made a comprehensive effort to identify and define the different problematic realities that affect previously disadvantaged South Africans. The policy-formulating mechanisms have also succeeded in transforming legal positions to applicable policy mechanisms.

The application of land reform policies in practice however is, in many instances, not a simple process. Problems are often due to the "distance" between legal experts formulating laws and policies and the people who benefit from the laws and policies. An attempt will be made to identify some of these problems. Due to the complexity of the situation it will obviously not be possible to describe all the problems that exist, nor to describe such problems comprehensively.

Redistribution and Restitution (and Birth Rights)

Earlier in this chapter it was stated that the distinction between redistribution and restitution is primarily fundamental. The restitution legislation and policy is aimed at the restoration of rights, while the redistribution legislation and policy is aimed at the redistribution of land resources to ensure that marginalized people and their families from the previously disadvantaged sector of the South African society get access to the relevant resources.

Restitution: the restoration of rights to land and resources.

Redistribution: redistribution of land resources to peoples previously disadvantaged by Apartheid policy and legislation.

Although this distinction seems to be obvious, praxis shows that it is contaminated by ignorance and historical factors. In order to demonstrate this point, examination of practical situations in the Provinces of KwaZulu-Natal and Mpumalanga may be useful.

For many years in these sub-regions, farmers had agreements with farm workers that allowed them to limited agricultural practices as part of their compensation for the work done on the farm. This resulted in a situation where most of the families living on farms kept cattle and goats and planted some crops. This practice had advantages for the tenants as they maintained a limited level of economic independence. Problems however arose when land ownership changed hands and the new landowner needed the grazing utilized by the families living on the land, or did not require the labour provided by such families. Families affected by these new circumstances could not easily negotiate to sell their skills on other farms, as other farmers might not be keen to compensate the worker and his family in the same manner (including grazing and cropping rights) as the previous employer. This situation resulted in continuous conflict when land ownership changed and created hardship for the affected families. A classic defence mechanism used in these circumstances by the tenants was to claim historic birthrights on the land for themselves and their parents. In many cases these claims were valid and landowners consequently allowed such people to remain on the farm. This *de facto* situation further resulted in a situation where tenants argue that even though title on paper went to white owners, their ties of settlement, cultivation and family history are just as binding as the paper on which the title is described.

Because of the success of such historic claims, farm tenants and their descendants still use this claim, but in the land reform context. However, the reality of land rights is that it does not make provision for linking land rights to a person's umbilical cord. In practice, claims based on this premise tend to cloud the issues in the praxis of land reform.

The critical question raised by these situations is how to ensure that historic practices and understandings fit into the opportunity stream of land reform legislation and policy?

The Need for Land and Economic Viability

The need for land reform to provide the poor with suitable land for residential and production purposes, and improve their living and socio-economic conditions, cannot be questioned. It can contribute to the alleviation of poverty and reduction in the current levels of environmental

degradation associated with overcrowded areas. It is accepted by Government that land reform will not, and cannot, enrich beneficiaries in purely financial terms, but does provide a basis for economic development and financial viability.

The central governments concern with economic viability is expressed in the refined land redistribution policy *i.e.* the Land Redistribution for Agricultural Development (LRAD) policy. This policy clearly demonstrates the Government's notion that land reform should not only redress the imbalance in land ownership, but that it should also create capital for the beneficiaries and the country.

Research done by the University of Stellenbosch and the Ithala Development Bank identifies operational management, and not land ownership as the critical factor in sustaining viable agricultural practices. This is an important finding, as it impacts on the willingness of central government to redress land imbalances in an economically viable manner.

Land Reform as a Complex Process

Previous discussion highlights the complexity of land reform in South Africa; the complexity of the process is unlikely to diminish in the foreseeable future. The characteristics of complex systems is discussed and described in detail by Cilliers (1995). The important aspects can be summarized as follows:

- Firstly, the land reform system consists of many elements with different characteristics that influence each other.
- Secondly, how these elements influence one another, is dynamic.
- Thirdly, the dynamic influence of the elements impacts on more than one of the other elements.

It is quite easy to visualize the elements that cause the complex nature of the land reform process. It is normal to find the following role players involved in a land reform project:

- The beneficiaries.
- The families of the beneficiaries (often this includes the extended family members).
- The local Department of Land Affairs official.
- The supervisor(s) of such an official.
- The seller of the land.
- Representative of the local Farmers Association.
- Representatives of the Local Government.
- Representatives of the Traditional Authority.
- Legal representatives of some of the role players.
- Trade Union representatives.
- The facilitating agent / consultant.

It is therefore not difficult to argue that land reform in praxis results in complex processes due to the complexities of the role players. The key question that arises from this observation is how many participating officials and facilitating agents are actually aware of the complexity of the process, and how many of them have the skills to lead such a process successfully?

The influence that the different elements in a complex system have on each other has, in itself, a number of important characteristics. These include:

- The influence is not linear. This means that small causes can result in big changes.
- The influence of the elements takes place primarily close to the influencing element itself. This results in a situation where the end result of the original influence takes place far from "home", without direct contact between the original influence and the last snowball effects.
- The feedback that is received by elements in a complex system can be either positive or negative. This differs from the nature of feedback in a linear system.

Furthermore, the elements in a complex system are in constant interaction with their own environment. This relationship is also dynamic and makes it difficult to define the exact nature of the different elements in a complex system. This reality results in a system in which elements are never in equilibrium with each other.

Complex systems further develop in time and history. The system therefore does not only develop "now", but has a history that is co-responsible for the behaviour of the elements. Lastly, no single element in a complex system fully understands the whole system. In order to be able to understand the whole system, the whole system needs to be within the single element.

ECONOMIC ISSUES

The fact that land reform is viewed by the government as an important mechanism to transform the South African society is universally accepted. Furthermore, it is accepted that the government will make substantial resources available in order to implement this policy.

Cost to Government (and the Tax Payer)

The cost of land reform for the government of South Africa is difficult to establish, as data in this regard is not published in the Department of Land Affair's publications. Any comments in this regard are therefore based on educated calculations and information gathered in the corridors of land reform.

Costs that the Department of Land Affairs incur relate to easily quantifiable activities and cost centres. These are called direct costs in this essay and will relate to the following:

- Staff.
- Planning.
- Acquisition of land.
- The cost of land.

Indirect costs that are not easily quantifiable, however, also exist and may be more than the direct costs of land reform. The relevant department is probably not able to define these costs accurately. Such costs will result from:

- Management procedures that define tasks vaguely and therefore result in incomplete or incorrect planning documentation. This is a recurring problem in land reform praxis because planning managers in regional offices operate under pressure and are often inexperienced in terms of the exact results that they require from external planners.
- Time delays between the different stages of a land reform project inevitably result in additional costs for an affected project. Costs are incurred when beneficiary lists need to be upgraded due to the death of beneficiaries. Further costs result from the re-negotiation of land prices because Options to Purchase clauses are not honoured.
- Staff turnover in the Department of Land Affairs inevitably results in delays of project progress.
- The fact that projects are not completed results in budget allocations that are not utilized and thereby result in increased costs.

Whilst the economic benefits, or potential benefits, of land reform in South Africa have not been quantified in detail, it is however, possible to deduct some important conclusions from available information and documentation:

1. It is important to give credit to the central government and its policy formulating mechanism for the comprehensive legislation and policy that has been developed over the past ten years. These laws and policies have succeeded, to a substantial degree, to define and describe the complex environment of rural land holding structures. It has furthermore developed policy frameworks that can be used to redress land-holding injustices of the past.
2. It is necessary to take cognizance of the fact that all the Department of Land Affair's efforts are not aimed at the transfer of land, or the transfer of land for capital growth purposes. This view is reflected in the two pieces of legislation – Land Restitution and Tenure Reform - discussed earlier in the Chapter, which have different objectives other than capital growth. These objectives include the following:

    - The Restitution Policy aims to facilitate the restoration of land rights (in both urban and rural areas) and provide alternative measures to people who lost their rights to land on the basis of racially discriminatory legislation and in furtherance of the apartheid policies. Restoration is the primary objective in this case, and not capital growth.

- Tenure Reform seeks to replace permit based land rights with a new system of land holding and establish tenure rights in terms of ownership. The Land Tenure Reform Programme is premised on the fact that the rights of the long-term tenure of the land should be treated as ownership rights.

With regard to the LRAD programme that is a refining of the Redistribution Legislation, the following comments are relevant:

- This policy was introduced in the latter half of 2001.
- Because the policy is still relatively young, very few projects have been finalized successfully.

The general opinion of experienced personnel involved in the planning of some projects under the LRAD banner can be summarized as follows:

- Some LRAD projects have limited potential to improve the household income of project participants.
- The limited potential relates to the actual agricultural potential of the land involved, and is not the result of poor planning or unsuccessful implementation.
- Some crops have lower risks for the producer and should result in more successful LRAD projects.
- Some agricultural industries, like the sugar cane and timber industries, are very well structured to provide support to emerging farmers participating in LRAD projects.

DISCUSSION VIEWPOINT

Land reform in South Africa can be executed successfully; however, in order to achieve success with the land reform programme the government will have to meet certain critical conditions. The following three conditions are regarded as non-negotiable:

1. DLA staff should be able to apply the relevant policy to each request in order to ensure that as many applications are as successful as possible. The proper training of staff is crucial to the attainment of this objective.
2. All the projects must be executed in a cost-effective manner. This means that no costs should be duplicated through inefficient

planning and approval procedures. It will further require that regional DLA staff know exactly what results they need from planning processes and can formulate appropriate planning guidelines for consultants.

3. Land reform can be executed successfully if the capital growth projects that the department subsidizes become self-sustainable in the short-, medium-, and long-term.

It is possible for the government to reach its goal and objectives with the land reform through the relevant legislation and policies. However, in order to achieve certain goals and objectives, some applied ethical matters need to be attended to. The following are the most obvious in this regard:

- Firstly, training of DLA field staff to ensure that they are able to fully understand, analyze and manage complex processes. The possibility of recruiting experienced external agents should be investigated as a means of ensuring that complex projects are executed successfully.
- Secondly, the DLA will have to create opportunities for their field staff and appointed consultants to design land reform projects creatively. It is generally accepted that land reform projects are complex processes and that results and outputs of different projects will differ from one another. Awareness of this fact will ensure that DLA staff and consultants exploit the unique potential of every project optimally.
- Thirdly, the DLA will need to create mechanisms through which its field staff and consultants become accountable for the work carried out. Land reform is a critical performance area of the national government's transformation strategy. Role players involved in the execution of this strategy must ensure the success of the land reform programme and thereby contribute to the positive transformation of South Africa.

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Chapter 4

BIODIVERSITY CONSERVATION

Michael J. Samways

INTRODUCTION

Biodiversity is the variety of life – its structure, composition and function. In cosmic terms, life as we know it is rare. Complex life is a mere speck in a huge void of comparative nothingness. Yet this blue-and-white planet, with its sufficient gravity, free water, warmth and fairly circular orbit around the sun, became the stage for what at first sight seems improbable. Over aeons of time, there was gradual appearance of increasingly complex organisms against an entropic background.

This rise of biotic complexity took some four billion years, and did so through a process of evolution involving three basic features: variation, selection and retention. In short, among the early molecules there was variation, and some of these molecules had greater survival value than others. These were selected on 'survival merit', and retained. Among the retained molecules, the process was repeated, billions upon billions of times. This was not a teleological process, rather, there was survivorship value in the prevailing environmental conditions. For life on earth, it was amino acids that combined into RNA (ribonucleic acid) that eventually led to more and more organized and efficient life activities.

The culmination of these evolving life forms is the human being, with the most complex nervous system known, the conscious brain. This, coupled with an upright stance and apposable thumb, has enabled us to modify the

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environment around us, from making spears and grinding corn to making fires and building spacecraft. Our high survival rate and our ability to explore and colonize new environments has meant that we have traversed, settled and imprinted ourselves across most parts of the world. Today we harness as much as 40% of the world's nett primary production, and have modified some 95% of terrestrial systems. Arguably there is no part of the world not reached by us or our products. In this phase of great expansion, a mere blink of a geological eyelid, there has been great cost to ecosystems and other organisms worldwide. We are now seriously rocking our ecological boat.

There have been major impacts on life throughout time, with several mass extinctions over the last 500 million years. Indeed, 99% of all organisms that ever existed are now extinct, largely from causes other than human. The difference today is that it is one organism, us, that is accelerating extinctions at a cataclysmic rate. We, through our conscious mind, know we are doing it. And indeed, in a matter of just a few years, we have developed the means of deliberately altering the course of evolution through genome modification.

What is biodiversity?

'Biodiversity', a contraction of 'biological diversity' is the variety of life. This includes genetic species, ecosystem and regional variation. It has three components: compositional (what that variety is made up of), structural (how that variety is assembled) and functional (how that variety works). It is the natural, intrinsic, biotic capital of the earth. It is also the base for our food, and is fundamental for all aspects of our welfare and survival.

Yet ethically we hardly know what we are doing. Our technology has outstripped our moral obligations to the world and its rich variety of life. We are attempting to correct this by developing a vision and strategy through initiatives such as the World Summit on Sustainable Development. But not all nations are buying into this futurism. We cannot, from a global perspective, simply continue to patch up. We must steer into a situation that does not compromise future generations. Meanwhile, we must be cautious and keep all the biotic parts because they may be valuable, indeed essential, to our future survival.

The Precautionary Principle

The Precautionary Principle is about keeping all the parts because we do not know how valuable or important they may be in the future. Biodiversity is so complex, so little known, and yet so important for us, that we would be wise to keep as many biotic components and interactions as possible. An apparently insignificant biological lock-and-key today, may be crucial for our survival tomorrow.

South Africa shares this vision of a sustainable future. This is important globally, because South Africa is the third most biologically diverse country in the world, after Indonesia and Brazil. Other countries in southern Africa are also enormously rich in endemics (local species) whether in arid zones, mountains or forests. South Africa alone has almost 10% of the world's plants and 7% of the reptiles, birds and mammals, even though it is only 2% of the global land area. South Africa, besides hosting the 2nd World Summit on Sustainable Development, has committed itself to conservation of biodiversity as outlined in the 'White Paper on the Conservation and Sustainable Use of South Africa's Biological Diversity'. Nevertheless, there are enormous challenges and these must be met if our children are to have a future.

South Africa's rich biotic heritage

South Africa is the third most biodiverse country in the world. Not only does it have an enormously rich variety of plants and animals but many of these are endemic and not replaceable from elsewhere. Percentage endemism at the species level is 100% for some worms, velvet worms and bees. Most of our other invertebrates are also endemic. Over two-thirds of the plants are endemic, about half the amphibia, birds and mammals and over four-fifths of the fish species are endemic.

CURRENT ETHICAL ISSUES

We may ask, why do we need biodiversity conservation?

Biodiversity conservation concerns everyone, and its loss means loss of livelihoods and hence loss of life itself. Indeed, it is the poorest communities that often depend most directly on harvesting of wild biodiversity. Conservation of biodiversity is therefore a direct, largely unappreciated, means of poverty alleviation. For the poorer communities, biodiversity is their capital, and sustainability is about only living off the interest and not reducing the capital. Reducing the biotic bank reserves leads to an increasingly eroding livelihood base. When biodiversity resources decrease in quantity and quality, it leads to a dangerously slippery slope of non-recovery. Soil alone has been described as that 30 cm between life and death of the planet. Furthermore, looking after what we already have (and take for granted) makes far more ethical, ecological and economic sense that over-exploiting what we have and then thinking that we can recover it at some undefined time in the future.

THREATS TO THE WORLD'S BIODIVERSITY

What are these threats?

Threats to the world's living systems are many, and often they compound each other. The 'Three Horses of the Apocalypse' that are undermining the variety of life on earth are habitat loss, landscape fragmentation and alien invasives. Organisms need to live somewhere, but these living areas, or habitats, are being lost at a rapid rate. Among these habitats are once widespread systems, such as grasslands (which originally covered 600 million ha worldwide, and of which only fragments remain), but also special ones, including caves, wetlands, tropical island lowlands and coral reefs. Some of these may be temporary but essential habitats for migrating animals.

Landscape fragmentation (sometimes referred to as habitat fragmentation) is the human-induced division and amelioration of formerly continuous landscapes. The division tends to follow distinct stages. Firstly, the landscape becomes divided, by, for example, a road. Then at nodes along the road, there is temporary or permanent settlement, which perforates the landscape. As these disturbed areas expand and as human pressure increases, the original landscape begins to be transformed and remaining patches become increasingly isolated from one another. This is fragmentation. Finally, there is attrition, where the remaining habitat patches become smaller and smaller through human demands upon them.

This may eventually lead to no natural patches or fragments being left, and the landscape is a mosaic of transformed patches. This is the patchwork quilt of intensively agricultural areas as seen from an aircraft.

As a result of increased human movement and trade, there has been a huge accidental and deliberate transportation of organisms. When they settle, establish and spread in their new home, they are termed 'alien invasives'. The problem has become increasingly acute because world trade has increased almost ten-fold since 1965. This, combined with the fact that alien invasives often gain a foothold in human-disturbed ecosystems, means that there has been a huge homogenization of biota worldwide. This has stimulated some observers to say that we are entering a new geological era, the Homogenocene.

Tragedy of the Commons

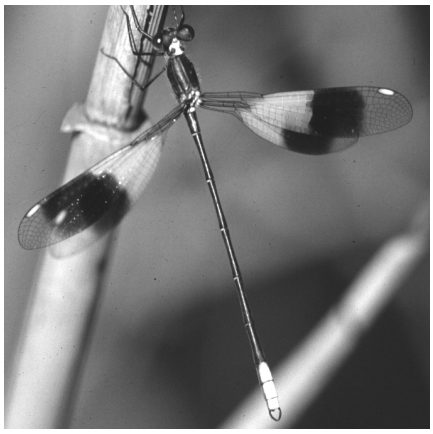
Worldwide we are using our natural resource base or biotic capital at a greater rate than it can be replenished. Part of human population density coupled with high consumption of resources is veiled by trade. When a commodity is short, we ship it in. This means that much of our impact we never see because the ecological damage is being done in a far-away place. This is symptomatic of the Tragedy of the Commons, where common resources are used consumptively with little thought for the future.

Human demand for ecological space

Each of us requires an equivalent of a biologically productive area of the globe to sustain us. With the world population today at over 6 billion people, this means that there is about 2.2 ha of biologically productive space available for each of us. The problem arises when we calculate our actual needs. For today, let alone the future, each of us, on average needs 2.8 ha, which is 1.3 times what is actually available. In short, we are living on borrowed ecological time as we are effectively reducing our biotic capital at a rapid rate. This capital is also being proportionately reduced because the population is growing, yet habitat destruction, water depletion, invasion by alien (foreign) organisms, pollution, loss of genetic resources and build-up of carbon dioxide in the atmosphere is still accelerating. This is a gradual process with many of the components interacting synergistically (*e.g.* habitat disturbance encourages invasion by alien organisms).

Synergisms

It is human nature to tease apart and identify problems and challenges. Yet in biodiversity conservation, many of the threats and solutions involve understanding synergisms. These arise when one impact compounds another so that there are several factors affecting a species or ecosystem. This leads to a dynamic effect where the pressures vary from one time and place to the next. The Basking malachite damselfly (*Chlorolestes apricans*), one of South Africa's rarest and most threatened animals, suffers from a combination of river pollution and silting, shading of its habitat by alien invasive trees and trampling of its egg-laying sites by cattle.

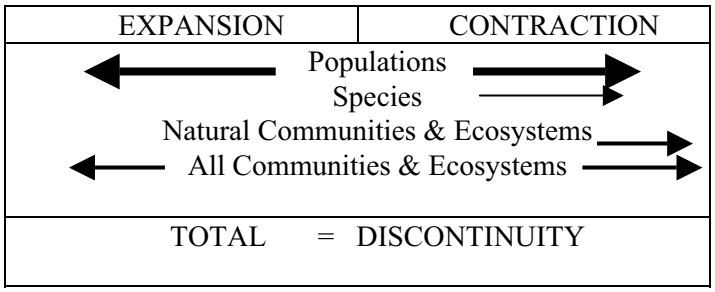


Basking malachite damselfly

Such a situation can only have one outcome, and that is what ecologists term a 'discontinuity', or a major ecological transition that inevitably will be devastating for most forms of life on this planet. Suddenly seeing the ecological light and mending our ways will not immediately reverse the situation. The impacts and synergisms have momentum, and it will take decades to slow and turn around the biodiversity tanker.

Discontinuities

Discontinuities may be considered at three levels: populations, species and communities, and ecosystems. Extent of the discontinuities (width of the arrow shafts) is already great for many populations because of various and synergistic impacts. Some species are benefiting from disturbance and their populations are expanding, especially among alien invasives. Species discontinuities (*i.e.* species extinction rates) are occurring as ecosystems such as forests are radically transformed. In turn, communities and ecosystems are suffering discontinuities with fragmentation and attrition of habitat fragments and increasing outside effects. (*N.B*. Species are not 'expanding'*, i.e.* species richness is not increasing beyond the background rate.) Many new anthropogenically-disturbed, agricultural and urban communities and ecosystems are appearing, conceding the fact that they are maintained through energy input and negentropy.



Threats to southern Africa's biodiversity

Only about one-third of the Earth's land is in the southern hemisphere. In the north, 39% of the Earth is land, whereas in the south it is only 19%. The southern African climate, in terms of conditions for biota, is moderate, and rich in species. This has been the case for millennia, with southern Africa only experiencing, at coldest, Pleistocene periglacial conditions at high elevations. Not that the climate has always been the same. The southern Cape was 5-6°C cooler 17-21 thousand years ago, while 5-8 thousand years ago it was slightly warmer than today. At that time, the Cape was drier and the Kalahari wetter.

It is these long periods of time with an absence of adverse glacial conditions, combined with various elevations, aspects of slope and nutrient-poor soil that together have been instrumental in generating the high levels of biodiversity. The Cape Floristic Kingdom (the only floral Kingdom within one country) is particularly rich in plant species, with 8 550 species in 90 000 km^2. This is at least as comparable with equal-sized areas in the equatorial forest regions. This richness derives from high species turnover across the land surface (beta diversity). Measured at a scale of 1 000 m^2, the Succulent Karoo has a species density of 113 species per 1 000 m^2 block.

It is against this background that one must consider the threats. Although fire is a natural phenomenon in southern Africa, with lightning strikes reaching over 10 per square km per year, human-induced fires are frequent, accounting for at least 64% of fires in South African ecosystems. Ironically however, it is not excess fire but lack of it that threatens southern African ecosystems. This is because much of the land has been fragmented into smaller patches and is becoming vegetatively senile. Fire is necessary because over the millennia most plants, and the responding animals have become dependent on post-fire ecological conditions.

Fire is largely responsible for maintaining the grassland and open savanna conditions of southern Africa. Savanna in southern Africa comprises 959 000 km^2, 46% of the subregion. This in turn has provided the ecological stage for a wide variety of browsing and grazing animals of all sizes, from grasshopper to giraffe. The indigenous large-hoofed animals had a major and widespread influence on southern African ecosystems. In most areas, these were later shot out, leading to the extinction, for example, of the Blue antelope, last seen in 1799-1800. Domestic animals largely have a similar impact on vegetal communities as do wild game, although with fencing and overstocking, the impact can be severe, especially in arid systems. Many succulents and shrubs do not have soil-stored seeds, which means that even when grazing pressure is reduced, recovery is poor. This situation is aggravated when livestock trampling damages delicate stem and leaf structures, which in turn reduces plant cover and enhances soil erosion. This then can lead to loss of the seed bank, leaving no propagules to re-establish the vegetation cover. When this happens, grasshoppers are lost from the system, and organic nutrients are not returned to the soil in their friable faeces. Sheep faeces, in contrast, are a poor substitute, and largely lock up these nutrients in the hard, dry pellets.

Relatively little of southern Africa has truly arable soil, and in South Africa only 11.4% of the land is cultivated or under permanent crops,

compared with 69% under natural pasture. Although widespread extinctions have probably been few, local extinction has been severe in some groups. Water extraction from rivers has led to considerable reduction in numbers of local populations of the Marbled malachite damselfly (*Ecchlorolestes peringueyi*). This extraction has been synergistic with the impact of alien trout, which eat the larvae.

Deforestation not only fragments populations but can risk extinction of localized forest endemics. The Queen malachite damselfly (*Ecchlorolestes nylephtha*) of the Tsitsikamma Forest needs organic pools in deep forest. It has disappeared from where this closed, natural forest has been opened or removed. This is of great concern because so little of South Africa is forested, with 59% of the Knysna Forest having been felled. It is crucial that the ancient forest patches of southern Africa with their rich, endemic fauna now be left intact.

Although the planting of alien trees, such as pine, amounts to only about 1.3% of South Africa, the localized impacts can be severe, especially to sensitive organisms such as blue butterflies (Lycaenidae), grasshoppers and ants.

As water is such a scarce resource in South Africa, and stream organisms generally sensitive to changed water flow, impoundments can have a major effect, especially when the flow regime is altered. What happens, at least with dragonflies, is that damming of streams and rivers, reduces the rarer species that need flowing water, yet it increases opportunities for widespread, opportunistic species that inhabit still water.

Urbanization in southern Africa is also having an impact. The Critically Endangered velvet worm *Peripatopsis leonina* that inhabited Lion's Hill, Cape Town, has not been seen for the last 95 years. The Brenton Blue butterfly's (*Orachrysops niobe*) last population is threatened by housing development along the Cape coast.

Global climate change will interact with the changes in the landscape. Its effect is unlikely to be linear, with enhanced temperature likely also to be linked with more extreme weather conditions. Predictions are that by 2030 the mean average global temperature, although only likely to increase by 1-3°C, is likely to change rainfall patterns and rhythms considerably. Theoretically, southern boundaries will move south by about 200-300 km. This is at least an order of magnitude faster than most natural changes in the past. This means that plants, and their associated fauna, are unlikely to be

able to track this change, especially as their progression paths have largely been blocked by modified ecosystems.

Similar problems face plants and animals when compensating for increased temperatures by moving up mountains. To compensate for a 3°C increase in temperature, organisms would have to move upwards by 500 m elevation. This assumes that they will be able to tolerate changed ultraviolet light levels, wind currents, rainfall, humidity *etc*. Furthermore, mountains are roughly conical, so less surface space is available to them if they are to move upwards. For the special organisms such as the flightless stage beetles, *Colophon spp*., which live on the tops of the Cape mountains, they may have nowhere to go.

South Africa, in terms of consumption of biotic capital, finds itself about mid-way between the richest and poorest nations. While the average Zimbabwean consumes resources produced by 1-3 ha, and the average Briton just over 6 ha, South Africans are using the equivalent of a little over 4 ha. This is tantamount to South Africa running on an ecological deficit of at least 1-2 ha per individual, and resources being used at least 43% too fast. Clearly, unless serious attention is given to maintenance of biodiversity in southern African, there is likely to be an ecological disaster.

While statistics on areas provide informative generalizations, we need to be aware that southern Africa is endowed with considerable endemic and irreplaceable species and unique ecosystems. 'Irreplaceability' refers to those organisms that if lost from this region, are lost from the world altogether. About 31% of the fynbos (the fine, bushy vegetation of the Western Cape) has been transformed, which is a relatively small figure compared with the extent of land transformation in northern hemisphere

Extinction in South Africa

The following list refers to known or highly probable extinctions of organisms in South Africa as a result of human impact.

Plant	15	Reptiles	1
Insects	4	Mammals	1
Velvet Worms	1		

This is a warning knell as many taxa of all kinds are threatened, making concerted efforts to save them essential.

countries. But such a figure for the fynbos represents an enormous impact on most local species which have limited geographical distributions and highly specific habitat requirements. In South African alone, currently 506 plant species are extinct, threatened or near-threatened. Of the 160 species of dragonflies, 12 are threatened and are totally irreplaceable. This is an indication of the huge transformation of freshwater ecosystems, especially in the Western Cape, where percentage endemism is particularly high.

Proportionate transformation of the Western Cape, a region of South Africa for which there are well-researched figures, has been from agriculture (26%), invasion by alien plants (3%) and urbanization (2%). Indications are that another 30% may be transformed by 2020. Some of the impacts have far-reaching effects, such as increased pressure on water resources, increased opportunities for alien invasive plants, and increased landscape fragmentation. This is illustrated by consumption of water which in the Western Cape is likely to exceed supply within 30 years. Agriculture and urbanization consumes 54% of the available surface water and alien vegetation about 24%.

Ameliorating the threats to biodiversity

South Africa's capacity to produce biological resources has increased by 5% over the last 30 years, through a 30% increase in agricultural land. One ecological cost of this has been to pose greater threats to the irreplaceable species and ecosystems of the region. Proclamation of formally protected areas (game and nature reserves) has helped mitigate this impact, with reserves accounting for 5-6% of South Africa, according to le Roux (2002). While this affords a future (global warming aside) for some vegetation types, ecosystems and species, it is of concern that of the 68 vegetation types in South Africa, 17 are seriously threatened, as over 40% of their extent is transformed.

There have been some major initiatives to increase area, and connectivity between areas, in southern Africa. The joining of the original Hluhluwe and Umfolozi game parks with a major corridor was a bold move. The recent proposals to form transfrontier parks across national borders is another major step for biodiversity conservation in the region.

Parks today are not considered as isolated pockets of protectionism, but part of the social landscape fabric, where local communities work with park custodians towards a win/win situation. Resources such as honey, thatching grass and firewood are harvested from some reserves. A prominent feature in common property resource planning is to involve all stakeholders from

the beginning. At Lake St Lucia, the largest estuary on the east coast of Africa, there were problems with illegal gill netting by local people from three tribal areas. This prompted the introduction of a system of legal, subsistence netting. The communities then developed their own rules as to whom within the communities is allowed to fish, and when and for how long, within the framework proposed by the park authority. An important starting point was to restrict access to the fishery specifically to the local people and to allow them to develop their own set of fishery regulations, with arbitration from the park authorities.

The current approach of involving surrounding communities in the management of national parks and other conservation areas is, in many instances, a radical shift from previous practices where surrounding communities were excluded from park policies and management. Involved communities can reap financial and material rewards by being part of the conservation system rather than being adjacent to one. Parks, in particular, are far less likely to suffer from poaching and other infiltrations when surrounding communities feel that they have a stake in the venture, as opposed to instances when they are not.

The Working for Water Programme is also a major initiative aimed at removal of alien invasive plants. Besides providing a considerable number of jobs, it is improving water security and reducing the effects of fire and flooding.

Another measure aimed at biodiversity conservation without compromising economic output in the commitment by the forestry industry in particular to maintain corridors of natural vegetation between the afforested patches. About one third of the land is set aside and used to maintain hydrological processes and the indigenous biodiversity. These corridors form a network across the afforested landscape, and in so doing, maintain genetic, behavioural and ecological linkage to ensure long-term survival of the organisms and communities. The success to date has been remarkable.

In addition to these regional and landscape-scale activities, there have been many initiatives focusing on particular species. Reversing the population decline of
the white rhino has been a major success. Even invertebrates such as the Brenton and Karkloof blue butterflies have been beneficiaries of specific and concerted conservation measures.

Conservation of the Karkloof blue butterfly

When whole landscapes are conserved this is known as the coarse-filter approach to biodiversity conservation. Sometimes however, it is necessary to overlay the fine-filter approach, where focused attention is given to the conservation of one species. Such is the case with the Karkloof blue butterfly (*Orachrysops ariadne*), with its special relationship with a rare plant and an ant in the mistbelt grasslands of KwaZulu-Natal. The butterfly is also the symbol of the tourist route, the Midlands Meander.

Karkloof blue butterfly

ECONOMIC ISSUES

Increased use of biotic capital means that there will be increased consumption of existing resources, increased degradation of those resources and an increased need to import supplies. As resources decline, so unemployment goes up. Yet all humans require basic resources for sustenance, whether they are employed or not. This means that the on-going consumption, without productivity, will inevitably further impact on biodiversity.

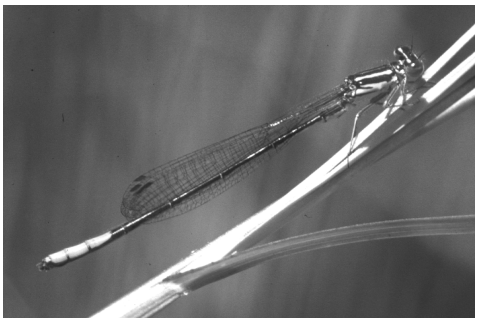
The message here is that to do nothing for biodiversity conservation will have enormous economic and hence social costs. The Working for Water Programme provides some significant insight. Alien invasive plants are costly, with the total annual cost to the USA alone being about US $25 billion. In the Western Cape, a sustained supply of water depends on maintaining the indigenous fynbos plant communities. These communities bind the soil and prevent erosion. Their low biomass uses little water and results in only low-intensity fires, which result in high water yields and low impact on the soil. The montane fynbos catchments fulfil about two-thirds of the region's water requirements, and the ecosystem services play a crucial

role in the region's economy and the gross domestic product. Furthermore, fynbos vegetation is harvested for freshwater flowers, dry flowers and thatching grass, providing a livelihood for about 30 000 people and an annual value of about R25 million.

The alien plant infestations have had a devastating effect on these ecological processes and hence economics. Nationwide, alien plants are using the equivalent of over 200 litres of water per person per day. While it costs only about R100 to remove a hectare of alien plants when the infestation is light, when nothing is done, and the infestation becomes dense, the cost of removal rises to R4 000 per hectare.

Removal of alien invasive trees

Alien invasive vegetation does enormous ecological and financial damage. The far-sighted Working for Water Programme is engaged in removing such invasives. Pictured here is a heavy infestation of alien trees in Mitchell's Pass, Ceres, which has since been removed.



Harlequin sprite damselfly

Alien trees along the water course in Mitchell's Pass, Western Cape

Some extremely rare and localized endemics are benefiting enormously from this programme. The Harlequin sprite damselfly (*Pseudagrion newtoni*) of Mpumalanga almost certainly would have become extinct if alien trees in its habitat had not been removed.

It is often not easy to cost out the value of biodiversity because so many of the benefits are far removed, both in time and space, and often indirect. For example, the annual export revenue of pine timber is about R240 million. Export to the European Union, the main market, depends on fulfilling the stipulations of the Forest Stewardship Council. If trees are not grown in the biodiversity-friendly way, logs are not exportable to Europe.

There are many, as yet untapped and even unknown, financial values to biodiversity conservation. Millennia of evolution have produced a host of biotic processes and products that have potential sources of antibiotics. Genes that control production of these products, as well as novel morphological features, also have considerable economic potential. This has been borne out by the great potential of indigenous silk moths (*Gonometa spp*.) which are considered a valuable natural resource in southern Africa.

While natural organisms cannot be patented, processes, techniques and synthetic analogues can be, which illustrates forcibly that the potential biotic wealth in southern Africa is enormous. The key now is to apply the precautionary principle, which means 'keeping all the parts' should some of these reap enormous financial rewards in the future.

FUTURE PERSPECTIVES: WHAT IS ATTAINABLE?

Arguably the evidence suggests that we are on an ecological Titanic. While all may seem well now, we are living on borrowed biotic capital and the many synergistic impacts inevitably point to a major discontinuity, and a major extinction spasm. Insects alone are estimated to be going extinct at the rate of 7-30 species per week. This is not an alarmist approach but a pragmatic one. We tend to view life through too short a time window. There have been many extinctions in the past, and the massive one 245 million years ago at the end of the Permian when most life forms died out, appears to have been the result of major synergistic impacts. Of course, the difference today is that we humans are the primary, and virtually meteoric, impact.

This is especially significant for southern Africa as on the one hand our water and soil resources are scarce (at least compared to the wealthy north-temperate areas) yet the human population has begun to stabilize. This stabilization in human population levels is not just from increased mortality but also from decreased natality. But a smaller, wealthier population is also likely, per capita, to put more demands on the relatively scarce resources. Such wealth comes about from trade. Resources that are scarce are brought in, and the very activity of trade places heavy demands on natural resources. This is illustrated by the human node we call the city, which is a nett importer of diverse resources often from distant locations.

We must see ‘sustainability’ as more than just a politically correct expression, with ‘non-sustainability’ like ‘murder’, being whispered as something shocking and socially unacceptable. We must seriously gauge the realities of what sustainability actually means in terms of biodiversity and human survival. The changing human demography in southern Africa is likely to alleviate pressure on biodiversity but, the juggernaut of synergisms and global warming is rolling on. This will have a major impact in southern Africa because much of the endemic biota is confined to small geographical areas, particularly mountain tops.

This may seem a bleak picture, but in terms of history of the planet it is not unusual. Only the causal agent is different. Let us remind ourselves again that most forms of life that ever existed are extinct. We are entering a new ecological phase in the history of the planet. It would be unethical to think otherwise. We can do our best to mitigate against, and buffer, the change. But there is only one real certainty in life, and this is that there will indeed be change.

Inevitability of change

In the history of life, there have been five mass extinctions. We are entering the sixth, and its cause is us. About 99% of all species that ever existed are now extinct, but most of the extinctions occurred between these catastrophic drops. Past extinctions have largely occurred when various adverse factors have been synergistic. This leads to a discontinuity, when ecological conditions change dramatically and quickly. While we may do our best to lessen these changes, and reduce extinctions, it is inevitable that massive ecological, social and economic changes will take place. This is largely because the stage is already set – we are on board an ecological Titanic. Re-establishment of the same level of biodiversity is likely to take 5-10 million years.

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Chapter 5

MEDICINAL PLANTS

Lyndy McGaw, Anna Jäger, Olwen Grace, Catherine Fennel & Johannes van Staden

INTRODUCTION

Healthcare in southern Africa is almost exclusively polarised between Western and traditional African healthcare systems, but a spectrum of healthcare options (*e.g.* complementary therapists, faith healers) occur between them. Although government health services in the region provide only Western therapy, the majority of people in southern Africa consult traditional healers for some or all of their healthcare needs. Since plants total some 85% of southern African traditional healers' *materia medica*, medicinal plants play a fundamental role in meeting the healthcare needs of people in southern Africa.

Population growth, urbanisation and increasing demands on traditional healthcare have resulted in a scenario where the supply of medicinal plants from the wild can no longer meet demands. The multi-million Rand trade in traditional medicine plants, and industries that rely on wild harvesting (such as essential oils) generate these demands.

The Flora of Southern Africa (FSA), encompassing Namibia, Botswana, Swaziland, South Africa and Lesotho, is well known for its richness and diversity of plant species. Approximately 22000 species are native to the subcontinent (as well as 900 species now naturalised) and represent a remarkable 10% of the earth's flora, yet it harbours the highest concentration (a further 10%) of threatened plants in the world (Marshall, 1998). Nearly 4 000 species are used medicinally in the region (Arnold, Prentice, Hawker, Snyman, Tomalin, Crouch & Pottas-Bircher, 2000), but they are threatened by overexploitation; traditional healthcare in the region is largely dependent

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upon their sustainable use. Statistics show that the cultural importance of traditional medicine drives the demand for traditional plant products, whether Western and alternative therapies are available or not.

A number of economic and ethical issues are raised when addressing concerns surrounding the use of medicinal plants in southern Africa. The economic value of the traditional medicines market is significant and the sustainable use and conservation of these plants must be carefully controlled. The possible incorporation of traditional healers into the primary healthcare system would be a monumental undertaking, but would bear considerable economic advantages in countries with overburdened Western healthcare systems. In considering the commercial development of medicinal plants, the issues of bioprospecting and intellectual property rights raise contentious ethical debates which must be resolved as a matter of urgency to ensure maximum benefit to both the community and the environment. Bioprospecting is often justified as an incentive for the conservation of biological diversity and as a means of development for poor countries, but in reality this has thus far not materialised to an acceptable extent. Issues such as these with closely entwined economic and ethical aspects require pressing consideration, not only by policy-makers in government, but also local communities, non-governmental organisations (NGOs) and the private sector.

ETHICAL ISSUES

Holistic traditional medicine versus Western biomedicine

It could be said that the major difference between traditional and Western medicine is the lack of a psychological element in the latter. Western health personnel undergo scientific training, and the care they give is based on scientific convictions. Western medicine is based on the underlying principle that drugs and treatments have been objectively and scientifically evaluated. This dependence on science implies that Western medical treatment targets the underlying biomedical problem. Any beneficial effect that could be achieved by influencing the patient's mind is regarded as unscientific.

Western medicine is based on the underlying principle that drugs and treatments have been objectively and scientifically evaluated.

Traditional medicine is based on an "holistic" approach based on medicinal and psychological therapies.

A traditional healer is trained during his or her apprenticeship to use perceptive powers, which are employed firstly in detecting the cause of an illness and secondly in providing a holistic treatment. This treatment might consist of medicinal and psychological therapies dispensed with social and cultural understanding. The patient often plays an active role in the treatment, in contrast to Western methods, where the patient mostly remains passive during therapy (diagnostic, surgical and therapeutic procedures). While Western biomedicine is in many respects superior to plant medicines, the traditional healer is often able to obtain satisfactory results on the basis of holistic treatment.

Traditional, alternative and complementary medicines have their greatest impact in holistically treating the patient. Non-Western systems harness the enormous power of the mind of the patient. By employing a combined medical, psychological and cultural approach, often with the patient's active participation in their own recovery, the healer is able to obtain results that could not have been achieved using plant medicines alone.

Traditional medicine as a component of primary healthcare

In recent years there has been a massive development in the Western healthcare sector, which is now reaching rural areas that previously lacked Western medical facilities. However, from a socio-political viewpoint, the value of traditional healthcare has not been underestimated, even if financial resources have been scarce. It is estimated that there are more people working in traditional healthcare than in the Western system. By sheer numbers and by being located where people live, as well as their familiarity with the cultural and socio-economic situation of patients, traditional healers are well suited as primary caregivers - a role which they have fulfilled since ancient times.

There have been calls from various sides to integrate traditional and Western healthcare systems into a single primary healthcare system for South Africa, a concept that, at first glance, can be appealing. Many traditional healers have expressed an interest in working towards an integrated system. However, Western-trained medical staff are less likely to favour working with traditional healers, whose treatments they may not understand or approve of. Added to this, medical doctors are legally and ethically prevented from referring patients to traditional healers, although healers will often refer a patient to a health clinic or doctor if the assistance they can supply is limited in a particular case. This means that the referral of patients will continue in a one-way direction. Perhaps there will be increased acceptance after more intensive scientific evaluation of the efficacy and safety of medicinal plants prescribed by traditional healers. Despite the fact that both traditional and Western healthcare practitioners have a common aim in helping patients, the two systems are fundamentally too divergent in their views for any meaningful integration to occur today. It can be hoped that better understanding between the systems will develop in the future.

Possibly the most pertinent laws and recommendations would encompass the preferences of patients themselves as the users of health services. Many diseases of psychological origin are culturally determined and a patient would not trust the capability of a Western health practitioner to successfully treat the disease, or even recognise and understand it. A study in Kenya investigated this question in some depth. Patients distinguished between the types of health practice they required for particular diseases. The clear result of this study was that patients preferred two health systems, not an integrated one. A similar situation was observed in Zimbabwe concerning treatment of infants with diarrhoea. Depending on the symptoms of the disease, the mothers of afflicted infants decided on the appropriateness of consulting a health clinic or a traditional healer. The majority of patients in southern Africa are likely to reach a similar conclusion, preferring a degree of cooperation between the systems, but in essence remaining with the choice of two independent systems.

How can traditional medicine be improved?

As an important part of primary healthcare it is necessary to evaluate how traditional medicine can be improved. Due to the political situation of the previous century, there are today 200-300 associations of traditional healers in South Africa alone. This situation has reduced the political influence of the largest health system in the country. The formation of a National Council of traditional healers might not be easy, but would provide a platform for improvement of traditional medicine on its own conditions,

setting realistic and acceptable standards. Registration of traditional healers, ensuring that only healers with certain approved qualifications are accepted, will go a long way in providing patients with the confidence that they will receive qualified treatment.

Although medicinal plants constitute only part of the holistic treatment provided by traditional practitioners, their importance cannot be underestimated. Research into the efficacy and potential toxicity of medicinal plants is required. Over the last decade many resources have been poured into research on medicinal plants, but very little of this work has resulted in practical applications or improvements in traditional medicine. This research must be more focused on the needs of people relying on traditional medicine. National research funding bodies (such as the Medical Research Council (MRC) and National Research Foundation (NRF) in South Africa), preferably in alliance with a National Council of traditional healers, could contract work to channel such research. A major priority is the safety of traditional medicines and treatment methods, so comprehensive toxicity studies are high on the list. The traditional preparation, which often consists of several plants, must be evaluated in its entirety for efficacy. In many cases it must be possible to reach a stage relatively quickly where clinical trials can be carried out, on the same ethical basis that 'natural remedies' in Europe undergo clinical trials. The knowledge on safety and efficacy obtained by research should be disseminated to healers all over the country. A National Body of traditional healers could potentially have a major role in distributing information to its members.

In a survey of patients in Durban, South Africa it was found that nearly all would prefer healers to have more modern and hygienic consulting rooms. Ninety nine percent of the patients interviewed would also prefer safer and hygienically packaged plant medicines (Mander, 1998). There is clearly a market in southern Africa for indigenous phytomedicines. These should be free of adulterants, and should preferably be standardised (with one dose containing a certain quantity of active compounds), so the pharmacological action can be predicted. Presently, several private initiatives are venturing into this field.

LEGAL ISSUES

Bioprospecting and intellectual property rights

Bioprospecting of plants entails the search for economically valuable resources originating from the flora of a country. This has often taken the form of 'biopiracy', or the appropriation, either open or undisclosed, of biological material without acceptable compensation to the original indigenous owners of the material or knowledge. In a positive sense, bioprospecting can make a valuable contribution to sustainable development, as it provides incentives for local communities to conserve biodiversity. Also, it is a potential source of income for developing countries that are unable to fully develop the commercial potential of their genetic resources.

Intellectual property rights (IPRs) such as patents, plant variety protection, copyrights and trademarks, have been defined as exclusive monopoly rights over a creation that society provides to the inventor for a period of time. This monopoly protection obviously restricts the dissemination of knowledge, but this is supposedly counterbalanced by the incentive that it provides to innovate. However, IPRs do not automatically help to encourage or reward innovation. It has been suggested that the type of rights Africa needs are not IPRs, monopolised through privatisation, but rights that support local communities and indigenous people. Clearly, the topics of bioprospecting and IPRs are a combination of legal, ethical and moral issues (see Chapter 8 for a detailed discussion of these issues).

> **Bioprospecting** is the search for new and useful substances, such as medical compounds, from natural resources. This often takes advantage of traditional knowledge, which should be rewarded by equitable compensation and protected by ethical intellectual property rights.

There is growing interest in untangling the threads of complicated bioprospecting legislation in developing countries. Large, commercial companies logically prefer to avoid the negative publicity of being seen to indulge in underhand, unethical activities, and developing countries are increasingly recognising the potential value of their bioresources. A major obstacle to the evolving legislation is dealing with the existence of customary law in the African context. This law does not recognise private proprietary rights but rather community resource rights. All resources are viewed as belonging to everyone, and they are regulated by the community's

cultural and local knowledge systems. Regarding the issue of compensation for commercialisation of this knowledge, the borders of the community need to be defined to ensure that all involved parties are included in sharing the benefits.

The protection of traditional knowledge and biodiversity is an important aspect of sustainable development, and needs to be decided by communities as customary laws are now seen to be inadequate. Intellectual property policies and laws are shifting such responsibilities to governments. The development of biotechnology and potential profits from traditional medicinal plant knowledge has resulted in trade policies that are biased towards first world corporations and institutes. This has impacted directly on the World Trade Organisation (WTO) and national trade policies. A lack of ethical considerations with regard to bioprospecting leaves indigenous communities without control and feeling cheated. Discussion at the Second South Biopiracy Summit hosted by Biowatch South Africa prior to the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg, to make corporations and governments more responsible and accountable, is extremely relevant.

The Convention on Biological Diversity (CBD) and Trade-related Aspects of Intellectual Property Rights (TRIPS)

The Convention on Biological Diversity of 1992 recognised that countries have the right of ownership of the biological resources within their borders, and also that local communities have the right to seek compensation for their knowledge of biodiversity. Guidelines proposed at the Convention, which have been ratified by 178 countries, regulate the transfer of biological material across national borders.

The 1995 WTO Agreement on Trade-Related Aspects of Intellectual Property Rights on the sovereign rights of states over their natural resources, as enshrined in the CBD, has been controversial since inception. The CBD upholds the concept of governments or communities within countries maintaining the intellectual property rights to their indigenous diversity and any constituents obtained from them. The WTO on the other hand states that intellectual property rights belong to the inventor of the technology, following a profit-based system. This lack of consensus, as well as the extent to which the knowledge, innovations and practices of indigenous and local communities should be eligible for intellectual property protection, has been a cause of major controversy in recent years. The TRIPS agreement does not

require the lawful acquisition of any material used during the innovation process. TRIPS and most patent laws do not require an inventor to disclose the country of origin of biological material used in the development of a new pharmaceutical. Another feature of the agreement is that WTO members may exclude various categories of genetic material from patentability, or they may alternatively grant patent protection under more restrictive conditions.

In 2001, the Council of Ministers of the Organization for African Unity (OAU) adopted a "Model Law for the Protection of the Rights of Local Communities, Farmers, Breeders and Regulation of Access to Biological Resources". This aims to assist African countries in fulfilling their obligations to TRIPS and the CBD. It also acts as a framework for member states to develop specific national legislation concerning access to biological resources and the rights of local communities, consistent with their policies, national objectives and level of socio-economic development.

Biodiversity is not a free resource. According to the Convention on Biological Diversity (CBD) of 1992, it belongs to the country in which it occurs, and local knowledge of it is owned by communities. In contrast, the World Trade Organization (WTO) recognises only ownership of technology, rather than knowledge. Southern African countries are presently under the guidance of the Organization of African Unity (OAU) in fulfilling obligations to both agreements.

ECONOMIC ISSUES

The value of medicinal plants

Trade in indigenous herbal remedies has flourished over the years despite legislative measures and law enforcement. It is estimated that 80% of the population in southern Africa relies on traditional medicine as a basic commodity. Plants are carefully chosen for specific characteristics, their symbolic value and for the form in which they are to be taken. For the majority of people who consult traditional healers or self medicate, rather than visit the proportionately fewer Western university-trained doctors, plant remedies are more accessible and, except in cases where pharmaceuticals are subsidised by the government, cheaper.

Medicinal plants have become an important commercial resource in southern Africa. Statistics for other countries in the region are lacking, but it is generally perceived that trends observed in South Africa are similar in other parts of the region. About 700 plant species are traded in South Africa; most are indigenous, although a few exotic species are traded, including substitutes for rare plants that are imported from India. At the two major nodes in southern Africa's medicinal plant trade, some 400 species are marketed in large quantities in KwaZulu-Natal (Mander, 1998) and 500 in the Gauteng area (Williams, 1996). This amounts to 20 000 tonnes of plant material, traded on a national level, with between 900 and 1 500 tonnes consumed in the city of Durban alone (Mander, 1998).

Current marketing practices are affected by several factors. Generally, street markets are more expensive than rural markets; followed by wholesalers and then shop traders and healers - each adding a substantial mark-up on the raw product. Packaged and semi-processed products sold by wholesalers may have a mark-up of 1200% while those prescribed by healers are nearly 20 times more expensive than medicines bought at markets for self-medication (Mander, 1998). The scarcity of popular plants has affected supply, with the result that prices for these plants have increased. Thus, while medicinal plants that are commonly available are sold in large quantities relatively cheaply, some plants, like *Siphonochilus aethiopicus,* are more expensive and therefore cut and sold as smaller affordable pieces. In the Gauteng area, where gatherers no longer visit traders, costs have increased because the traders have been forced to purchase plants elsewhere. It is generally thought, though, that prices are affordable. Households spend between 4-8% of their annual income on traditional medicines. In KwaZulu-Natal, this generates US$13.3 million (or R130 million). Some estimates are even higher. Based on the conservative assumption that 30% of the population spends R10 a year on traditional medicines, the market for medicinal plants may be worth more than R135 million a year. This is a significant amount of the total market in South Africa, which is conservatively estimated to be in the region of US$60 million or R600 million. Thus the trade in medicinal plants, be it informal, forms part of a multi-million rand 'hidden economy'.

> Approximately 80% of people living in southern Africa use traditional medicines. There is a well-developed but largely informal trade in plant medicines to supply traditional healthcare, with a value of US $60 million. The medical plant trade has great potential for development that could empower southern Africa in the estimated world market.

Despite the fact that few efforts have been made to develop the current market, a growth in demand for medicinal plants, both locally and internationally, is expected. The local medicinal plant industry has the potential to benefit economic and social development, especially in the empowerment of black women whose only source of income is that earned from the sale of plants. Internationally, bioprospecting has become a multi-billion dollar business which has resulted in growing interest from pharmaceutical companies for novel drugs from plants for both the African and overseas markets. With the rich biodiversity of the south comes a competitive advantage. The exchange of genetic material may be important for developing regions like southern Africa as it trades resources on the world market in exchange for the new technologies of industrialised countries, in what is sometimes referred to as the 'Grand Bargain' (Wynberg & Laird, 1997).

Continued trade is, however, dependent on conservation, since overexploitation is expected to lead to a decline in resources. Scott (1993), predicts this to mean a loss of 50 000 plant species, which, in economic terms, represents a loss to the pharmaceutical industry of 25 prescription drugs with a market value of US$25 billion. This is certain to have a negative impact on both the welfare and economy of the people in southern Africa who use traditional medicines. The most likely scenario is for the business sector to lead developments in the market. Only when consumers, market players and industries are supported will the medicinal plant industry result in economic growth, social development and biodiversity conservation.

CONSERVATION ISSUES

Conservation and protection of medicinal plants

The flora of southern Africa is threatened by exploitation for a multitude of uses, including grazing, fuels, timber and medicines. The current rate at which medicinal plants are used cannot be sustained, due to the combined effects of the decline in natural vegetation, and increasing consumer demands that drive the lucrative trade in plant medicines. At risk of over-simplifying the scenario, two key issues arise in the context of this discussion: medicinal plants must be secured for their critical role in traditional healthcare, and the impact of traditional healthcare on the southern African flora must be reduced.

Historically, traditional medical practitioners harvested medicinal plants to meet the needs of their practice, with little impact on natural resources. Today, however, many rely on the medicinal plant trade for herbal medicines. Among the many reasons for this are the depletion of natural vegetation caused by urbanisation and agriculture, and population growth that has made their practices busier. For instance, travel time to collecting localities of some popular but increasingly scarce species increased by 45% between 1988 and 1996, whilst others became available exclusively on import from neighbouring countries. When traditional medical practitioners do not harvest medicinal plants personally, herbal products are purchased from gatherers, urban retailers, herbalists and market traders. Gatherers are typically women who harvest the largest volumes of medicinal plant products, to be sold directly to practitioners and herbalists, to retailers and informal traders, or sometimes traded informally themselves. They occupy the base of the trade pyramid but, because of their precarious socio-economic situation, cannot afford to practice sustainable collecting methods that may reduce their harvest. Traditional methods of harvesting have given way to ones that allow larger volumes of material to be gathered as quickly as possible, but with increasingly harmful effects on the environment. For example, a small hand-held tool was traditionally used to harvest bark from trees, but an axe or cane knife, that can inflict far more severe damage on a tree, is more commonly used today. The traditional healthcare sector has grown into a large-scale commercial industry, supplied by a complex trade network that threatens the very resources on which it depends.

The supply of medicinal plants is not a problem intrinsic to traditional healthcare, but is more serious in southern Africa than elsewhere on the continent. Southern African systems of traditional healthcare make use of plant products with a long shelf life, including bark, roots, bulbs and seeds, whereas leaves are most commonly used in other regions of Africa. Storability is important in southern Africa, as a lengthy time period may lapse between harvesting and sale of plant products, but harvesting is more likely to damage or kill the plant than if leaves were removed. Like most ethnomedical systems, traditional healthcare in southern Africa is closely linked to natural resources within a worldview that values all elements of the landscape. Due to their cultural importance in maintaining a relationship with the ancestors, plants are crucial for the reinforcement of tradition. Protection of vegetation – both natural and cultivated – at burial sites is common, and many beliefs and taboos associated with plant collection may be interpreted as conservation measures. Purposeful conservation practices are traditionally implemented by community leaders and enforced by community headmen and policemen. Customary law dictated sustainable

patterns of land tenure and resource use in communities, but involvement of the commercial sector in medicinal plant harvesting has altered customary practices. Likewise, conservation efforts in communities and areas protected by legislation are now frequently disregarded because of the lucrative demand for commercial harvesting. In recent times, customary principles have been promoted as an aspect of community conservation, where communities are encouraged to manage their natural resources in conjunction with governmental and non-governmental agencies.

Sustainability broadly refers to the use of resources to meet present needs, without compromising the ability of future generations to meet their needs. Overexploitation for medicinal purposes is seldom the only factor affecting the sustainability of plant resources: land use changes, commercial trade in medicinal plants, and other significant factors contribute to the threat. The problem of a non-sustainable supply of medicinal plants therefore needs to be conceptualised and addressed within a multi-faceted approach, including historical and socio-economic problems, as well as depleted natural resources and projected demands on them. The effects of overexploitation on medicinal plants are far-reaching: the impact on biodiversity extends in a 'downstream' effect on communities and, at the individual level, patients of traditional healthcare. A reduction in the quality of life of those communities and the exaggeration of poverty in rural areas are ultimate consequences. Inevitably, the loss of potentially valuable genetic resources affects the whole of society. To secure the medicinal flora of southern Africa, an effective solution must be found to meet the often conflicting needs of consumers and conservation.

Natural resources cannot meet current, or foreseeable, demands for medicinal plant products, and the medicinal flora of southern Africa shows obvious signs of stress as a result of overexploitation. Nearly 160 species used in traditional medicine satisfy IUCN (The World Conservation Union) criteria for Red Data List status. Sixty-two species are locally extinct in the FSA region. For example, *Warburgia salutaris,* source of a very popular and valuable medicinal bark, is extremely rare in KwaZulu-Natal and extinct even within the boundaries of protected areas. Another important medicinal plant species, *Siphonochilus aethiopicus*, is extinct at the provincial level. Trade figures from the province of KwaZulu-Natal in South Africa, an important hub in the southern African medicinal plant trade, indicate that conservation measures have not been successfully implemented in the past: nine of the ten most-traded plant species are, in fact, banned from harvest or purchase without permits and are Red Data Listed. Legislation protecting and regulating the use of plant species in southern Africa is generally less

rigorous than for animal species, non-existent, or people are ignorant thereof. Neither policy nor legislation can be effective in sustainable management without physical reserve management, but conservation policies that relied heavily on law enforcement have been largely ineffectual and politically non-sustainable in the past. Policing – where natural resources are guarded from people – remains a common approach to conservation in southern Africa but, in many parts of the subcontinent, natural resources will be harvested irrespective of whether it is permissible or not. Successful conservation therefore lies in the sustainable use of existing natural resources but, since the demand for medicinal plant products cannot be met by *in situ* conservation alone, alternatives to wild harvesting are needed.

Perhaps the most obvious alternative to harvesting medicinal plants from the wild is to grow them. The need to cultivate popular indigenous plants was first suggested nearly 60 years ago and trials have shown good potential to meet demands and lessen the effects of the medicinal plant trade on biodiversity. Since then, however, commercial cultivation of medicinal plants, particularly slow-growing trees, has been largely neglected due to a lack of farmers' understanding of marketing and cultivation economics. Conservation-through-cultivation, in accordance with guidelines of the World Health Organization (WHO), the IUCN and the World-Wide Fund for Nature (WWF) (Anon., 1993), allows simultaneous *ex situ* conservation of medicinal plant species and *in situ* conservation of natural populations in their habitats. Indeed, the reintroduction of cultivated plants to their natural habitats where they are locally extinct is set to become an important conservation tool in the future. Among the merits of using cultivated rather than wild-harvested plants is that inconsistencies in the quality and composition of medicines are reduced, safety improved and probabilities of inappropriate use lowered. Management practice aimed at sustaining other plant harvests, such as timber and fuel wood, shows great potential as an alternative to wild-harvested medicinal plant products. Orchestrated timber and bark harvesting, using efficient techniques, could result in fewer trees being felled and less damaging effects on indigenous forests. Plant part substitution is another useful alternative to non-sustainable harvesting: leaves and twigs are harvested instead of less sustainable products like bark, bulbs and roots, to reduce the damage inflicted by harvesting. It is well known that within one plant species, different organs contain similar chemicals and therefore show the same medicinal efficacy. Laboratory investigations have demonstrated this in the bark and leaves of two very popular and critically threatened tree species, *Ocotea bullata* and the aforementioned *Warburgia salutaris,* respectively. In KwaZulu-Natal, South

Africa, some traditional medical practitioners grow young trees of these species to produce high leaf yields that are used instead of bark.

In the past decade, interest in the overexploitation of medicinal plants in southern Africa has grown, and questions of conservation, usage regulation, sustainability and alternatives to wild harvesting are receiving increasing attention from all scientific angles. Threats to southern Africa's medicinal flora could be dealt with through resolute conservation policy and harvesting pressure on natural resources relieved by sustainably-managed or cultivated resources. By securing the medicinal plants of southern Africa, the future of traditional healthcare in the subcontinent is assured.

The use of medicinal plants in southern Africa is not sustainable at current rates of exploitation. At present, nearly all medicinal plants traded and used in traditional healthcare are wild-harvested. The consequences are species extinctions that, in turn, impact on medicines used in traditional healthcare. Conservation of the environment, and cultivation of plants to supply the medicinal plant trade, will help meet the needs of both the flora and the people of southern Africa.

DISCUSSION VIEWPOINT

Traditional knowledge protection and conservation of biodiversity must take into consideration communal land rights, collective ownership of traditional knowledge, and indigenous resource management systems. The OAU Model Law provides a basis for national consultation, but local communities themselves must define the rights that govern their resources and knowledge. Non-governmental organisations (NGOs) have an essential role to play in assisting rural communities to make their voices heard in the policy-making process. NGOs can also help to develop innovative approaches to the problem, including income-generation programmes for communities, development projects and ideas for shared management. It is a high priority to encourage collaborations between interested parties, leading to constructive development without exploitation. The formation of a National Council representing the interests of traditional healers could ensure that the healers possess a forceful bargaining arm in future bioprospecting deals. Government should play a major part in encouraging

conservation and sustainable utilisation of resources through community participation. This can be achieved by providing loans, consultations and technical advice to local people to encourage cultivation of medicinal plants and value addition at community levels. The economic potential of bioprospecting can be pivotal in attracting necessary investment from the private sector. Private companies can stimulate local industry by forming collaborations to develop herbal and pharmaceutical products.

It is important for research and development efforts to focus on the value-addition and sustainable utilisation of medicinal plant resources to avoid countries becoming bulk exporters of cheap crude materials, leading to the rapid depletion of medicinal plant resources. Prime objectives should be to supply the medicinal plant sector with a strong scientific base, and to develop skills, raise awareness of all participants, add value to the resource and contribute both to the socio-economic welfare of communities, and conservation of the precious resources. From time to time, the status of resources should be surveyed and a socio-economic assessment of the local community should be undertaken to evaluate the overall impact of bioprospecting practices. In southern Africa new laws to control bioprospecting and to protect traditional knowledge are currently being drafted but it remains to be seen whether these will be sufficiently progressive to deal with all aspects of this sensitive issue.

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Chapter 6

ANIMAL RIGHTS AND ANIMAL WELFARE

Theresa Coetzer and Dean Goldring

INTRODUCTION

Animals interact daily with each of us as they sing a dawn chorus, provide us with companionship, food and sustenance (draft animals) and wild animals fascinate us in their natural environment. South Africa has eleven official languages, reflecting the country's ethnic and multi-cultural diversity. The way in which animals are treated is often closely linked to individuals' cultural and religious backgrounds. It is incumbent on each one of us to respect animals. This chapter is an introduction to help the reader become aware of and acquainted with animal ethics and animal welfare in the work place and home environments.

ETHICAL ISSUES

Differences between animal rights and animal welfare

Animal rights - animals are considered to be sentient beings (*i.e.* they are conscious and feeling creatures) with inherent value and are therefore entitled to the moral concern of humans. The key issue to the assigning of rights is the acknowledgement of the intrinsic value of animals. This does not ask that animals be treated like humans, but that their species-specific interests be honoured, otherwise this would just represent another form of

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anthropocentric thinking. The implied direct moral obligations that man has to animals are contrary to traditional indirect obligations, where humane treatment of animals only stems from a person's respect for the animal's owner or for other people's sensitivities to cruel treatment of animals.

Animal rights: animals are considered to be sentient beings with *inherent value* and therefore are entitled to the moral concern of humans.

Sentient beings: animals that demonstrate perception and feeling.

Animal welfare

Whereas acknowledgement that animals have intrinsic value is a prerequisite for assigning rights to animals, it is not necessary to accept such rights for the sake of animal welfare - it is only sufficient to acknowledge that we have certain duties to animals. Therefore animals do have rights; they are entitled to humane care.

Animal welfare: acknowledge that a`nimals have an intrinsic value.

The moral status of animals

The concept of animal rights originated from the notion that animals deserve moral consideration as articulated by Tom Regan in his book *The Case for Animal Rights* (Regan, 1984). According to Regan (1984), animals have the right to be treated with respect as sentient beings with inherent value. All beings that have inherent value, have it equally (egalitarian view). This viewpoint that the equal interests of all beings subjected to a particular action must be viewed equally constitutes the first principle of utilitarianism. The second principle is an acceptance of utility, *i.e*. to do that which will bring about the best compromise between contentment and frustration for all affected by the outcome of the act. It is therefore not equal treatment, but equal view of their abilities to perceive their surroundings, most importantly their ability to suffer, that is important. In the words of the founding father of utilitarianism, Jeremy Bentham on animals, "The question is not, Can they reason? nor Can they talk? but Can they suffer? (Bentham, 1962).

The question about the moral status of animals is akin to the declaration of human rights. There are certain human rights that apply to every human being irrespective of race, sex or culture, because there are no moral grounds for treating men and women of different races unequally. The question arises whether visible differences between humans and animals include morally relevant features that justify unequal treatment.

People who sympathise with the animal rights view in the Regan mould are committed to a total disbanding of commercial animal agriculture, total abolition of the use of animals in research and total eradication of commercial and sport hunting and trapping. A slightly tempered version of utilitarianism applied to animals is found in Peter Singer's writings (Singer, 1975), such as his seminal work Animal Liberation. This Australian philosopher and one of the fathers of the Animal Rights movement condones the use of animals in experiments that have a chance of curing a major disease. However, in considering whether such experiments are justifiable, scientists must also be prepared to use a mentally retarded human being. This does not propose the use of human in experiments, but is a test of the importance of the experiment, because the willingness to use an animal rather than a human is a case specieism that is morally as deplorable as racism and sexism. People prescribing to both schools of thought may choose not to eat animals (vegetarians) and not to use their products, such as eggs, milk and leather (vegans), but for different reasons. The former group sees using animals as a food source as a violation of animals' rights to be treated with respect. The latter group will not consume animal products unless the animals suffer in no way, *i.e.* live free and under stress-free conditions (free ranging chickens and cattle grazing in meadows) and are killed in a humane fashion.

Philosophers have generally held the view that impartiality is required when considering ethical issues. However, it is appreciated that decisions are not made on the basis of reason alone, but that emotion enters the equation. This element of sympathy is essential when considering how we treat animals. In many instances the attitude that people have towards animals may stem from their distance from the farm and laboratory. Relatively few people have first-hand experience of commercial farms or research laboratories. This makes people oblivious of the route their meat takes to the table, thereby mediating the responsibility for their actions. People who grew

up on farms tend to view animals as objects that can be used, while pet-owners are more emotionally involved with their animals.

Animals in agriculture

Since the earliest times, cruelty to animals (that is the deliberate, sadistic, useless, unnecessary infliction of pain, suffering and neglect on animals) has been prohibited. The Bible prohibits the yoking of an ox and a donkey together, because the donkey being the weaker of the two will suffer unduly. Civilised societies condone cruelty to animals and this forms part of their consensus social ethics. Over the past fifty years there has been a shift in Western Societies (UK, Europe, North America and Australia) that the consensus social ethics encompass more than cruelty to animals.

What brought this change about is the change in the use of animals from purely agricultural to areas such as research. Animals were domesticated almost exclusively for use as traction power, or to use animals and their products as sources of food, fuel or clothing. It could be viewed that there was some form of "social contract" between man and animals in a mutually beneficial relationship. Man provided food and protection against the elements and predators and in turn animals provided food, fibre and work power. Traditional agriculture had at its core good husbandry, *i.e.* keeping animals under their natural conditions and enhancing their well-being by providing the necessary protection and nutrition. Self-interest and taking care of animals were thus intertwined and there was no need to have laws against animal abuse in agriculture. The anti-cruelty ethic and accompanying laws (UK Animal Anti-cruelty Act of 1822) were sufficient to deal with any unnecessary or deliberate cruelty to animals.

Since World War II there has been an exponential increase in biomedical research, especially drug production that uses animals in experimentation (see later), as well as a dramatic increase (five-fold in thirty years) in industrialisation of animal agriculture. The decrease in farm workers with a concomitant increase in numbers of animals necessitated improved technology to keep large numbers of animals in environments that are most conducive to increased productivity, *e.g.* laying hens in battery cages. This practice of keeping large numbers of animals in confined spaces was only made possible by the development of vaccines and the use of antibiotics.

Although increased urbanisation of society on the one hand necessitated intensive agriculture for adequate food production, the realities of confinement agriculture caused public outcry. The power of public perception is probably best illustrated by the promulgation of legislation in

Sweden in 1988 that limits confinement agriculture in that country to a large extent as a result of lobbying by the children's author Astrid Lindgren (Rollin, 1995). An entirely new set of ethics and accompanying laws thus needed to be developed to encompass the new uses of animals. Scientists and farmers are not deliberately cruel to animals, in fact anticruelty laws do not pertain to animals used in research. The first laws pertaining to the use of animals in research was the UK Cruelty to Animals Act of 1876 that was amended in 1986 with the promulgation of the Animals (Scientific Procedures) Act.

ANIMAL RESEARCH AND EXPERIMENTATION

History of the use of animals in research

Animals are mainly used in experimentation in the fields of biological, medical, veterinary and agricultural sciences. In the latter three fields, animals are mainly used in experiments designed to collect data that pertain to and are useful for the animal species used. In the medical field, which is also the largest user of animals in experimentation, animals are mainly used to model human diseases or as a substitute for man.

As early as 400 B.C. vivisection (cutting into living organisms) was practised by Greek philosophers, laying the groundwork for medical research. Studies were mainly anatomical and later supplemented by physiological studies by the Roman, Galen (130-201 A.D.), who described the functions of blood from his studies on apes and pigs. Experimental medicine and biology was only revived again during the Renaissance period with, amongst others, Harvey's empirical studies on the function of lungs. During this period animals were not considered to be sentient creatures. Descartes (1596-1650), a French philosopher and idealist, suggested a mechanical approach to the understanding of living organisms. Animals were described as differing from man because of the absence of a soul and thus consciousness. He also argued that animals cannot form statements by which they make their thoughts known and they do not act from knowledge, only from the disposition of their organs. He concluded that animals had no capacity for reason and, like machines, could not feel.

Although Leonardo Da Vinci predicted as early as the late 14th century that experimenting on animals will one day be considered a crime, it was only in the 16th century that Voltaire (d 1778) ridiculed Descartes' notion that speech gives living beings the ability of thought, feeling and memory and he maintained that animals and man have similar behavioural trends.

Publications by Bentham (1962) (described earlier in the chapter) and a Mr Feltham were not in line with popular opinion of the time, that man was using his God-given right (Genesis 1:26 And he said let us make man to our image and likeness; and let him have dominion over the fishes of the sea and the birds of the air, and the beasts and the whole earth and every moving creature that lives on the earth) to use animals freely in various ways. Introduction of the British anti-cruelty act in 1822 led to the founding of the RSPCA (Royal Society for the Prevention of Cruelty to Animals). England was the first country to make laws against using animals in experimentation with the publication of the Cruelty to Animals Act in 1876. It permitted painful experiments on animals only for special purposes and under certain conditions.

At the end of the nineteenth century animal experimentation increased dramatically. This was due to a number of discoveries and publications. Anaesthetics were discovered around this time and used in animal experimentation. Charles Darwin published his Origin of Species in 1859, emphasising the evolutionary progression from animals to man and thus endorsing the use of animals as a model for man. However, Darwin was not happy that animals suffered during experimentation. The emergence of microbiology in the 1880's emphasised the importance of using animals to produce antisera against infectious microbes and to test the safety of vaccines.

An exponential increase in the use of animals in research was brought about by the development of new biomedical fields, especially the pharmaceutical industry, at the beginning of the twentieth century. The number of animals used in animal experimentation world-wide peaked in the 1970's before declining sharply, a trend that is still continuing, mainly as a result of public outcry and new legislation.

CONTRIBUTIONS OF BIOMEDICAL RESEARCH TO HUMAN AND ANIMAL HEALTH

Biomedical scientists have made significant contributions through their research findings to enhance the well-being of both humans and animals. Many of these research findings were only made possible through the use of animals in experimentation. The earliest examples are found in the work of the fathers of microbiology, Robert Koch (1843-1910) and Louis Pasteur (1822-1895) in the mid-19th century who proved a direct relationship

between specific microbes and animal and human diseases and the development of resistance against the diseases.

Koch obtained the anthrax bacillus (*Bacillus anthracis*) from diseased animals and injected them into healthy mice that subsequently became ill. When he incubated the spleen from infected mice in bovine serum, the bacilli grew and produced spores. He was able to induce anthrax in mice inoculated with the spores. He developed a set of criteria (Koch's postulates, published in 1884) to prove the causal relationship between a microbe and a specific disease. Pasteur found that the organism that causes chicken cholera (*Vibrio cholera*) became harmless (*i.e*. lost its ability to infect healthy chickens) over time; however, attenuated forms of the microbe could be used to induce immunity in chickens against cholera. He named the attenuated organism a vaccine (Latin *vacca*, cow) in honour of Edward Jenner who showed years earlier that samples from cowpox lesions could be used to protect people against smallpox. These studies laid the groundwork for developing vaccines against a number of infectious diseases, *e.g*. measles, mumps, poliomyelitis, tuberculosis, rabies, tetanus, diphtheria and recently against Haemophilus influenza type b (Hib) that causes meningitis in children.

Before the technology was developed to produce proteins by genetic engineering in bacteria, diabetes patients had relied for fifty years on insulin extracted from the pancreas of pigs or cattle. Open heart surgery, that, today saves 0.5 million lives per annum world-wide, was made possible because of 20 years of research on animals. These are only two examples of a very large number of life-saving procedures in medicine that have resulted from animal-related research.

It cannot be denied that there have been failures and over-use of animals in experimentation. The anti-nausea drug, thalidomide, was extensively tested on animals where no teratogenic effects were observed. However, the drug was not tested on pregnant animals and once this was done, foetal deformities were observed in mice, rats, rabbits, hamsters and a number of monkey species.

Over time both scientists and the public showed an increased concern for animals, leading to a change in the use of animals in research and drug testing. A key publication by the British zoologist, William MS Russel, and microbiologist, Rex L Burch, The Principles of Humane Experiment Techniques in Experimentation (Russel & Burch, 1959) outlined ways of eliminating or moderating inhumane features of animal experimentation.

They proposed the Three R concept (Replacement, Reduction, Refinement) as a guideline to effect this:

Replacement refers to the substitution of living animals where possible with scientifically valid alternative methods such as in vitro techniques (cell and tissue culture) and, insentient material such as computerised models, videos and films.

Reduction refers to a decrease in the number of animals used in an experiment to the minimum number required to obtain information of the required degree of precision. This is done by the right choice of strategies in the planning and performance of research, *i.e.* the use of suitable experimental procedures, by standardising the animal population used, by controlling the environmental conditions, including nutrition, and by the application of statistical design and analysis.

Refinement refers to a decrease in the severity of painful or stressful experimental procedures applied to those animals that still need to be used. This can be effected by applying the correct animal husbandry and handling techniques or by using anaesthetics. This requires proper training of all personnel that interact directly with experimental animals.

Increasing concern for animals used in experiments led to the proposed Three R's concept:

Replacement: substitution of living animals wherever possible.
Reduction: decrease in the number of animals used in experiments.
Refinement: decrease in the severity of painful or stressful experiments.

Some practical consequences of this approach have been in the LD50 (lethal dose 50%) tests for toxicity of drugs, the LD80 test for vaccines and the production of the polio vaccine. The LD50 test required 200 rats, dogs or suitable animals to be force-fed different amounts of the tested substance to determine what dose will kill 50% of the animals. Today between 3 and 18 animals are used and if the first three are killed, the experiment is terminated. In the LD80 test for vaccines, experimental animals are inoculated with the vaccine before the vaccinated animals and a control

group are both challenged with the infectious agent. The vaccine passes if 80% of the experimental group survives and 80% of the control group dies. Today antibody levels are measured in small blood samples collected causing minimal discomfort to the animals. This approach, linked to the use of improved statistical analyses of the results, requires the use of only half the number of animals. Whereas 5 000 monkeys were used in the 1970's in the Netherlands to produce the polio vaccine, today ten monkeys are used to obtain kidney cells that are grown in culture to obtain the equivalent amount of vaccine. Recently the infectious poliovirus cDNA had been synthesized *de novo* in a laboratory for the first time and may be used in future as a source of vaccine that eliminates the use of animal cell culture.

ALTERNATIVES TO ANIMAL EXPERIMENTATION

Scientists are now continually working on ways to replace animals in research. This area of research was most prominently brought about by the pioneering work of the Fund for the Replacement of Medical Experiments (FRAME), founded in 1969 by Dorothy Hegarty to follow a middle course between the abolitionist view and the research community's commitment to using animals in research. FRAME worker, Andrew Rowan, a South African Biochemist, who obtained his PhD at Oxford University, and animal rights campaigner, Henry Spira, targeted the cosmetics industry and their use of the infamous Draize test. In this test, a test substance is placed in one eye of a restrained rabbit and changes in the cornea, conjunctiva and iris are observed over a seven-day period to ascertain whether damage is permanent or temporary. One by one, cosmetics companies donated large sums of money to fund research into alternatives. In 1992, the European Centre for the Validation of Alternative methods was founded and since 1993 a World Congress on Alternatives has been held every three years where scientists have been able to share information. In most Universities and Research Institutions where animals are used in experimentation, the research workers have to provide proof that no alternatives to using animals are available before they given permission to proceed with animal-based experiments.

WELFARE AND ECONOMIC ISSUES RELATED TO LARGE-SCALE FARMING

Good animal husbandry or stockmanship is equally fundamental to successful intensive agriculture practices as it was to traditional small-scale farming. Any consequences of poor handling practices such as injuries,

bruises, reduced weight gain, milk production and pregnancy rates decrease profitability. However, most farmers do not treat their animals as mere economic commodities, but care deeply for them. Farmers do not deny that cattle feel pain during castration, dehorning and branding and they feel as uncomfortable with these procedures as the general public, but perceive them as "necessary evils" of their profession. Many of these procedures have been refined or are subject to regulations in an endeavour to make them more humane. Castration is less painful in very young animals and is not permitted without anaesthesia in calves older than eight weeks in the UK. Nose printing in cattle may soon replace hot iron and freeze branding as a means of identification similar to human finger printing (Grandin, 2000).

The beef and dairy industries constitute enterprises that are very close to the ideal social ethic of animal husbandry. The animals live for most of the time free ranging as they did hundreds of years ago and spend only short periods of time in feedlots and attached to milking machines. Although these enterprises may conjure up the general perception of "contented cows chewing their cud", they are criticized for ozone depletion and contributing to the greenhouse effect, the negative impact of red meat on human health, the separation of calves from cows and the production of white veal. Some practices such as castration are controversial. Steers are easier to handle and their meat is more tender; however, bulls show superior feed conversion and their meat is leaner. Ironically growth hormones, produced by the testes, need to be replaced in castrated animals to improve production. These growth hormones are absorbed by meat consumers and their use is increasingly being banned world-wide. The production of white veal has been described as the most reprehensible form of confinement in agriculture. Male calves are removed from their mothers shortly after birth and kept in confined spaces (veal crates) and fed on an iron-free milk diet. The lack of exercise retards muscle development to keep their meat tender and the nutrient deficient diet leads to anaemia to ensure the required pale pink or white colour of the meat (Anonymous, undated).

Commercial pig farming is often criticised because the animals are permanently kept in confined spaces under environmentally controlled conditions. Pigs are generally considered to be the most intelligent of farm animals and could "easily get bored". In this regard, research by DGM Wood-Gush (Wood-Gush, 1983) on the ethology of pigs is often quoted. Their studies on pigs taken from a commercial enterprise into open conditions, similar to those of the European wild boar, showed that they are social animals that build nests, defecate a distance from the nest and spend most of their time foraging. Conditions prevailing in confined environments

are thus very far removed from their natural environment and often results in behavioural problems such as bar, chain and vacuum chewing. It was found that it is not so much the reduced space as the lack of enriching environmental features that is at issue. A simple solution may be the provision of straw that would serve as nesting material and satisfy their need for foraging (Rollin, 1995).

Next to pig farming, many view the poultry industry as the epitome of "factory farming". Laying hens are kept in battery cages, up to six birds per cage. These conditions are believed to promote cannibalism and feather-pecking. The hens' beaks are trimmed to prevent these injuries, but the absence of anaesthetics during this procedure raises welfare concerns. Broilers are raised in houses on the floor in deep litter systems that are environmentally controlled, but dimly lit to promote feeding and rapid growth. However, they are afforded sufficient space to stand normally, turn around and stretch their wings and their space requirements have to keep up with their growth rate (SAPA Code of Practice). There has consequently been a market for "free-range" eggs and poultry meat world-wide. Moreover, conventional battery cages will be banned in Europe in 2012 and replaced by enriched cages that include a nest, litter area, perches and significantly increased surface area per bird and height of cage.

Over the past two decades more attention has been given to the welfare and ethology of farm animals. The findings of a large body of research are continually being published in specialist journals and adopted Associations of the different farm animal species' Codes of Practice. This constitutes a natural extension of farmers' dictum, "we take care of our animals and they take care of us".

ECONOMIC ISSUES

Transport and slaughter of animals

Although rare instances of apparent neglect of animals during transport to abattoirs are usually prominently reported in the press, they are usually unintentional because it is in the farmers' interest to deliver animals in the best possible condition. The price paid at large abattoirs is based on carcass quality and any bruising during transport reduces carcass value. Withholding feed from animals for 24 hours prior to slaughtering, weight loss during long periods of transport, rough handling and the level of stress induced by transport and handling lead to carcass shrinkage and thus economic losses to the farmer.

The norms set in South Africa for the humane treatment of livestock from production to slaughter are contained in a Code of Practice (Handling and Transport of Livestock, 2000) drawn up by the Livestock Welfare Coordinating Committee. This Committee was established in 1978 to coordinate efforts in the interest of livestock welfare and represents the members of twenty-one animal welfare organizations and organizations in the livestock industry and the State.

The code encourages awareness in the Meat Industry that livestock (cattle, sheep, pigs and goats) are living sentient beings. The coordinating committee calls on its members to eliminate cruel or inhumane handling of livestock during all phases of production, transport, marketing and slaughter to enhance the moral conscience and financial interests of the Livestock and Meat Industry. The code describes conditions for penning of animals (size of pens for different types of livestock to allow sufficient space for all animals to lie down simultaneously, provision of adequate feed and water, cleaning and maintenance of pens). It advises on the handling of livestock with patience and tolerance, taking the animals' natural behaviour into account. Acceptable instruments are listed for use in driving of livestock on the hoof and the use of specific devices that will cause pain and discomfort are prohibited. Permissible distances and duration thereof for driving animals on the hoof as well as guidelines for adequate watering, are given. Guidelines for the transport of livestock include floor construction, provision of protection from the elements, especially pigs from direct sun, height of sidewalls and sizes of loading/offloading openings are also given. Specifications by animal type are given for the correct density of packing of animals in vehicles. The watering and feeding of animals prior to loading is promoted and the loading and off-loading procedure is covered in some detail.

Recommendations on the distance, duration, feeding and watering of livestock during transport are given, with specific attention to un-weaned animals. The drivers' responsibilities during transport of livestock are covered, as well as specifications for restraining animals during transport in a humane manner. Under all sections the conveyance of diseased, emaciated, injured, disabled or exhausted animals or cows with udders distended with milk or animals blind in one or both eyes is prohibited except for short journeys for the purpose of obtaining veterinary care. It is not permitted to drive heavily gravid animals on the hoof. When animals are injured during a journey, they need to be taken to the nearest available veterinary hospital, clinic or animal welfare centre for the necessary care,

while emergency slaughter should be carried out in instances where failing to do so will constitute cruelty.

> The norms set in South Africa for the humane treatment of livestock from production to slaughter are contained in a Code of Practice.
>
> The Code is based on the recognition that livestock are sentient beings.

In South Africa, the SPCA conducts regular inspections of abattoirs, where they focus on the handling and penning of animals from arrival at the abattoir to time of slaughter, *i.e*. whether adequate water, feed and space to lie down are provided. They inspect the efficiency of the respective stunning procedures for the different types of livestock and adherence to the permitted delay between stunning and when bleeding is induced. They also monitor the transport of animals to abattoirs to ensure humane treatment of animals (Daniel Stewart, SPCA, personal communication).

Poultry production

The Southern African Poultry Association Code of Practice was compiled by the Association "as an objective guide for all poultry produced in South Africa and in an endeavour to lay down the accepted norms of the Industry, incorporating various legal requirements where necessary to ensure the well being for poultry in commercial operations, research and educational facilities".

The Code deals briefly with aspects of importation of breeding material and the minimum requirements for monitoring the health status of flocks. Most of the code is devoted to the handling and housing of poultry under the headings of hatcheries, production of hatching eggs (layer and broiler stock and commercial table eggs), broiler production, free-range system, barn-type housing, catching and transport and processing plants (abattoirs). Attention is given to procedures that prevent unnecessary suffering of chicks and adult poultry, *i.e*. handling of young chicks, elective surgery for morphological alterations (beak trimming, dubbing, claw trimming and identification marking and devices), standards and methods for euthanasia and disposal of non-saleable chicks and transportation of chicks. Preparation for receiving chicks on farms, their handling, specifications for housing chickens on the floor (layer and broiler breeders and broilers) and in cages (layers) that

includes those of environmental conditions, provision of feed and water, space requirements and the supervision and protection of chickens. The minimum requirements that should be met for free-range and barn-type housing of chickens are stated. Guidelines for the catching of the different categories of chickens are given and aspects of transport covered include the responsibilities of the driver, vehicle specifications, guidelines pertaining to the transport of day-old chicks and adult birds and the humane handling of culled poultry. Finally, recommendations for the handling of chickens and checking for injured and dead chickens at the abattoir are made as well as procedures given for the stunning and slaughter of chickens.

LEGAL ISSUES

The interaction of humans with farm and other domesticated animals and wild animals in South Africa is subject to a number of laws, briefly described below. At present no separate laws exist in South Africa to regulate animal experimentation, although this has been under statutory review for a long time. The Department of Agriculture published the "National Guidelines For The Humane Treatment Of Animals Used In Research, Education, Diagnosis And Testing Of Drugs And Related Substances In South Africa" in 1990, which, although inadequate, are still in use. Standards South Africa is currently facilitating the compilation of a very comprehensive set of guidelines based on those of the European, Australian and Canadian Councils on Animal Care. Tertiary and research institutions in South Africa apply self-regulation in the form of review of experimental procedures and teaching activities that involve animals by institutional Animal Ethics Committees (AEC). Research using animals can only commence once approval is given by the AEC. The AEC includes academic experts, veterinarians and lay-people. Research involving wild animals usually requires a permit from the relevant authority, *e.g.* National Parks Board.

The Animal Protection Act (No. 71 of 1962) as amended

This Act consolidates all the earlier laws relating to the prevention of cruelty to animals and applies by definition to all domestic and wild mammals, birds and reptiles which are held in the captivity or control of any person. Offences in terms of this Act include cruel treatment, poor housing, malnutrition, neglected parasitism, disease or injury, exposure of animals to danger of attack by other animals and improper conveyance of animals, and are applicable in situations which may arise in the procurement, transportation, housing, breeding and use of experimental animals.

Although the Act was never specifically designed to regulate biological experiments it does define an offence as the commission or omission of any act which will cause any unnecessary suffering to any animal. The interpretation of the word unnecessary is important in this context for whatever may be convenient, desirable or profitable to mankind may not automatically be deemed to be a necessity.

This Act also empowers authorised officers of animal welfare societies without a warrant and at any time with the consent of the occupier, to enter any premises in which any animal is held for the purpose of examining the conditions under which it is kept. If consent is refused by the occupier of the premises, an animal welfare society officer may obtain a warrant from a magistrate which will give him legal authority to enter and carry out an inspection. He/She may also without a warrant, arrest any person who is suspected on reasonable grounds of having committed an offence under this Act and seize anything in the possession or custody of that person at the time of the arrest and take it forthwith before a magistrate.

There have been several prosecutions of persons who have been found guilty of contravening the Animal Protection Act in the capture, transportation and use of laboratory animals.

Animal Disease and Parasites Act (No. 13 of 1956)

This legislation consolidates and amends the laws relating to animal diseases and controls the movement of animals from place to place in South Africa and the importation of animals, parasites or infectious agents into the Republic of South Africa. Under this law animals, parasites or infectious agents and animal products specified by the Veterinary Division of the Department of Agriculture may only be moved under the authority of a permit issued by a State Veterinarian. These laws are applicable to domestic livestock, pets and indigenous and exotic wild animals.

Nature Conservation Ordinance (No. 15 of 1974)

Under this Ordinance the Natal Provincial Administration established a Nature Conservation Branch for the advancement and control of Nature Conservation. This Ordinance consolidates and amends the laws relating to Wild Animals, Problem Animals, Fisheries and Indigenous Plants and the hunting of game in KwaZulu-Natal.

Under this Ordinance permits are required for:

- The keeping of wild animals in captivity.

- The importation into, or exportation from, KwaZulu-Natal of wild animals.
- The transportation of wild animals.
- The importation of exotic animals.
- The keeping and transportation of problem animals.

DEFINITIONS

Wild Animal - any vertebrate animal including birds and reptiles (but not fish) which are kept or bred in captivity or elsewhere, belonging to a non-domestic species whose habitat is either temporarily or permanently in any part of the RSA or Namibia and includes the carcass, egg, flesh (whether fresh or cured), biltong, unprocessed or partly processed hides, skin, thong, tusk, bone, horn, shell, scale, claw, hoof, paw, tail, hair, feather or any other part of such vertebrate animal.

Exotic Animal - any live vertebrate animal including birds and reptiles (but not fish) belonging to a non-domesticated species the habitat of which is not the RSA.

Problem Animal - any species of wild animal or exotic animal alive or dead as contemplated in Subsection 36(1) of the Ordinance. These animals are declared vermin and the Chacma baboon and Vervet monkey are included in this group.

Prohibited Acts in respect of live Problem Animals

Any person who possesses, sells, buys, donates, receives consequent upon a donation, imports, conveys, breeds, releases in the Province, keeps in captivity or controls any live problem animal or is in charge of such an animal without being the holder of a permit issued by the Director of the KwaZulu-Natal Nature Conservation Services whereby he/she is authorized to do so, shall be guilty of an offence.

DISCUSSION VIEWPOINT

The authors are of the opinion that it is important that we as a society are informed and aware of issues surrounding animal ethics and animal rights as we strive to improve our lives and well being in a rapidly changing technological age. It is by being knowledgeable and taking responsibility that we will be able to influence farming practices, research, and make personal choices to ensure the well being of animals.

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Chapter 7

AGRICULTURAL BIOTECHNOLOGY

Annabel Fossey

INTRODUCTION

Biotechnology in the broad sense is not a discrete technology. It is a collective term that refers to a wide range of useful, enabling agricultural, industrial and medical technologies that includes, but is not limited to genetic modification and manipulation that have wide applications in research and commerce.

Biotechnology has been practiced by human society since the beginning of recorded history in activities such as brewing, baking and the production of fermented foods such as yoghurt and cheese. Alcoholic fermentation is undoubtedly the oldest known enzyme reaction. Until 1857, when Louis Pasteur proved that fermentation occurs only in the presence of living cells, people believed that these reactions were spontaneous. He identified microbes as the causative agents that changed food. Subsequently (1897), the German chemist Eduard Buchner discovered that a cell-free extract of yeast can cause alcoholic fermentation and proved that yeast cells produce enzymes that bring about fermentation. We know today that all living organisms produce enzymes, which are proteins that are responsible for many life processes. These and many other discoveries lead to the improvement of the reliability of traditional fermentation and the insurance of safe preservation of food and drink.

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During the 1940s, methods of growing microbes in large fermenter vessels were developed for the production of penicillin and other antibiotics used in medicine. This fermenter technology today permits the commercial production of a wide range of products, including enzymes for food and drink production processes, vitamins, amino acids and other useful chemicals.

In the brewery industry brewers have always maintained their own strains of yeast for beer production. In the same way other producers of enzymes and other fermentation products nurture specially-selected strains of production organisms. Traditionally the development of new strains involves laborious testing of populations of microbes to detect naturally-occurring genetic variants with useful properties. It was in 1973 when the two scientists, Stanley Cohen and Herbert Boyer, managed for the first time to make very specific changes to the genetic make-up (DNA) of microbes, thereby introducing the so-called new technology 'genetic engineering' (also referred to as genetic modification). Genetic engineering techniques developed using microbes have since been applied to plants and animals.

The rapid development and advancement of genetic engineering techniques during the last 20 years have been responsible for tremendous scientific and commercial interest in biotechnology, the founding of many new companies, and the redirection of research efforts and financial resources among established companies and universities. These techniques provide scientists and technologists in a wide range of fields with the tools to implement exciting commercial applications.

These technologies that utilize living organisms such as microbes, plants or animals, or parts of living organisms, such as cells or proteins have, over the past several decades, become totally integrated into the practice of plant and animal breeding and microbiology, such that the distinctions between the “old” and “new” technologies have become blurred. They encompass advances in biology, genetics and biochemistry to technical and industrial processes as diverse as fish farming, drug development, forestry, crop development and fermentation.

Although the term biotechnology refers to a much older and broader range of technologies, the techniques of genetic engineering are of such importance that the two terms have become virtually synonymous.

Working definition of Biotechnology.

Biotechnology is the application of biological systems and organisms in the production of useful goods and services.

HOW BIOTECHNOLOGY WORKS

Genetic engineering (genetic modification / manipulation) has become one of the central-most technologies used in biotechnology and a closer look at the principles of these techniques is useful.

DNA (deoxyribonucleic acid), a nucleic acid, is the blueprint for the individuality of animals, plants and most microbes; some viruses use RNA (ribonucleic acid). Organisms rely upon the information stored in its nucleic acid for the management of every biochemical process. Life, growth and unique features of an organism depend on its nucleic acid, which are long chainlike chemical structures, circles in bacteria, partitioned sequentially into regions, genes that are associated with specific features or functions of an organism.

The DNA (deoxyribonucleic acid) from different organisms is essentially the same, simply a set of instructions that directs cells to make proteins that are the basis of life. Whether the DNA is from a microorganism, a plant, an animal or a human, it is made from the same source materials. One of the great scientific discoveries of biotechnology is that DNA from any organism will function if it is transferred into any other organism.

Today it is possible to transfer a specific piece of DNA from one organism to another, after the discovery of many enzymes which change the structure of DNA in living organisms. Some of these enzymes can cut and join strands of DNA. Using such enzymes, it is now possible to cut specific genes from DNA and to build customized DNA using these genes (also referred to as DNA recombinant technology). Selected genes are pasted into the DNA of a vector DNA strand, strands of DNA such as viruses, which can infect a cell and insert themselves into its DNA. In this way the recipient cell (organism) that receives foreign DNA, is genetically modified. As a result, for example, we can cause bacterial cells to produce human molecules. Cows can produce more milk for the same amount of feed. And we can synthesize therapeutic molecules that have never before existed. The possibilities are beyond our imagination. With this knowledge, genetic engineers started to build vectors, which incorporated genes of their

choosing and used these new vectors to insert these genes into the DNA of living organisms.

Principle steps to produce a genetically modified organism (GMO).

1. Remove the desired gene from the donor DNA.
2. Insert selected gene in vector DNA.
3. Use vector to transfer donor DNA into recipient DNA.

From an ethical perspective, biotechnology is an especially challenging domain to examine for at least three reasons:

1. Visibility given to biotechnology.
2. Expanding range of areas of research and development with commercial potential and implementation.
3. Considerable range of ethical concerns intertwined with scientific, philosophical, economic and political issues.

PLANT BIOTECHNOLOGY

INTRODUCTION

Most plant biotechnology, about 80%, is directed toward the improvement of food plants; the remainder of the work is concerned with non-food crops such as tobacco, cotton, ornamental plants and pharmaceuticals. Initially research focused on the improvement of qualities of value to the farmer, funded mostly by the seed industry. Lately applications of biotechnology have been focusing more directly on commercial food processors and consumers. Although many genetically modified food plants have been tested, very few have been approved world wide.

What is plant biotechnology?

Traditional plant breeding involves the selection of parental plants with desired traits, crossing and then the collection and planting of seed. The results of such crosses are then evaluated after the cultivation of the progeny. This is a relatively slow and labour-intensive process. It is important to note that plant breeders work with entire genomes, and when a cross is made to introduce desirable traits, one or more undesirable traits are also introduced; and these must then be painstakingly "bred out". The techniques of biotechnology can be used to speed up the process and improve the precision of plant breeding.

MAIN TECHNIQUES OF PLANT BIOTECHNOLOGY

Plant tissue culture

Plant tissue culture is the cultivation of plant cells or tissues on specially-formulated nutrient media. In appropriate conditions and supplemented nutrient media, entire plants can be regenerated from a single cell. This technology permits rapid production of many genetically identical plants (clones). Tissue culture has become an essential tool in modern plant breeding and has also become the basis of a major industry, providing high-value plants for nurseries. It is the technology used to multiply plants that do not produce seeds, such as the banana plant. Plant cell suspension cultures in fermenter vessels have been attempted with the aim of producing valuable products such as medicines and natural food flavourings, but to date success has been limited.

Plant tissue culture is making a valuable contribution to the conservation of threatened species and is also used to multiply plant varieties that cannot be maintained in a normal seed bank.

Genetic modification

Genetic modification is the controlled modification of the DNA of a plant variety. It relies upon the isolation of specific segments of DNA using specialised enzymes (restriction enzymes) to cut the DNA at specific places. Selected DNA fragments (genes) are then transferred into a plant in various ways:

- The best-established gene-transfer method that is used to modify the genetic make-up (transformation) of plants uses a soil bacterium, *Agrobacterium,* as a vector (Figure 1). *Agrobacterium* is a natural genetic modifier. Upon entry into a plant cell, it alters the DNA of the plant cell and causes the formation of outgrowths (galls) on the

plant. Scientists have modified the mechanism used by *Agrobacterium* so that the desirable DNA is transferred to the plant cell rather than the genes responsible for gall formation. The production of genetically modified (transgenic) plants using this technology has been successfully used with a wide variety of plants and has been particularly successful with tree species. However, *Agrobacterium* does not affect the most important cereals, so other ways to produce transgenic plants are used.

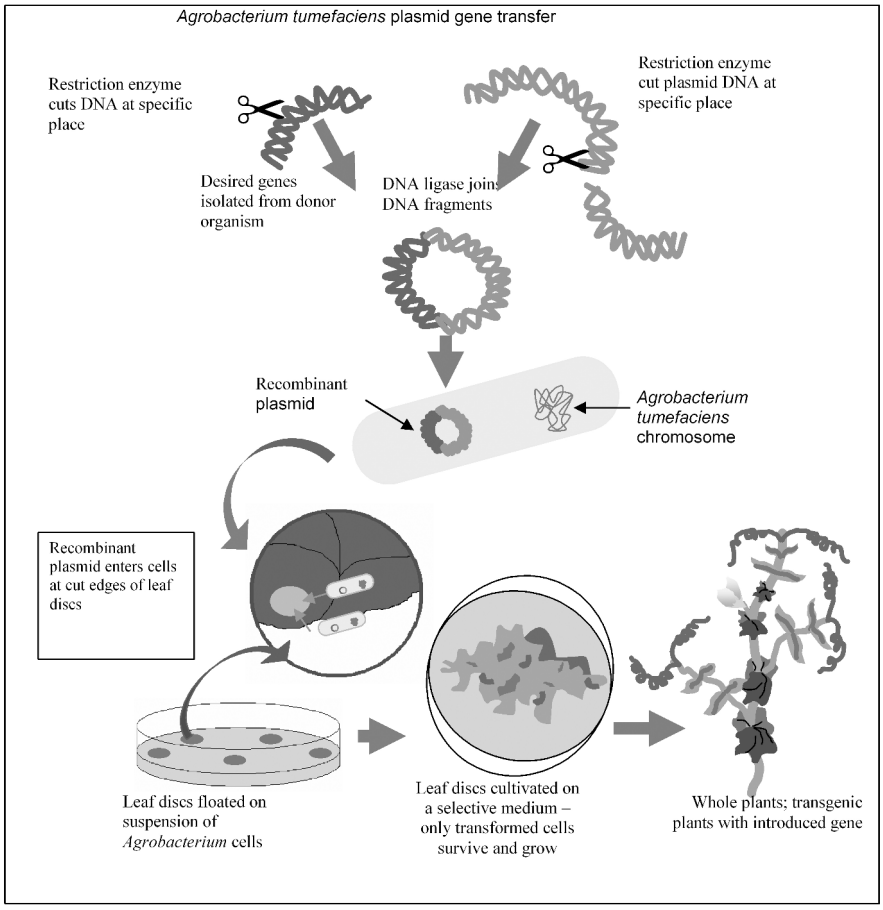

Figure 1. Formation of transgenic plants using Agrobacterium

Ballistic impregnation

Ballistic impregnation is a method that has achieved some success with cereals and other crops. It involves sticking the DNA that is to be introduced

into the plant onto minute tungsten or gold particles (Figure 2). These particles are then "fired" into the plant tissue. A proportion of the plant's cells take up the DNA from the metal pellets. Whole plants are then regrown from the cells by tissue culture.

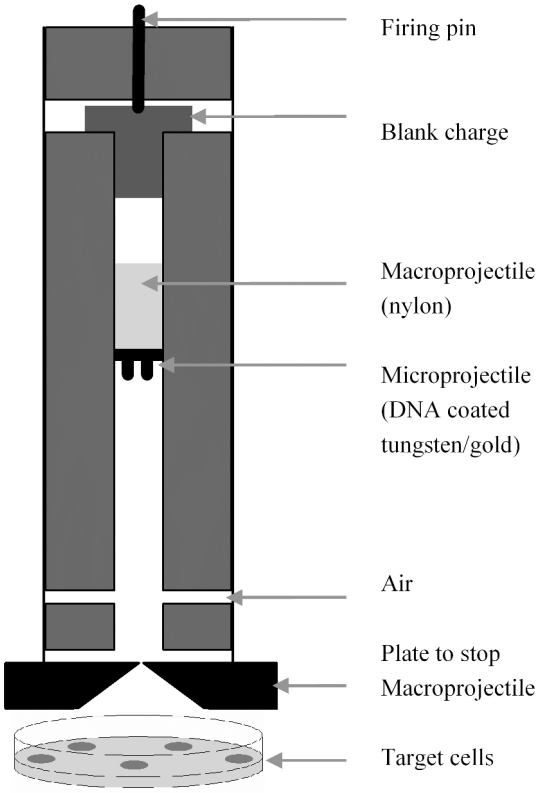

Figure 2. Ballistic gun used to propel DNA coated tungsten or gold into target cells

Electroporation

Electroporation involves using micro- to millisecond pulses of a strong electric field to cause minute pores to appear momentarily in the plant cells, allowing DNA to enter from a surrounding solution. This works best with plant tissues that have no cell walls, such as protoplasts or the tubes which develop from pollen grains.

Why marker genes are required in DNA transfer technology

Only a small proportion of the treated cells successfully incorporate introduced DNA with all current DNA transfer techniques. *Marker genes* are therefore linked to the transferring DNA before their transfer. These marker genes are then detected in the target tissue indicating the successful transfer of the desired DNA. To date, the main markers used are genes which allow the plant to grow in the presence of a specific antibiotic or herbicide.

POTENTIAL RISKS AND BENEFITS OF GENETICALLY MODIFIED CROPS

Recombinant DNA and gene-transfer technologies have become routine technologies in the production of transgenic plants and have been used to produce herbicide- and insect-resistant crops, rice with enhanced levels of vitamins and many more. Genetically modified (GM) crops have become the focus of a worldwide controversy, particularly regarding the release of GM crops into the food chains (GM food). Some social and environmental groups have labelled GM food as "Frankenstein food", "mutant crop" and "genetic pollution". Greenpeace activists have launched worldwide anti-GM food campaigns. Whether their concerns have foundation or not, they have created major opposition to the development of GM foods which must be addressed by society, institutions and corporations involved in biotechnology.

Are GM foods safe?

Opinions range from one extreme – that all GM crop production should be stopped and GM foods destroyed, to the other - that all GM foods are completely safe and have the potential to improve human nutrition and uplift the health of human life throughout the world. Most people, however, have opinions somewhere between these extremes; and emphasize that there are many applications, recognizing that some GM foods may contain toxins or allergens and that their cultivation could lead to a decrease of biodiversity. Some of the potential benefits of GM foods are listed below (Table 1).

Table 1. Potential benefits of GM foods

	Potential benefits of GM foods
1.	Foods that enhance nutritional quality – such as vitamins and minerals.
2.	Production of vaccines and pharmaceuticals.
3.	Insect resistant crops.
4.	Herbicide resistant crops.
5.	Disease resistant crops.
6.	Delayed ripening of fruit – extending shelf life.
7.	Production of biodegradable plastics in crops.
8.	Biological control of weeds.
9.	Genetic control of flowering time, seed content, *etc*.

A paper in 1999 in Nature entitled "Transgenic pollen harms monarch larvae" (Losey, Rayor & Carter, 1999) led to major concerns about the possible ecological effects of GM crops. The results published in this paper were based on feeding monarch butterfly larvae on milkweed leaves coated with pollen from corn plants containing a gene controlling an insecticidal protein (*bt* toxin) from the bacterium *Bacillus thuringiensis*. Many larvae died, resulting in concern about the effects of 26 million acres of *bt* corn growing in the United States of America. Later studies demonstrated that these results were possibly ill founded for several reasons: (1) corn pollen does not adhere well to milkweed leaves; (2) the amount of corn pollen present on milkweed leaves near *bt* corn fields is much lower than the amount used in Losey's investigation; (3) the most widely grown lines of *bt* corn have a very low level of toxin in pollen; and (4) in the field, most corn pollen is released before monarch butterflies lay their eggs. Nevertheless, public concern has been greatly influenced by the publication of this work, with less publicity given to subsequent studies. Consequently, this has alerted researchers to the possible ecological effects that GM crops may

have and has stimulated discussion and research. Some of the potential risks of GM foods are listed below (Table 2).

Table 2. Potential risks of GM foods

Potential risks of GM foods
1. Production of toxins and allergens.
2. Unexpected deleterious effect of "unnatural" products.
3. Transgenes may "escape" to related species with deleterious effects.
4. Pollination of "organic" crops reducing their value.
5. Possible harmful effects on honey bee population.
6. Possible harmful effects of transgene products on other species such as monarch butterfly.
7. Reduction of biodiversity.
8. Economic losses due to international boycotts of GM products.
9. Increased dependence of farmers on large agrochemical companies.

How is GM food safety assessed?

The Food and Agriculture Organization (FAO), the World Health Organization (WHO) and the Organization for Economic Cooperation and Development (OECD) has promoted the view that GM food safety should be assessed according to the principle of "Substantial Equivalence". This involves comparing GM food to the food from which it is derived. There are three possible outcomes:

1. The product is substantially equivalent to the parent.
2. The product is substantially equivalent to the parent except for defined differences.
3. The product is not substantially equivalent to the parent.

The outcome of the comparison guides the depth of the safety assessment that follows the assessment. Depending on the extent of the difference between the GM food and its parent, the product undergoes an evaluation looking at the following areas:

- **General safety**
  - Sources of genetic material.
  - Fate of introduced protein during processing and/or digestion.
  - Presence of allergens and/or enhanced levels of natural toxins or anti-nutritive factors.
- **Toxicology**
  - Any changes in levels of pre-existing natural toxins as a consequence of genetic modification.
  - Toxic screening of any new or substantially modified components.
- **Nutrition**
  - Any change in nutritional composition especially in key elements which have significant impacts on the whole diet.
  - Any changes in bioavailability of nutritional components.

ETHICAL ISSUES

Within the next few years literally thousands of genetically modified food products or products with genetically modified components could find their way onto the world's markets. The pursuit of this biotechnology addresses four main categories: health, products, the environment and business.

Transgenic crop development has changed the nature of plant breeding substantially, raising a number of practical and ethical implications/concerns associated with this technology which are not readily understood by the public and has often become a highly emotive issue when publicized through the news media. In particular, these concerns relate to the associated risks and benefits to humans and the environment, the balance of the distribution of benefits and on the technology being good or bad in itself.

Risks, benefits and impacts on society and the environment

Major concerns for the development and deployment of transgenic crops refer to: the risks, the benefits and the impact on the environment, which are referred to as "extrinsic" concerns.

The questions that require answers are:

- Do GM crops represent the solution, or partial solution, to world hunger?
- What are the unacceptable risks to the environment and human health?
- How can equitable sharing of the benefits of technological advances be improved?

The view that scientists are, in the main, trustworthy and ethically sound and that agricultural research is intrinsically good, has been altered since the advent of genetic engineering. It is generally recognized that these new technologies challenge existing values and systems and stimulate change in traditional concepts of nature and human identity.

Transgenic food and human hunger

For the most part, the myth that the "older" technologies, alone, will be able to alleviate world hunger should be dispelled. It is a common held view that current agricultural practices need revision if they are to reduce poverty and hunger of the ever increasing world population. In the main, the multi-faceted nature of hunger is ignored and these views are mainly based on the shortage of food, while other aspects such as the distribution of food, land tenure, overpopulation, poor health and poor education do not feature. The arguments that GM crops could alleviate world hunger needs to be viewed with caution, especially when the following is considered. Little is known about GM crops and their role in rural subsistence farming and GM crop research resides mostly with chemical companies that focus on the production of dependent crop varieties and value-added production, rather than on staples. Although it is probably true that genetic engineering could produce endless varieties, its role in abolishing malnutrition in developing countries is questionable and could ultimately jeopardize small rural farmers, whom are mostly the conservators of rural land, adapted over thousands of years to local environments.

If the question is asked, how will increased agriculture be accommodated? There are really only two possibilities: (1) current farming areas should be intensified or (2) current cultivation areas should be increased to include new areas. These options do not bode well, the first promises deterioration of already damaged environments and the second requires encroachment of important ecosystems such as tropical forests, savannahs and their associated biodiversities.

In theory, cultivation of GM crops could, through intensification of agriculture, contribute to increased agricultural production and an alleviation of human hunger, while promoting environmental conservation. Unfortunately, poor farmers will not be able to purchase sophisticated GM crops, and it is unlikely that seed companies will change the focus of their research. It therefore seems unlikely that GM crops, as the only solution to hunger, will make the required impact.

GM crops and the environment

The question of major interest is: should the environment be protected because of intrinsic moral value or because it is a valuable resource for humankind? Clearly, the key issue in the development of GM crops lies in the conflict that exists between the needs of humankind and the respect for nature. Furthermore, concerns for the environment differ from country to country, especially in developing countries where governments often do not provide sufficient legislation or are unable to effectively manage legislation for the protection of the environment. Also, it is known that modern intensive agriculture adversely affects the environment through its reliance on chemical soil nutrients and pesticides to control insects, pathogens and weeds.

It has been suggested that GM crops engineered to tolerate the environment better represent an improvement in crop production, thus an ethical advancement, while others regard such crops as environmentally unfriendly. Their introduction could affect surrounding non-farmed environments. The question is whether or not this new technology will promote sustainable farming practices?

One of the major applications of this technology is the production of GM crops that are herbicide resistant. There is much debate whether this will lead to more or less use of herbicide and whether the resistance genes would be passed on to non-target species and create invasive herbicide resistant weeds. Little is known about the escape of transgenes to the environment, but possible effects could be limited through engineering sterility into the GM crop to ensure reduced flow into the farming and natural environments. Generally, crops do not survive outside the farming environment and would therefore probably be out-competed should they spread away from the farming environment.

Another application of this technology that has attracted criticism is the engineering of pest and disease resistance. For instance, engineered virus resistance could result in the evolution of new and harmful viruses. Crops engineered to produce harmful toxins (mainly *bt* toxin) may poison non-

target hosts. There is already evidence that targeted pest species have developed resistance to transgenes, much in the same way as naturally occurring resistance genes, which indicates that nature treats transgenes much in the same way as natural genes. For the plant breeder these solutions may therefore only be short-lived.

On the other hand, agrochemical control of crop pests remains inefficient and environmentally unsuitable and is generally viewed as unethical. GM crops could offer a more precise and environmentally friendlier remedy.

Trees, the next targets to be engineered, are usually regarded as part of the natural environment, which raises new ethical and environmental concerns due to their long-lived nature. Forests, particularly tropical and sub-tropical forests represent substantial reservoirs of biodiversity. The possibility exists that transgenic trees produced for commercial use could escape into natural forests, where the consequences could be disturbing and not easily reversed.

The question of erosion of genetic diversity also needs consideration. The use of genetically uniform and high performing GM crops could reduce the need to cultivate and maintain land races that are the usual suppliers of genes to plant breeders. Biodiversity, on farms and in uncultivated environments are already showing decline due to current farming practices. Whether GM crops will improve or reduce erosion, is a debatable issue. The greatest biodiversity exists in delicate uncultivated areas of some of the world's poorest countries.

Transgenic crops and their effects on the environment remain controversial because of the difficulty to gauge the risks involved and a general lack of knowledge of their long-term effects.

GM crops and human health

Plants are the basis of the human diet. The unfortunate careless representation by the media of transgenic organisms has aroused concern that human health may be adversely affected when GM foods are consumed. When human health is at stake, utilitarianism cannot be practiced, nor are cost-effective analyses useful, and yet retailers opt not to sell GM foods, but continue to sell tobacco, alcohol, sweets and fatty foods; obviously ethically inconsistent.

A major concern is the potential toxic or allergenic affect of the GM foods. Research has indicated that natural food as well as engineered food contain putative toxins and allergens. It is interesting however how little is

known about the toxicity of non-engineered foods. In the case of engineered food, extensive screening is undertaken in advance to reduce the chances of releasing potentially dangerous foods. Careful labelling of products of engineering would be informative to customers with allergies.

Human health is currently being affected by the excessive use of large amounts of pesticides which pollute the environment, and accumulates in plantation workers, particularly in the case of banana plantations. Would it not be ethically justifiable to produce transgenic banana varieties that require less pesticide application?

Another important aspect is the view of strict vegetarians. What are the views of strict vegetarians on the introduction of animal sequences into food plants to improve the nutritional value of the food plant? Also, what about engineered plants that produce important human molecules such as insulin and growth hormone?

At the heart of this debate lies the question; does genetic engineering of humans, plants, animals and microbes require different ethical considerations?

GM crops, socio-economic impact and distribution of benefits

In the short term it seems that the poorer communities and countries of the world are bound to lose with the implementation of this technology. Most of the products are aimed at large-scale farmers or to the more sophisticated consumer, for example, the production of artificial sweeteners, vanilla and various oils. An additional problem is that the large producers of GM products create a dependency in the farming community, ultimately for corporate financial gain. The recent controversial application of the "terminator technology" that ensures that farmers cannot save seed at the end of one crop cycle for sowing during the following cycle, has raised many ethical concerns. Farmers that sow these seeds will be completely under the control of the seed supply company, precluding the use of farm-produced seeds, which is common practice in many developing countries. In this case, business ethic and humanitarian ethic are in direct conflict.

The following situation serves to illustrate the ethical problems concerned with distribution of benefits of transgenic technology:

In 1998 Monsanto announced its intention to invest $550 million in building a Roundup (glyphosate) production plant in Brazil. The Brazilian government had made Roundup-resistant soya its first legally approved genetically engineered crop, grown by large landowners who feed it to cattle

for export. These wealthy farmers are able to afford an increase in soya production areas, especially into rainforests to make more cattle pasture available. This will severely affect the crops of subsistence farmers who do not grow soya and who are unlikely to receive any benefit from this technology.

Ownership of genes and the need for patents has become a major business regarding this technology. Plant breeders have for many decades developed and improved new varieties which have not been accompanied by any specific benefit sharing. Many of these crops have also been used as foundation genotypes for transformation. Plant breeder's rights have to some extent corrected this unfair situation, however, many exotic genes have entered crops through conventional breeding practices, which will be impossible to trace and thereby compensate the owners.

Article 19, of the Convention on Biological Diversity (CBD), which resulted from the Earth Summit held in Rio de Janeiro in 1992 stressed the need for especially developing countries, to provide genetic resources for biotechnological research. Although developing countries recognize the need for this type of research, there are many ethical-related issues being debated in the context of intellectual property rights (IPRs) of which the most concerning is the patenting of food crops and life forms. A patent granted on a staple food crop from a poor country to developed countries sets a dangerous precedent and should be regarded as ethically unsound.

Fundamental ethical concerns

Many religious beliefs exist that clearly separate right from wrong, implying that the future of humankind lies with a divine power. Although divine responsibilities are unclear, human interference remains questionable and has contributed greatly to the anti-GM food debate.

ECONOMIC ISSUES

The biotechnology industry has seen huge corporate investment and growth over the last two decades. In particular, during the 1990's one saw a number of corporate mergers and acquisitions on a scale that has seldom been seen before in the agricultural industry. This has resulted in the industry being dominated, to a very large extent, by five or six global corporations. According to Tokar (2001), it is estimated that the biotechnology industry "represents an estimated $13 billion in corporate revenues". The massive expansion in the industry can be gauged from the

fact that "the biotech industry's overall market capitalization skyrocketed from $97 billion in 1998 to a staggering $350 billion in early 2000" (Lahteenmaki, 1998; Rifkin, 2000). This is an industry that is driven by very large corporations with considerable influence, particularly in the areas of seed, pharmaceuticals and agricultural chemicals (Tokar, 2001).

Savings for the farmers

Growing genetically modified crops resistant to pests or diseases could reduce the reliance of agriculture on chemical sprays. This would make the crop easier and cheaper to grow for the farmer and also reduce other indirect costs such as spraying.

Better business

Biotechnology, potentially, represents huge commercial profits for corporations and institutions involved in this area of research and development. The patent laws allow private companies to develop and market unique products, which have the potential to be of considerable benefit to an economy.

The possibility of producing superior crop genotypes that are resistant to herbicides, pests and diseases in a much shorter period of time than conventional breeding (which may take decades) is directly beneficial to farmers and growers by reducing management costs and thus increasing profitability.

The initial results of a survey of the economic implications of adopting a GM cotton crop (Bt cotton) on the Makhathini Flats region of the Republic of South Africa, provide cautious optimism regarding the impact at farm level. By the second year the Bt adopters were clearly gaining economically, in terms of increased yield and lower insecticide costs and thus a higher gross margin. A further important consideration is the potential reduction in pesticide poisoning and benefits to the environment.

POTENTIAL VALUE TO SOCIETY

The following points of discussion are often cited by certain scientists and supporters of biotechnology as being the major benefits to humankind.

Improvement of the nutritional value of food

Biotechnology can be used to improve the nutritional value of foods when released after extensive testing for the presence of allergins or toxins that can reduce the nutritional value. In the case of Brazil nuts, the introduced gene produced a protein that was responsible for the allergenic responses. This allergenicity was also transferred to soybeans, which has consequently never been marketed.

Food is also being modified to increase its nutritional value through altering the vitamin, mineral, carbohydrate, protein and fat profiles.

The general public remains generally very resistant to GM food. Recently (August 2002), a statement by Philip T. Reeker, Deputy Spokesman of the U.S. department of state's office of International information programs, on biotechnology and U.S. food assistance to southern Africa, expressed the deep concern about the worsening food crisis in southern Africa. Thirteen million people are at risk of starvation. Nearly one million metric tons of food will be needed in the next few months to avert famine. Despite the urgency of the need, misinformation about the safety of agricultural biotechnology is preventing U.S. food assistance from being distributed to those in need.

Improvement of health

GM foods also have the potential to become relatively cheap sources of human therapeutics, especially for the poorer, developing countries of the world. For instance, the introduction of genes can be used to produce antigens. Such engineered foods can be used as edible vaccines against a wide range of diseases, which could be of great value in developing countries as immunization will be the fraction of the cost of conventional immunization programmes.

Fight hunger

Biotechnology can produce disease resistance crops, modify crops to be cultivated in a wider range of conditions and increase yields; thus help farmers to feed more people.

Better for the environment

The development of herbicide, pest and disease resistant crops reduces the reliance of agriculture on chemical sprays. For example the development of herbicide resistant crops generally involves transferring genes with resistance to environmentally friendly herbicides such as glyphosate (Roundup). This allows growers to spray such herbicides without damaging the crop plant.

DISCUSSION VIEWPOINT

Agricultural biotechnology offers new scope for rapid gains in agricultural productivity and, probably in the area of plant breeding the most spectacular changes have been seen. Although it represents a host of new opportunities, it has come with much distrust on the part of pressure groups, the media and the public in many countries. The transfer of genes from any source creates safety, environmental, social and ethical concerns for many people. Misinformation about the safety of agricultural biotechnology is preventing the U.S. from distributing much needed food to thirteen million people at risk of starvation in southern Africa.

A major issue raised by opponents of GM crops is that consumers and farmers will not benefit, but that the plant breeding companies will be the major beneficiaries. In developing countries, agricultural systems are vastly different; where input costs, pesticide safety and farm labour are major concerns, no data is available for sub-Saharan Africa on the potential benefits to farmers. At this stage the long term consequences cannot be predicted.

With regards to the future, the potential to eliminate human suffering is enormous. According to the World Health Organization, more than a million children die every year because they lack vitamin A in their diets. Millions more become blind. GM rice or corn with all essential vitamins for children has the potential to provide these children with essential nutrients.

Finally the question is whether this technology will be able to revolutionize farming, save the environment and make money and thus address the humanitarian, environmental and business ethics simultaneously?

ANIMAL BIOTECHNOLOGY

INTRODUCTION

Animal biotechnology covers many well-established technologies, mostly involving reproductive physiology in livestock breeding. However, during the past decade a range of emerging technologies have been introduced which are constantly being improved and extended to a wider range of species.

ANIMAL BIOTECHNOLOGIES

Reproductive technologies such as artificial insemination (AI) and Multiple Ovulation and Embryo Transfer (MOET) are well established technologies in livestock breeding. With AI, the best males can be selected for breeding, which means that the average estimated breeding value (EBV) of the males is higher, resulting in an increased nett-merit of the progeny when compared to natural mating with lower selection intensity. In the case of MOET, multiple ovulations is brought about by hormone injection, mating, and then multiple embryos collected and transferred to host females. These host females do not make any genetic contribution to the breeding programme. As with AI, MOET also facilitates the selection of fewer females as donors of genetic material. MOET improves the rate of genetic improvement because of:

- The possibility of an increased selection intensity.
- The possibility of a reduced generation interval.
- The possibility of estimating breeding values more accurately.

Emerging and new technologies

Emerging animal biotechnologies
• Non-invasive procedures for repeated oocyte pick-up from both pubertal and sexually mature females.
• Oocyte recovery from pre-pubertal females provide exciting opportunities for reducing generation intervals in species with relatively long generation intervals.
• Rapid development of *in situ* oocyte retrieval procedures, particularly in young females, has been encouraged by recent complementary advances in the efficiency of *in vitro* fertilization and embryo culture.
• Semen and embryo sexing.
• Transgenesis.
• Cloning.

Oocyte pick-up refers to a procedure whereby ovarian follicles are aspirated *in situ* to recover oocytes for subsequent *in vitro* fertilization from both adult and juvenile females. Ultrasound-guided transvaginal oocyte pick-up (UG-OPU) has been developed for a range of livestock. In this procedure, the ovaries are stabilized by rectal manipulation and the ultrasound probe and aspiration needle are introduced into the vagina. Follicles are visualized by ultrasound and individually pierced and aspirated under vacuum.

Endoscopic-guided transvaginal pick-up (EG-OPU) has also been developed for various livestock types but whilst this procedure provides for direct visualization of the ovaries, selective aspiration of the surface follicles and less invasion of the ovaries, EG-OPU can nevertheless be more traumatic to the vagina, fornix and abdominal organs than UG-OPU.

The attraction of UG-UPO, for example in cattle is that this technology can be applied at all stages of the oestrus cycle. It is also applicable in heifers and cows with abnormalities of the reproductive tract and can be used to obtain oocytes during the first trimester of pregnancy. It can also be applied to pre-pubertal heifers. The process can utilize semen from different bulls and it is likely that its use will be further enhanced with the refining of semen and embryo sexing.

Semen or embryo sexing has a long history of research. The prospects of practical implementation in the near future seem reasonable. The main impact of semen sexing is to lift the efficiency of production systems rather than to improve the rates of ongoing genetic improvement.

Transgenic animals are usually preferred to modified microbes or plants for two main reasons. Firstly, animals are closer biochemically to humans which is of importance for the making of pharmaceutical molecules, and secondly, they are able to produce large amounts of products.

There are five major reasons why genetically modified animals are produced:

1. To identify, isolate and characterize genes in order to understand more about their function and regulation.
2. To provide research models of human diseases, to help develop new drugs and new strategies for repairing defective genes ('gene therapy').
3. To provide organs and tissues for use in human transplant surgery.
4. To produce milk which contains therapeutic proteins; or to alter the composition of milk to improve the nutritional value for human infants.
5. To enhance livestock improvement programmes.

There are two major ways to produce transgenic animals.

1. **Pro-nuclear injection** involves microinjection of DNA (genes) into one-celled embryos (single recently-fertilized eggs) (Figure 3). The embryos develop in a surrogate mother and the offspring are tested to see if they possess the donated gene.

2. **Gene targeting in embryonic stem (ES) cells** is used to target the insertion of donor DNA by homologous recombination by disrupting or replacing an endogenous gene (Figure 4). It can also be used for simply adding new genes.

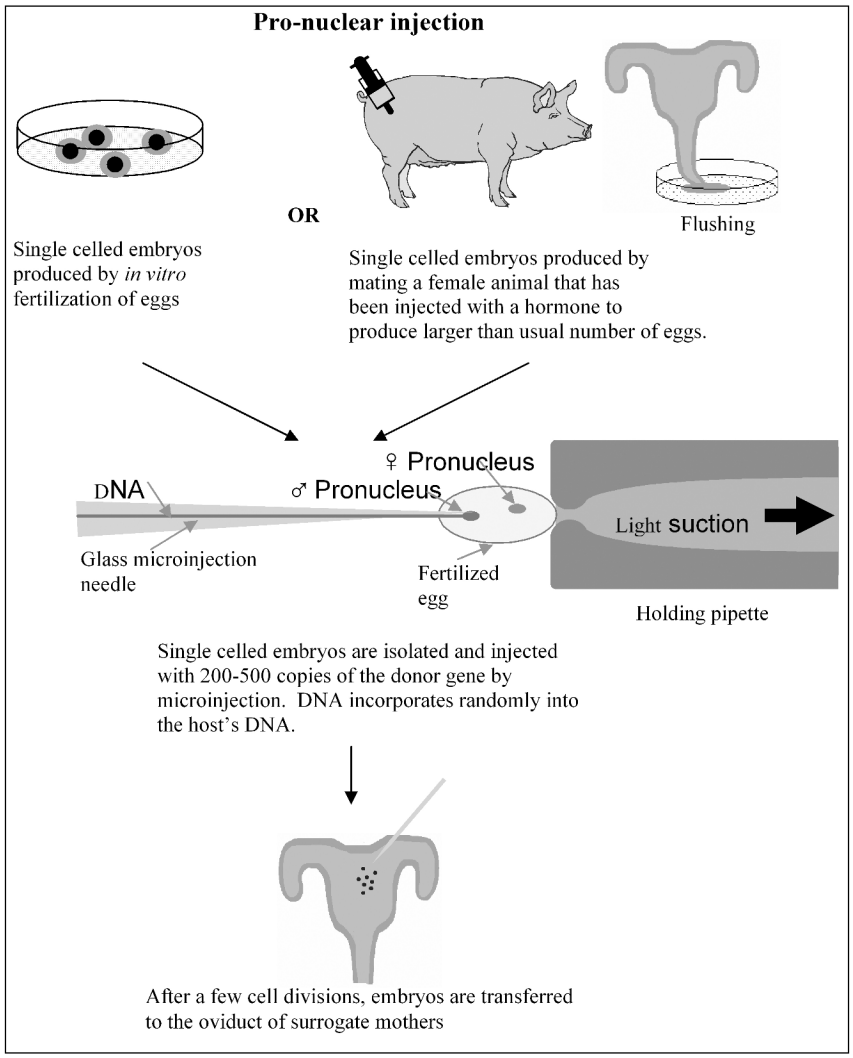

Figure 3. Production of a transgenic animal through pro-nuclear injection

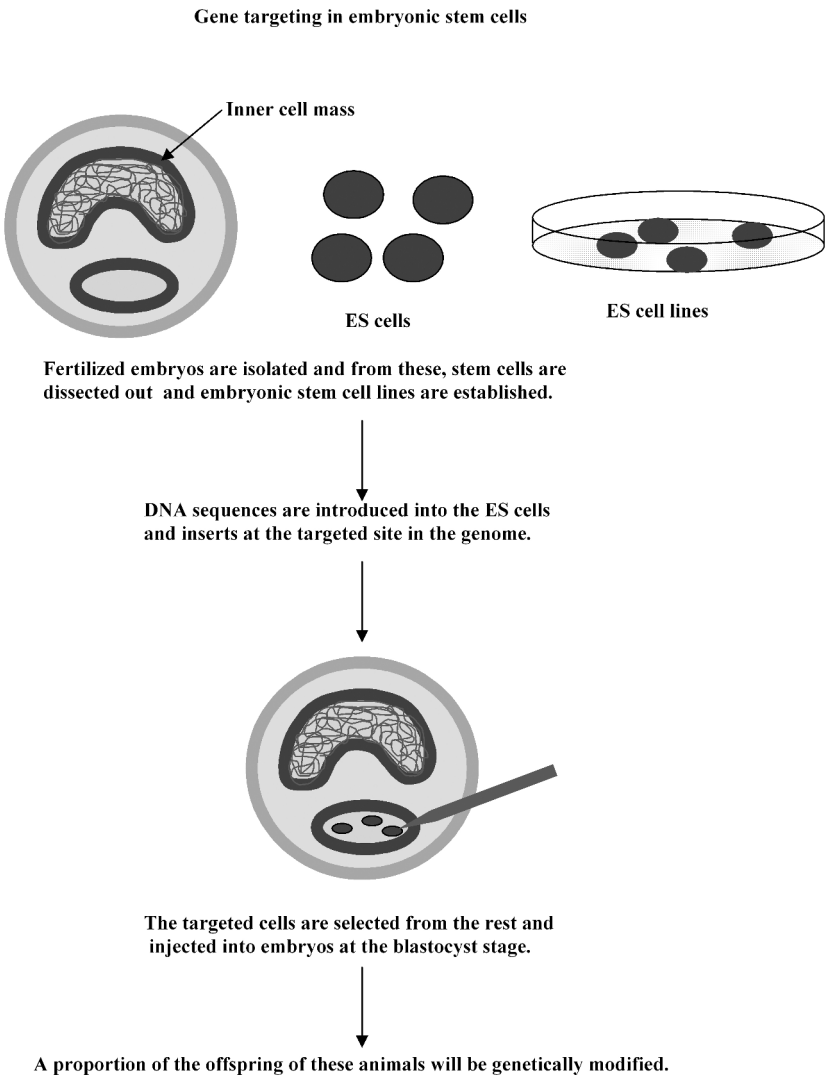

Figure 4. Gene targeting in embryonic stem cells

Animal cloning is a procedure pioneered by a group of Scottish researchers at the Roslin Institute in Scotland. They successfully cloned the first animal, a ewe named Dolly in 1997. Dolly had only one parent as she was cloned from a single cell from an adult sheep utilizing the newly developed technology of nuclear transfer. In nuclear transfer, a whole nucleus

containing a full set of nuclear genes is introduced into a specially prepared recipient egg of which the nucleus had been removed. The result is a copy, a clone, of the donor cell that contains the same genetic material (Figure 5). The mitochondrial genes, which form a minute amount of the total genetic make-up of an individual is contributed by the recipient egg. The resulting clone is therefore not an exact genetic copy of the nucleus donor.

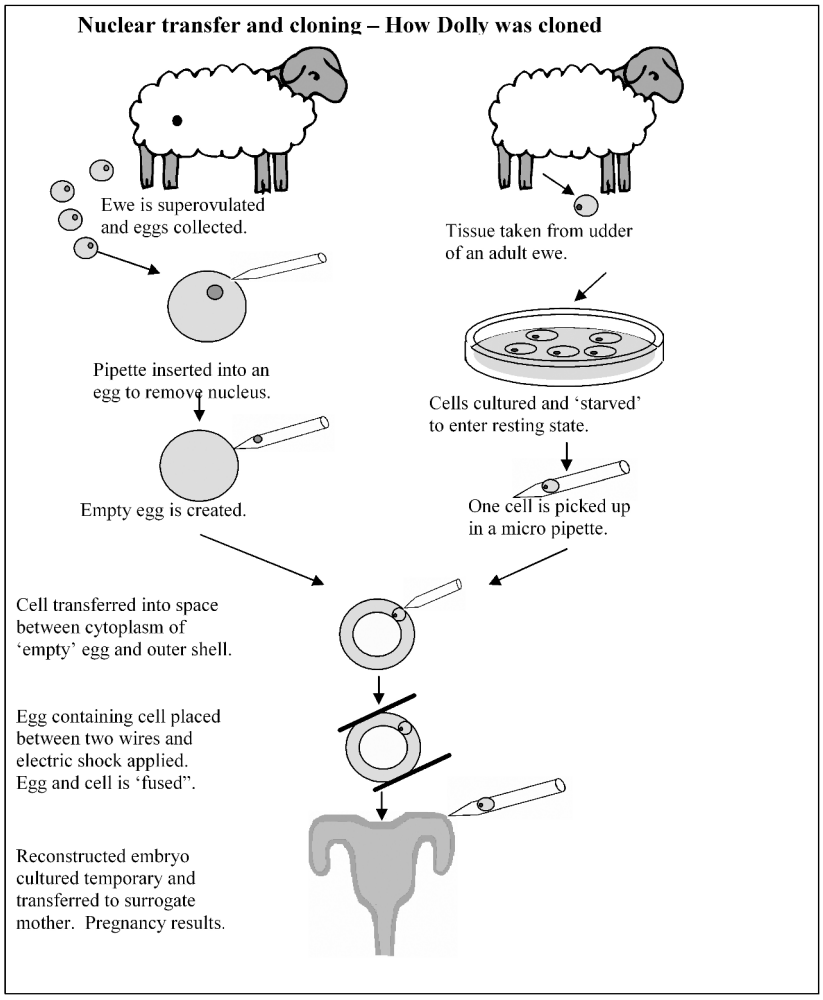

Figure 5. Cloning through nuclear transfer: Creation of Dolly

The main applications of nuclear transfer will be in allowing more precise genetic modification. Several applications are envisaged:

Envisaged applications of nuclear transfer

- Provide founder animals for multiplication of genetically identical laboratory animals.
- Improve the production of transgenic animals, and for reducing the number of animals needed to establish a transgenic line.
- Enable genetic targeting in livestock in order to establish more sophisticated genetic modification.
- Assist scientists with the identification of genetic contribution to different diseases, and thus distinguish between nature and nurture effects.
- Facilitate the study of age-related changes in cells, and their contribution to increased incidence of conditions such as cancer.
- Provide a source of replacement grafting such as to treat conditions such as leukaemia and Parkinson's disease.
- Producing multiple copies of the very best performing animals could produce more effective herds and transfer more effectivity to the farming community.
- In conservation, use these sources of cells for long term storage and to inflate population numbers of endangered species.

POTENTIAL RISK AND BENEFITS OF GM ANIMALS

What are transgenic animals used for?

In animal transgenesis, genetic modification is usually considered in terms of three broad areas, *i.e*. input traits, output traits, and value-added traits.

- Input traits help livestock and dairy producers by increasing production efficiency which can be achieved through faster and more efficient growth rates, resistance to diseases and increased milk or wool production.

- Output traits help consumers or downstream processing by enhancing the quality of the animal's product. This can be achieved through the production of leaner and more tender meat or by producing milk that lacks allergenic proteins or results in increased yogurt or cheese production.

- When new genes are added or genes are modified, transgenic animals can show completely new functions, which are considered to be value-added traits.

A representative, but by no means exhaustive list of purposes for which transgenic animals have been used indicates the wide-ranging application of this biotechnology:

- **In normal physiology and development**

  Transgenic animals can be specifically designed to allow the study of how genes are regulated, and how they affect the normal functions of the body and its development. Transgenic animals have been used to study complex factors such as a factor that is involved in regulating growth, the insulin-like growth factor, by introducing genes from other species that alter the expression of this factor, either enhancing or suppressing its production, and studying the biological effects that result. This provides valuable information about the biological role of this factor in the body.

- **In the study of disease**

  Many transgenic animals are designed to increase our understanding of how genes contribute to the development of disease, to mimic human diseases and to investigate new treatments for diseases.

- **In the production of biological products**

  Transgenic animals that produce useful proteins to treat human disease or proteins that have industrial value in animal milk (sometimes called "pharm" animals) can be created. For example, large amounts of a human protein (α-1-antitrypsin) are used to treat

a life-threatening condition called emphysema. Transgenic sheep have been developed which make the protein in their milk in larger quantities than could be produced by conventional cell-culture methods. On the horizon are therapeutic proteins, which may be used to nourish infants or treat emphysema, cystic fibrosis, burns, gastrointestinal infections and immunodeficiency diseases. Products such as insulin, growth hormone and tissue plasminogen activator that are currently produced by fermentation of transgenic bacteria may soon also be obtained by milking transgenic cows, sheep or goats.

- **In the safe testing of vaccines**

  Transgenic mice are being developed for use in testing the safety of vaccines before they are given to humans. For example, the suitability of using transgenic mice to test the safety of the poliovirus vaccine is currently being investigated.

- **In the safe testing of chemicals**

  Chemicals in our environment, and chemicals that are used as drugs to treat illnesses, are tested in animals to see if harmful side-effects result; this is known as toxicity or safety testing. Transgenic animals have been produced that carry genes which make them more sensitive than non-transgenic animals to toxic substances. The advantage is that results could be obtained more quickly and with fewer animals.

- **In human organ donation**

  Pigs containing human genes in their cells have been produced with the eventual aim of providing organs for human transplantation. Usually an organ transplant from an animal (xenotransplantation) would be rejected by a patient's immune system. However, by inserting a human gene that causes a human protein to be present on the surface of the animal cells, it is hoped that the organ will be recognized as "human" or "self" by the immune system of the patient, and will not be attacked by the cells that protect our bodies.

- **In agriculture**

  Transgenic farm animals that have been produced include cows that produce more milk, sheep that produce more wool and fish which can grow bigger or can survive in colder temperatures than normal.

- **In research**

  Transgenic animals are used to identify the functions of specific factors in complex homeostatic systems through over- or under-expression of a modified gene (the inserted transgene); in molecular biology, the analysis of the regulation of gene expression makes use of the evaluation of a specific genetic change at the level of the whole animal.

Possible risks associated with transgenic animals

Risk issues concerning transgenic animals lie in the safety of consuming transgenic animal products, environmental safety and animal safety.

- **Human consumption of transgenic animal food products and general human safety**

  The principles for assessing food from transgenic animal food products are quantitatively the same as for non-transgenic food products. However, transgenic animals used for the production of non-food pharmaceuticals might present additional concerns regarding the nature of the products they produce. The safety of food products that are derived from non-food transgenic animals might present a concern if the non-food product is found in parts of the animal that may be sold.

  Transgenic animals intended for use as food will involve the expression of new proteins in an animal, hence the safety, including the potential allergenicity of introducing new proteins into the food supply may be of concern and could change the nutritional value of the GM food product.

  There is particular concern that xenotransplantation could result in the spread of diseases from animals to humans.

- **Environmental safety**

  The inadvertent release or escape of transgenic animals (particularly fish) into the wild where they could breed or compete with the natural population is often cited as a potential risk to the environment. The actual risk associated with this will depend on the type of animal and the nature of the genetic modification; however, where appropriate, procedures must be in place to address this concern.

  In the case of aquaculture (a multibillion business in America) traits currently being tested in transgenic fish include; increased

growth rates that are 3-11 times faster with more efficient feed utilization, increased tolerance to cold water and improved disease resistance.

- **Safety and risk issues associated with transgenic fish**
  Introduction of a protein that is potentially allergenic or toxic to humans. Escape of a transgenic fish into the wild, leading to interbreeding and/or competition with the natural population.

- **Animal safety**
  There is evidence that biological products can leak into the blood supply of transgenic animals that are producing them. Although the leakage of certain products, for example α-1-antitrypsin, does not represent a risk to the animal, other products could interfere with normal bodily functions.

Benefits of animal cloning

Unlike the prospects of human cloning, the prospects of animal cloning are endless and scientists are extremely excited.

- **More efficient production of transgenic animals**
  Cloning makes it possible to produce transgenic animals more effectively, by generating large numbers of transgenic animals, which can be used for various functions. The need to recreate a transgenic animal is minimized.

- **Animal health and medical research**
  Animals are often used as models for research. Cloning provides the means to generate large numbers of identical animals, which could facilitate scientific testing of for instance experimental drugs, nutrition or housing conditions.

- **Xenotransplantation**
  Xenotransplatation involves replacing diseased human organs with animal organs, a procedure made necessary by the chronic shortage of human organs available for transplantation. Cloning may enable the multiplication of created transgenic animals suited to such transplantations.

- **Agriculture**

  Most obvious benefits of cloning would be the ability of a farmer to have a herd of superior performing animals in one generation and for breeding companies to sell cloned embryos in a manner similar to the way in which semen is currently marketed.

- **Conservation**

  It has also been proposed that cloning could be used to increase the population of animals of an endangered species. The mouflon sheep, which is a wild Mediterranean sheep with less than 1000 animals remaining, was successfully cloned. For an endangered species like the Giant Panda, it may mean the difference between existence and extinction.

- **More economical production of biological products**

  One of the most immediate advantages of animal cloning will be in the area of pharmaceutical production. Cheap and plentiful bioengineered drugs that are made from human proteins will most likely be the first practical application. The ability to clone will allow scientists to genetically engineer animals for a particular protein and then mass-produce them.

- **Research**

  One of the largest areas that will be affected by the possibility of animal cloning is animal research. If the animals used in experiments are exactly the same physiologically, the experiments are much easier to control and fewer animals will be needed for experimentation, with better results

  The study of animal clones and cloned cells could lead to a greater understanding of the development of the embryos and of ageing. Cloning could be used to create better animal models of diseases, which could in turn lead to further progress in understanding and treating those diseases.

Risks of animal cloning

The risks of transgenic animals are no different to the risks of cloned transgenic animals. However, there are a number of unique risks pertaining specifically to cloning.

- **The cloning process**

  The overall rate of successful cloning is currently low and frequently associated with developmental abnormalities in cloned animals, which clearly demonstrates the need for further research before cloning becomes regular practice. Is has also been reported that cloned animals experience health problems throughout their life. Cloned animals may age prematurely; Dolly was diagnosed with arthritis at a seemingly young age and cloned mice had a shorter than normal life span.

- **Loss of genetic diversity**

  On farms, this practice has the potential drawback of loss of genetic diversity in livestock herds, but this could be avoided by limiting the number of cloned embryos of a given animal that were sold.

  Although cloning is a means to assist the recovery of endangered species, it would be hindered by a lack of genetic diversity and would not address the larger issue of how the animal became endangered.

Trends in animal biotechnology – current research projects

Research activities
• Improvement in established technologies such as cryopreservation, pregnancy tests, AI, in vitro fertilization, embryo transfer, gene transfer *etc.*
• Reduction of difficult births by having young born much smaller.
• Development of low fat and low cholesterol meat, eggs and milk.
• Development of high protein milk.
• Identification and transfer of disease resistant genes.
• Identification of enzyme deficiencies before embryo transfer.
• Control of timing and rate of ovulation to increase litter size.
• Genetic modification for earlier puberty and decreased gestation.
• Increased appetite to increase yield relative to maintenance costs.
• Genetic modification to eliminate seasonal breeding constraints.
• Development of *in vitro* spermatogenesis and oogenesis to ensure unlimited supply of gametes and thus eliminating the need for keeping breeding animals.
• Development of genetic models to study disease and cellular processes.
• Production of animals that produce pharmaceutical products for human needs.

ETHICAL ISSUES

"Only when ethics becomes a legitimate – and rational – part of the scientific attitude will concerns about particular aspects of animal biotechnology be taken seriously, or taken at all" (Burkhardt, 1998).

Animal biotechnology is morally a sensitive issue, because of the concerns about the treatment of animals and also about the nature of modern biotechnology itself. Alongside the potential benefits, genetic modification and manipulation of animals raises a variety of ethical concerns. These concerns are either fundamental moral objections to the human use of animals or specifically to their genetic modification (intrinsic concerns), or concerns about the consequences of genetic modification of animals (extrinsic concerns).

INTRINSIC CONCERNS

From a religious perspective, there are varying viewpoints as to why animal biotechnology is seen as "wrong". Essentially, the view is that this technology is trying to "displace the Creator", or to "play God". However, the belief that modern biotechnology is intrinsically wrong need not rest only upon a religious basis. Simply stated, modern biotechnology is viewed by some as intrinsically wrong because of the belief that nature and all that is natural is valuable and good in itself. Modern biotechnology is therefore viewed as being unnatural and that it goes against nature, and in some cases crosses species boundaries.

More specifically, transgenic animals can create particular problems for some religious groups. For Muslims, Sikhs and Hindus it is forbidden to eat foods containing genetic material from animals whose flesh is forbidden. Some will however argue that that all living things share a great deal of genetic material and transferring a gene from an animal to another organism does not involve any incorporation of the animal's identity. In contrast, some maintain that it is precisely the genes of an individual that makes it distinctive. Cloning of animals is objected to by some critics, because the deliberate production of genetically identical animals fails to respect the uniqueness and individuality of all animals, particularly if the aim is production-line uniformity.

Species change through natural events and it is extremely difficult to challenge species boundaries through selective breeding. However, this

technology which allows direct genetic modification, potentially offers limitless possibilities for transferring specific genes between widely different species, which brings about genetic change in a single generation. This raises new ethical issues not raised with traditional selective breeding. This technology provides the means to modify an animal's DNA fast, and very precisely, thereby increasing the power or control that can now be exercised over the shape of the lives of animals. Also, if it is accepted that some examples of animal biotechnology are not intrinsically wrong, the question is, how far can this technology legitimately go?

Nowadays most people would agree that animals have the right to be treated as sentient beings which means free of pain and suffering. The spectrum of opinion regarding the relative weightings that should be accorded to human and animal interests ranges from the position that human interests are always sufficiently important to outweigh animal interests, to the position where they are never sufficiently important. Many arguments (about consciousness, self-consciousness, cognitive ability, language capacity, moral sense, quality of life and evolutionary status, for example) have been used in attempts to find morally relevant differences (or, conversely, similarities) between humans and animals which could justify (or preclude) treating animals as means to human ends. None of these arguments so far has succeeded in attracting general philosophical agreement (See Chapter 6 – Animal Rights and Animal Welfare for a detailed discussion on these issues).

EXTRINSIC CONCERNS

Animal welfare during the process of genetic modification

The techniques used during genetic modification include procedures such as the administration of drugs to donor female animals to induce super ovulation, followed by timed mating and collection of fertilized eggs, genetic modification and then implantation into surrogate mothers, by laparotomy. Although both the induction of super ovulation and laparotomy are established techniques carried out under general anaesthetic, laparotomy can cause post-operative pain, and super ovulation can cause discomfort. Furthermore, foetal death can occur during development *in utero*, and some additional deaths can occur post-natally. It is uncertain at what stage in development, foetuses can experience pain and distress, or how far the welfare of the mother is compromised by foetal death. However, in the larger farm animals it is known that miscarriages cause distress to the mother. Losses during production mean that relatively large numbers of

donor and recipient animals must usually be used in order to produce a relatively low yield of genetically modified animals.

Animal welfare as a result of genetic modification

In research, animal models are deliberately produced to mimic human disorders or to study physiological development. This is accomplished by introducing gene deletions ('knock-outs'), mutations, or defective genes to cause or simulate a wide range of genetic diseases, or developmental or gene function abnormalities for research purposes, which by the nature of the modification cause discomfort to the animals concerned.

In any procedure of genetic manipulation, unintended deleterious or harmful side effects can occur. Such side effects may be caused when the new genetic material is expressed and unpredicted physiological changes occur; or they may be caused when the introduced DNA disrupts the function of one or more of the animal's own genes, due to the random nature of the DNA insertion process. The result of the unpredictability of DNA insertions currently can be fatal for the developing embryo. In instances where the result is not fatal, the welfare of the resulting animal can be seriously compromised. Although direct genetic modification can produce genetic changes more rapidly than selective breeding, of great concern is this unpredictability of the outcomes. The current status of the art is such that only a small percentage of embryos used in transgenic procedures will express the foreign DNA and not all of these will survive. Surviving animals that do not express the foreign gene might be used for other purposes, but those that are not used are killed and therefore wasted. Surviving animals may suffer unnecessarily. For example, transgenic pigs, which were given the cow growth hormone gene to increase the amount of meat they would yield, were found to suffer from arthritis, ulcers, kidney disease and fertility problems.

In this fast-developing science the potential costs and benefits cannot be assessed as easily as in other areas of science. The potential effects of the procedures are often uncertain and it is therefore especially important that the justification for such work is reassessed as the work progresses to gain experience in order to predict more accurately the potential costs and benefits. In terms of animal welfare, databases recording information about genetically modified animals tend not to provide indications of welfare problems. A greater awareness of possible welfare problems is needed and it is therefore important that the effects of genetic manipulations are fully documented in as much detail as possible together with a record of whether the desired benefits actually are achieved.

It should be noted that whilst most genetic modifications tend not to benefit the animals concerned, some genetic modification might aim to benefit animal welfare such as producing resistance to disease.

Currently, genetic modification involves the transfer of one or a few genes, for instance the production of human growth hormone by transgenic pigs. The human protein may be only very slightly different from the pig protein but nevertheless it is found naturally only in humans. Whilst it is currently feasible to transfer only a few genes between species, in future it may be possible to transfer many more genes and scientists therefore need to be alerted to the biological implications and related ethical concerns that might arise.

Safety

Presented here is a list of several categories of concern about risks to safety that need consideration.

Potential risks of genetic modification and/or manipulation to safety
• Modified animals might 'escape' and breed with other domestic or wild animals, so transferring the new gene(s) to these populations.
• The risk of the use of retroviruses as DNA vectors during production of genetically modified animals might inadvertently result in the transfer of retroviruses to other organisms.
• Risks to human and animal health from consumption of genetically modified animals and their products.
• Risks that drug resistant gene markers used in some genetic modification procedures might inadvertently be transferred and expressed.
• 'Ecological' concerns about the wider effects of producing disease-resistant animals.
• In xenotransplantation, concern about risks that human recipients of animal organs might become infected with animal viral diseases, which might then infect the wider population.

ECONOMIC ISSUES

Improved farming practices

Purpose-produced animals could greatly enhance the profit of a farmer. In combination with cloning, large numbers of transgenic animals can be produced, as in the case of transgenic cows that produce more milk, sheep that produce more wool and fish which can grow bigger or can survive in colder temperatures than normal. Cloned animals, especially females for breeding, could hasten the genetic improvement of the herd.

Disease is one of the battles that all farmers face. Transgenic animals that are disease resistant have the potential, in combination with cloning, to greatly enhance farming practices on modern day farms. The potential of supplying more resilient animals to the rural farmer is also a possibility.

Better Business

Biotechnology represents huge commercial and corporate profits especially in the human medical field. Transgenic lines created for a particular purpose can be established. Lines for the production of therapeutic proteins and lines that can be used in transplantation surgery are good examples.

VALUE TO SOCIETY

Improvement of the nutritional value of food

Biotechnology can be used to improve the nutritional value of foods, meat and milk, after extensive testing for the presence of allergens or toxins that can possibly reduce the nutritional value has been undertaken.

Improvement of health

One of the greatest contributions that is envisaged with this technology is to human health improvement, through the use of better animal models in, especially disease research, the production of human therapeutics and human transplantation.

Better for the environment

Cloning has the potential to ‘save’ endangered species.

DISCUSSION VIEWPOINT

Genetic modification is still a new science with many problems. The effects of the insertion of genes is unpredictable and consequently, the results of this technology vary considerably as well. The knowledge of molecular biology is much too incomplete to be able to predict the effects of an inserted gene even when the position of its insertion is exactly known. Accurate record-keeping and regular assessment and reassessment is required in order to understand the outcomes, effect on animals involved and on the society participating. Hopefully, as the science improves and scientists' understanding of biotechnology improves the benefits of this technology could be immeasurable. However, animal biotechnology will only deliver the promised benefits if the industry and government can establish and abide by an ethical code. Public policies must be based on better understanding and appreciation for the power of the market place and the rights of the public to feel secure about their food supply and other uses of transgenic animals.

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Chapter 8

THE EFFECTIVE PRACTICE OF AGRICULTURAL SCIENCE

Trevor R. Anderson

INTRODUCTION

Agricultural scientists strive to become the most effective they can in the practice of their field. Today this requires them to acquire a wide range of knowledge and skill competencies not only in their particular scientific discipline but also in areas of philosophy, ethics, law, public relations and business. The aim of this chapter is to give the reader a profile of an effective, modern agricultural scientist, including an idea of the most important issues that s/he faces when operating within this very demanding and, at times, rather hostile environment.

The generic nature of this chapter means that its contents have implications for all the topics covered in the rest of this book. The reader is thus encouraged to link as often as possible to what they have read in the other chapters. To assist in this regard, this chapter contains extensive cross-referencing to the other chapters.

NATURE OF (AGRICULTURAL) SCIENCE

In order to practise agricultural science effectively, it is essential to have a clear understanding of the nature of science, as such knowledge will tell us what it means to sustain the integrity of science and the professional behaviour of scientists.

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So what is science all about - what is its inherent nature, character or basic constitution? The understanding of science by scientists and the way it is understood by the lay citizenry has over the last century been narrowed to mean, "getting to know scientific facts". Indeed 'philosophy of science', as the broad area of science which deals with how science is expanded and explored, has been ignored in science education at all levels and is considered by most scientists and laypersons alike as something 'up in the clouds' and 'irrelevant' to the practice of science. In this section, an attempt will be made to illustrate that a good understanding of the nature of science can significantly enhance the practice of science and the development of various cognitive skills that are crucial for the doing of good science.

So what is the nature of science and how can knowledge of it enhance effective practice of science? Table 1 summarises the major features that characterise the nature of scientific knowledge.

Table 1. Factors characterising the nature of scientific knowledge (after Lederman, 1992)

Science knowledge
1. Is indefinite in nature (never absolute or certain).
2. Is dynamic and ever changing.
3. Is tentative (subject to revision).
4. Is temporary (likely to eventually change).
5. Is dependent on the consensus view of the community scientists.
6. Has 'grey' areas which may, or may not, become generally accepted by the community of scientists.
7. Is partially subjective in terms of conceptual understanding and interpretation of results.
8. Is a product of the cognitive, practical and technical skills used obtain results.
9. Is a product of human imagination and creativity.
10. Is a product of how scientists visualize phenomena.
11. Is a product of human endeavour/enterprise affected by conceptual knowledge, social fabric, power structures, politics, socio-economic factors, philosophy, worldviews, culture, ethics and religion.
12. Is dependent on the use of good, valid and reliable scientific methods.

13. Is affected by the limitations of the methods and techniques used to obtain the results.
14. Involves both observation and inference.
15. Includes theories which are inferred explanations for observable phenomena.
16. Includes laws which describe relationships between observable phenomena.
17. Has a history and progresses by building on old models of the natural world, not replacing them.

An awareness that scientific knowledge is indefinite, tentative, temporary and therefore dynamic in nature (Points 1-4; Table 1), should encourage science thinkers (scientists and interested citizens) to more readily challenge, question and critique what they hear and read, and not treat scientific knowledge as hard inflexible facts like many media lead them to believe. Developing such critical thinking would certainly make for more effective scientific practice.

Awareness that the acceptance of scientific results is dependent on the consensus view of the community of scientists (Points 5 & 6; Table 1) can enhance scientific practice in several ways. Everything depends on the consensus opinion at the time and, true to human nature, it is forever changing. Thus it should not be surprising to anyone when a scientist is booed as a crackpot only to be proclaimed a hero at a later stage. This was indeed the case in the last century when a theory of continental drift was first proposed. The first thinkers in this area were in fact awarded the "Crackpot" award and today it stands (a cracked pottery vase) in a display cabinet at the University of Wisconsin in the US. Only later was the theory accepted when many other thinkers started to see merit in it and developed it further. It is also important to realise that it is fine to challenge scientists attempting to maintain the *status quo*, to question current knowledge, and to have one's thinking and work labelled as alternate. Greater acceptance of the importance of such diverse thinking to scientific progress should lead to more open-mindedness, more scientists exploring the fringes of science and, therefore, more effective practice of science.

Knowledge of the history of science (Point 17) and its development will also enhance the effectiveness of an agricultural scientist. For instance, it is important to realise that scientific models of the past were not wrong just because there are now better models available to describe a particular natural phenomenon. The older models were simply more

limited than the newer ones. The model that the earth is flat was useful for explaining local systems but not for discussions and predictions involving the whole globe. Thus, scientific progress is not about replacing old models, but more about building on such knowledge to produce new models that are more useful.

INTEGRITY OF SCIENCE AND SCIENTISTS

An understanding of the *nature* of science (see previous section), and scientific research, enables us to better understand what is required to sustain its *integrity*. Since science is a human endeavour, carried out by humans for humans, the integrity of science will depend on, and be mirrored by, the integrity of the scientists themselves as well as other stakeholders involved in some or other way in the process and application of science.

But what is the meaning of integrity? Since science involves the search for "truth" and depends very heavily on *sound* practice and the *honest* performance, reporting and interpretation of results, scientists clearly need to show high integrity when performing their job effectively. This is supported by the following quotation from Standards for the Ph.D. degree in the Molecular Biosciences:

> "Science depends upon integrity. Every instance of dishonesty, no matter how trivial it may seem, has the potential to be harmful to individual scientists and to the relationship between science and the rest of society".

The integrity of science, and therefore of scientists, is about maintaining a reputation and image among people of a profession of highly respected, upright, competent and trustworthy scholars who can be relied upon to perform their job in a manner that is in the interests of improving the human condition (See section on Communicating Agricultural Science to the Public). Unfortunately, or fortunately depending on how one looks at it, human trust is extremely fragile and often requires only one negative incident to be irreparably damaged. Science and scientists are not immune from this human trait and an issue perceived by people to be unethical can negatively affect public impression of, and confidence in, science; erode scientific norms

within science, harm individuals and, thereby, seriously damage the integrity of science.

There is no single code of ethics for scientists but there are some basic ethical norms that are accepted by most scientists as being important for maintaining the integrity of science. This is supported by the words and ideas of Carl Sindermann (Sindermann, 1982), in "Winning the Games Scientists Play", who writes: "Since the very essence of science is to discover by observation and experimentation what is true and real, it is essential that professional scientists conform to a basic code of ethics." These are listed in Table 2, without further comment.

Table 2. A basic code of ethics for agricultural scientists (Lederman, 1992)

1.	Be aware of the nature of science and scientific research (See Table 1).
2.	Use accepted scientific methods.
3.	Be as objective as possible in interpretations of data.
4.	Be honest in performing experiments and reporting results.
5.	Be careful, and avoid errors, in the performance of research.
6.	Give credit for ideas, data and conclusions of others.
7.	Do not disclose results to media before peer review.
8.	Do not dramatize scientific results.
9.	Disclose ("whistle-blowing") and challenge unethical conduct of scientists.
10.	Eliminate scientific fraud and the abuse of scientific results.
11.	Do not manipulate scientific results for financial or political gain.
12.	Do not consult outside areas of competence.
13.	Promote openness and transparency in the sharing of idea, results, conclusions, and techniques.
14.	Make use of independent "watch dogs" from the non-scientific community.
15.	Oppose vocal individuals and minorities who use a few events to try and call a halt to whole areas of scientific research, or to question the entire ethos of science.
16.	Make scientific knowledge, legislation and human behaviour compatible.
17.	Allow scientists freedom to do research on any hypothesis or issue.
18.	Stay aware of social responsibilities towards the well-being of society and the potentially beneficial/harmful implications of research.

19.	Actively develop integrity in science students - the future of science!
20.	Promote image of scientists as a community of trustworthy scholars.
21.	Promote public understanding of science for the image of "good science".
22.	Educate prospective scientists in the habits of good science.
23.	Be culturally, racially and gender sensitive.
24.	Make scientists aware of ethical standards, conduct and professionalism.
25.	Nurture a good relationship of mutual respect with students, colleagues and society.
26.	Stay within the law when performing their function.
27.	Do not deny opportunity for promotions of individuals and to use resources for scientific advancement.
28.	Use all human, animal, plant, microbial and non-living resources efficiently, not wastefully, and with respect.

Thus clearly there are numerous ways in which agricultural scientists can maintain the integrity of their profession but it is not always so simple for them to implement them. Firstly, hearing, or being exposed to, what is right and wrong does not necessarily mean that they will implement the ideas. They need to first learn such knowledge and incorporate the ideas into their repertoire of skills that they use automatically. Secondly, even if such knowledge and skills become intrinsic to them, they will still interpret and judge the ideas according to their own values and belief systems, which means that they may, or may not, implement the ideas in the same way that others might do, *i.e*. there will be a diversity of opinion about what constitutes being ethical and unethical. Indeed sometimes the boundaries between these two extremes are very subtle and need to be discussed by the community of scientists. Finally, even if the scientist is "sold" on a particular idea s/he might not implement it because of various pressures that come to bear. These include: pressure on them to be more productive - the "publish or perish" syndrome; the desire for power and/or financial gain; perhaps a promotion on the line, or peer pressure of various sorts. All these factors, can harm the effective practice of agricultural science, and damage the integrity of the profession.

COMPETENCIES OF AN EFFECTIVE AGRICULTURAL SCIENTIST

Most agricultural scientists are expected to acquire a wide range of competencies in areas such as research, administration, as well as for consulting with industry, the law, the public and even the media (Table 3). In the sections which follow, some of the ethical skills and practices required of agricultural scientists when doing research (discussed in more detail later) are described, or consulting with industry and the law (discussed in more detail later), or the media (discussed in more detail later). A brief discussion on some of the more important competencies is hopefully adequate.

If a scientist is not aware of the nature of science (Competency 1; Table 3), *i.e*. what it is all about and how it is done, then it is not possible to do good science and be an effective scientist. Furthermore, as discussed above, science without integrity (Competency 2; Table 3) is not good, respected science and, therefore, such a person will also not be effective as an agricultural scientist in the public stage.

Table 3. Overview of ten major competencies of an effective agricultural scientist

Competencies (Knowledge and Skills)
1. Knowledge of the nature of science.
2. Understanding of the meaning of integrity of science and scientists.
3. Conceptual understanding: Own discipline and cross-disciplinary.
4. Procedural knowledge: Concepts, skills and practical techniques for doing scientific inquiry.
5. Cognitive skills: critical thinking, reasoning, comprehension, creativity, analysis, synthesis, evaluation, visualisation, modelling.
6. Open-mindedness to change in agricultural science.
7. Personal and interpersonal skills and behaviour: motivation, energy, time-management, project management, productivity, negotiation, consultation, innovation, problem-solving, tenacity, people management skills, ethical skills including respect of race and gender, listening skills, decision–making, team-work, collaboration, application, implementation.
8. Communication skills: Oral and written presentation and publishing.

9. Educational skills: Teaching and learning.
10. Administrative skills.

Sound conceptual knowledge (Competency 3; Table 3) is absolutely crucial for the competent agricultural scientist. Although such knowledge is often taken for granted, research has shown that "experts" can hold misconceptions that can seriously interfere with their ability to do their job effectively. Furthermore, modern agricultural scientists need to understand what conceptual knowledge is marginal, but of relevance to their discipline and to be able to work competently across such disciplines.

Another non-negotiable competency for agricultural scientists is proficiency in procedural knowledge (Competency 4; Table 3). Procedural knowledge consists of both the concepts of scientific inquiry (*e.g.* concept of a 'hypothesis' or 'control') as well as the process skills required to implement such concepts (*e.g.* how to set up and test a hypothesis, or determine and use an appropriate 'control'). Some scientists more commonly, although erroneously, describe procedural knowledge as the 'scientific method' (Lederman, 1998).

Competency 5 (Table 3), involving a wide range of cognitive skills, is also fundamental. There is a large body of knowledge in the science education literature on how cognitive skills such as critical thinking, reasoning, comprehension, creativity, analysis, synthesis, evaluation, visualisation, and modelling, are acquired. Although all these skills are equally important competencies for the agricultural scientist, visualisation and modelling techniques promise to play an increasing role in future developments in agricultural science.

"O*pen-mindedness* to change" has been included as a competency (Competency 6; Table 3) because this property has played a major role in the advancement and achievements of agricultural science over the past few decades. Thanks to this characteristic of the modern agricultural scientist, agriculturists have undergone a drastic paradigm shift from a more traditional "farmer Brown" culture, with fixed *status quo* attitudes and ideas on how research should be done and applied in the world, to far more progressive attitudes and more holistic and global ways of thinking. The upshot has been a vibrant, dynamic and modern culture of cross-disciplinary agricultural scientists who are actively researching the important grey areas (Table 1) of agriculture, and playing leading roles in key issues affecting the welfare of humans, and the plants, animals and microbes that populate the earth.

In the future, the continued effectiveness of agricultural science will depend on the open-mindedness of its scientists and their resistance to any barriers to change that might arise. Typical barriers that have been reported to affect transformation processes and, therefore, effective progress in any field include, historical habit, certain values and conservative attitudes of individuals, cultural traditions, fixed policies, political goals, philosophical approaches, psychological factors, peer pressure, and even practical and logistical factors. In this regard the following words of Dalin (1978) are appropriate:

> "Realise that you have innovators, early adopters, early majority, late majority and laggards in every change system and be more understanding of such characters.…. People tend to continue with activities which are known and which provide a certain security, rather than ….with unknown consequences. Terms such as 'homeostasis', 'habit', Self-distrust, insecurity, regression and dependency on authority figures ….innovations are rejected through ignorance, …. Maintaining the *status quo* by following the norms of influential and inter-personal relations, or by creating substitutes."

Agricultural scientists require a wide range of competencies in order to function effectively, most of which need to be explicitly taught, as they won't necessarily be learnt through experience alone. The following words of Sindermann (1982), aptly describe the needs of scientists:

> "The good scientist is usually blessed with an above-average core of energy, intelligence and perception that is closely interactive with personal characteristics of productivity, insights, thinking and reasoning skills, creativity, synthetic and analytical ability, enthusiasm, effective oral and written expression and professionalism" (Sindermann, 1982).

Ethical Issues in Scientific Research

In this section, selected ethical issues that agricultural scientists might have to deal with in their practice of scientific research are discussed. These issues include fraud, plagiarism and the problem of proper acknowledgement of individuals for their contributions.

Scientific Fraud

Although most cases of scientific misconduct do not actually infringe on the law, the major characteristics are the same, namely to falsely deceive people for personal gain. The National Academy of Science (1992), in the

USA is more specific in defining misconduct in science as "Fabrication, falsification, or plagiarism, in proposing, performing, or reporting research".

> A researcher would be guilty of fabrication should they manufacture sets of data, and make claims to results, without performing any experiments. Fabrication also includes the creation of data points to supplement incomplete data sets; and the extrapolation of curves, and the prediction of trends, beyond the range of the data obtained. Falsification would include making inconclusive data appear conclusive; selecting out and discarding co-ordinates that are too far from the expected graphical trend, or too different from the mean value; or selecting certain trends in data which fit a preconceived pattern.

Then there is the issue of incompetence and ignorance of what constitutes good ethical science. In this regard, The National Academy of Sciences (1992) states, "Misconduct in science does not include errors of judgement; errors in the recording, selection, or analysis of data; difference in opinion involving the interpretation of data; or misconduct unrelated to the research process." Thus misconduct is about being consciously devious for personal gain, not about incompetence. Ignorance is another issue, since it brings in a question of accountability of individuals for their actions. Finally, there is the question of the severity of the unethical action and whether there is a continuum between ethical and unethical extremes and to what extent can the boundary be moved by the different ethical norms across different cultures. It is important to be aware and sensitive to different perceptions of the meaning of ethical and unethical when practicing as an agricultural scientist.

Plagiarism

Plagiarism has been described by Sindermann (1982) as the, "Outright lifting of data or text from the published work of others without permission from, or credit to, original sources." Resnik (1998) adds to this by stating that, "Plagiarism occurs when someone falsely represents another person's ideas as his [/her] own through irresponsible citation, attribution, or paraphrasing". It is not only data, words, phrases and ideas that can be plagiarized but also anything that has been created by scientists including techniques, web and e-mail information, video and oral material, computer software and programs, and any other intellectual property (see section on intellectual property rights). Plagiarism is often a problem among many

scientists, especially science students, who haven't been educated properly as to correct procedures for referencing or citing sources.

Giving credit

The question of giving credit to individuals for their scientific work has probably been the source of debate in every laboratory at some time in its history. Since ideas, results and publications are to scientists like money is to entrepreneurs, it is not surprising that such debates have sometimes led to major conflicts and even break-ups of research teams. The following are typical questions that might arise when the issue of giving credit is debated when, for example preparing a paper, writing a review or presenting work of others orally:

- Which work did you do and which work was done by someone else?
- Who deserves credit?
- What type of credit should be given to each person?
- Who should be given authorships?
- What were the relative contributions of the authors to the work?
- Who should be referenced?
- Who should be acknowledged?
- How should they be acknowledged?

The subjective nature of this issue means that it will always be difficult for researchers to totally agree with each other when addressing the above questions, as there will seldom be one right answer. In many cases the best one can hope for is a compromise. Generally speaking, though, authorship is first and foremost awarded for conceptual inputs, either for conceptualising the project (formulating research questions) and/or for analysing and interpreting the results. Any other contributors usually receive acknowledgements. Situations like this also lend themselves to the opportunistic activities of certain scientists who might try and claim authorship (instead of acknowledgement) in return for rather limited, routine assistance.

Whatever the nature of the fraud, misconduct, or plagiarism it is the duty of all scientists to promote the integrity and effective practice of their profession (See Table 2), to be sensitive to, and eliminate, the devious ways of unethical scientists, and to ensure that scientists get credit for their work regardless of the nature of the contribution. This will require a two-pronged approach: firstly in the short-term there will need to be more policing of fraud and plagiarism and more serious penalties; secondly, ethics as a subject will need to be explicitly taught to all science and agricultural

students, either as a separate course or, preferably integrated where appropriate into all courses.

CONSULTATION WITH INDUSTRY AND THE LAW

All agricultural scientists need to learn how to consult and interact effectively with industry and in some cases also the law. In this section the major issues facing agricultural scientists when they perform such consultations are discussed.

Vulnerability to exploitation

Most salaried scientists practise their art within the rather protected environment of a university or a government institution, away from the financial stresses of the often cut-throat business world. In this world creative thought is more important than efficiency and money. Thus they are usually not well prepared for dealing with industry whose priorities are very different. This renders them more vulnerable to exploitation. It is not uncommon for instance that people from industry will expect free advice from scientists or, worse still, pay relatively miniscule amounts for student bursaries and running expenses for a project in which the industry stands to gain millions of rands when the research knowledge or technology is applied.

Furthermore, the scientist might not only be paid nothing for his/her inputs but also, the contracts might disallow publication of the work, since this would destroy patent ability of the work and any competitive edge the industry might have over its opposition. This means that the scientist would be prevented from doing what is the most important measure of the success of their work- publishing. Further, it is considered unethical in the scientific community if withholding key results from the public domain interferes with scientific progress. Related to this is that much of industry is unaware of the importance of giving scientists credit for their research despite ownership of their intellectual property. They have the idea that if they have bought the rights to using the knowledge and technology developed by the scientists that they have also bought the rights to claim credit for doing the work. Not only is this unethical but, once again, the scientists are disadvantaged as they depend very heavily on publications and credit for doing their work for career advancement.

Even if the legal side of contractual agreements and financial compensation is in order, there are many other issues that scientists need to be aware of when consulting with industry. For example, when industry invests in contractual work they usually expect a particular research outcome (which may not be in keeping with the nature of science and how it is carried out). In some cases, *e.g.* in the case of pollution problems, this might put pressure on the consultant to give advice, to produce research results, or to falsify data, in order to validate and support the industry's position (otherwise the scientists might lose the contract). In such cases, industry might try and buy the scientist into supporting the industry position in court cases and public issues. Thus the agricultural scientist needs to be continually aware of their ethical obligations to upholding the integrity of science and scientists when dealing with industry and being vulnerable to exploitation by industry.

Competence to consult

In the above section I mentioned the problem of ignorance and lack of competence regarding contractual agreements with industry. This also includes being able to deal with lawyers who industry will deploy in order to perform various tasks for them regarding contracts and the resolving of industrial disputes. In such cases scientists can be called upon to act as expert consultants in legal cases, *e.g.* on mining pollution, rhino horn poaching, drug cases, food industry disputes, *etc*. Should this occur, it is important that the scientist should only accept such a consultancy if they are competent to do so, *i.e.* they have an established reputation (which can be verified) as an expert in the area of controversy and would, if necessary, be able to support their evidence with key publications in the field. Also they should be prepared to verify the credibility of their evidence by demonstrating that any tests or research they have done to acquire the evidence was done using well-established methods and techniques and the results are within acceptable confidence limits. It is important that the scientist presents the fact to the court as clearly and succinctly as possible and, under no circumstances, offers advice or interpretations that cannot be substantiated by his/her data or knowledge from the literature.

INTELLECTUAL PROPERTY RIGHTS (IPR): PATENTS AND COPYRIGHT

Intellectual property rights (IPR) constitute ownership rights over ideas and inventions. The principal intellectual property rights are patents,

copyrights, trademarks, geographical indications and industrial designs. A detailed coverage of the problems revolving around IPR is beyond the scope of this book as it involves highly complex and extensive legal issues. In this section, two of the major issues that might be of greater relevance to scientists in their practice, namely patents and copyright, are discussed.

Patents

> A patent is an exclusive right granted to the owner of an invention, usually for up to 20 years, which prevents anyone else from commercially producing, using, distributing or selling the invention without the patent owner's consent. The patent owner may give permission to other parties to use the invention, or sell the right to the invention. To be patentable, an invention must be novel, have practical application and fall within the list of items considered patentable by law.

There has been much debate over the years as to what should be considered as "patentable" under law. Novel products of scientific research and invention, such as laboratory equipment, and chemical and medical products are clearly patentable, but should natural products such as human genes be patentable? Currently natural products such as human DNA are not patentable; they only become patentable when they have been modified by scientists, such as for example DNA analogues.

Another hot debate raging revolves around the exploitation and patenting of the traditional knowledge and practices of indigenous communities (see Chapter 5 – medicinal plants). Since traditional knowledge of things like herbal remedies is a valuable source of information for the development of pharmaceuticals and other biochemicals, indigenous communities are vulnerable to exploitation. Thus the question arises, in what way should such communities benefit from the contributions they have, directly or indirectly, made to the development of patented industrial products? Since this issue links directly to issues of land-use (Chapter 3), conservation and biodiversity (Chapter 4), and biotechnology (Chapter 7) discussed elsewhere in this book, it will not be discussed any further here.

Patents in many ways go against the ethical performance of science, which advocates transparency and sharing of ideas in the interests of

scientific progress. Thus agricultural scientists are often torn between financial gain from their work and the desire to publish and share their work with others. However, since most industries will only invest in research and development if they can buy exclusive rights to any inventions many researchers, in order to obtain funding for their research, will compromise their values by agreeing to non-publishing clauses and other demands of industry.

Copyright

> Copyright means the *right* to make a *copy* of something. The owner of a work, which is protected by copyright, is the only person who has the right to copy this work or permit someone else to do so. Even un-copyrighted material is protected by law. Copyright applies to all literary works including, scientific literature, textbooks, computer programs, diagrams, pictures and other images.

Copyright acts are continually being reviewed but generally give the owner, or someone authorised by him/her, permission to reproduce or modify copyrighted materials, to distribute and sell copies of the copyrighted work and to present the copyrighted work publicly. Authorisation usually requires written permission, payment of a fee, as well as clear referencing of the source of the material. The act usually allows an individual to photocopy, download, save and print out documents for their own personal use, without permission but, once several copies need to be made then permission is required. The act also allows for what is termed *fair use,* which includes the reproduction of copyrighted materials for purposes such as criticism, comment, news reporting, teaching (including multiple copies for classroom use), scholarship, or research for educational purposes but not for financial gain.

Computer software is also subject to copyright usually enforced by means of a *licence* for an individual or a *site licence* for a university or business. When one buys software, one may think that one has bought the programme, but usually one has bought the *licence*, or right, to use the programme and its documentation- not to make copies of it without permission, which is termed *software piracy*.

COMMUNICATING AGRICULTURAL SCIENCE TO THE PUBLIC

A chapter on the effective practice of agricultural science would be incomplete without a section on the issues relating to the communication of agricultural science to the public. This is because agricultural science has a major impact on almost every facet of human life (*e.g.* food, health, recreation) and, therefore, scientists should feel morally bound to keep the public well informed of their activities, so that they can make their own decisions on, for example, whether a particular product is beneficial or harmful to humans, and whether it is economically sound to produce it (for a detailed discussion on this aspect see Chapter 7 – Agricultural Biotechnology).

As true professionals, scientists should feel accountable to their clients, the public. In turn, the public as responsible citizens should pressure the scientists to keep them informed as this acts as an important control against any unethical practice that might discredit the profession. By promoting good communication and transparency between both parties, the integrity and image of science as a profession of upright, trustworthy scholars will be promoted (See Table 2). Keeping the public well informed is not only a moral issue; it is also a selfish issue. If politicians, business people and the media become more familiar with a scientist's work they are more likely to receive good research funding for projects and improve their chances of things like promotion in their careers.

For good reason, agricultural scientists should make a contribution towards promoting public understanding, awareness and impression of agricultural science. The question is, what type of knowledge does the public need to have in order to understand agricultural science, and do different members of the public (*e.g.* politicians, business people, *etc*) require different types of knowledge. The diagram in Figure 1 shows some of the major factors affecting public understanding, awareness and impression of agricultural science. This is also the type of knowledge that the public needs to be informed about. Furthermore, to answer the second question above, ideally every member of the public should have at least some knowledge of each type, but the extent of such knowledge should depend on the public role of the individual.

In order to make judgements about agricultural science, the public needs to have some appreciation of what science is all about (*i.e. The Nature of Science*; Table 2), how science is done (*Procedural Knowledge*; Table 3) and the specific concepts (*Conceptual Knowledge*; Table 3) of relevance to the particular issue. This will enable them to appreciate that scientists can

never be absolutely certain about their results- that at best they can be confident within the limitations of their current knowledge and the methods and technology currently available to them for producing the research results.

But this does not mean that a particular product, that has been well researched, will not work- it simply means that scientists cannot possibly detect every potential alternate effect that might arise. But then the same holds for everything we use (*e.g*. cell phones and the brain cancer issue) and consume (*e.g*. plant products sprayed with chemicals) – there will always be hidden risks or unexpected benefits - the main thing is to be able to make an *informed* judgement. In this regard, when for example politicians claim they have data in their possession that says GMOs are bad or that HIV does not cause AIDS, then the informed public will be able to ask questions (and expect answers) such as, Was it respected scholars who did the research? Was it good science? Were established methods and techniques used? Were there appropriate control experiments?

Those members of the public, likely to ask the above sort of questions would need to have the appropriate knowledge of nature of science, science procedure and concepts. Others might be more interested in how agricultural science can be usefully applied (knowledge of applications; Figure 1) for the benefits of humans; whether it is for their health, nutrition and recreation; or, for the development of the economy, jobs, social conditions, or financial gain (see Figure 1). Finally, perhaps above all other interests, they might be interested in the professionalism of scientists (Table 2) - whether they can trust them as ethical and competent experts who will not make irresponsible decisions and recommendations that might affect their welfare.

Agricultural scientists depend quite heavily on the media for communicating all this knowledge (Figure 1) and formulating an image of them as competent professionals. Thus it is highly desirable that agricultural scientists and media people learn to communicate well with each other, with each party being sensitive to their particular needs, expectations and *modus operandi*.

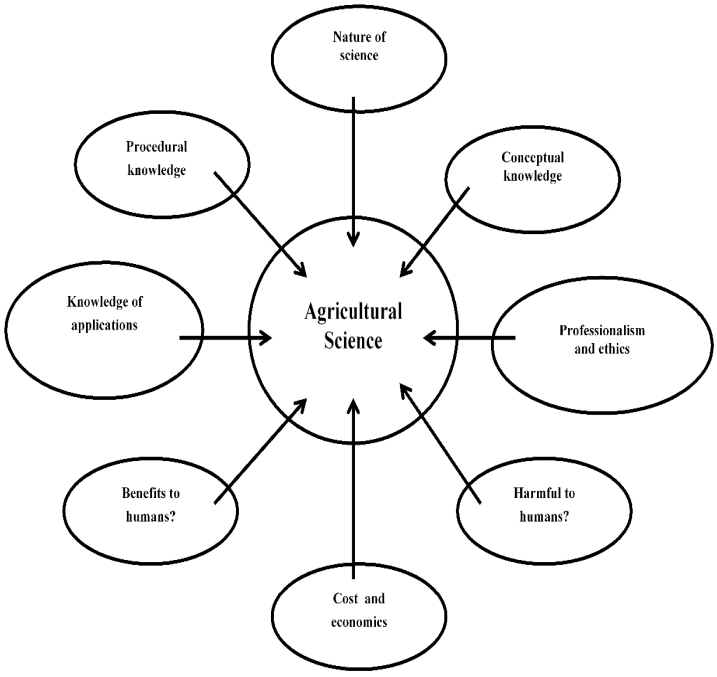

Figure 1. Factors affecting public understanding and awareness of agricultural science

The needs of the media are quite simple- they require a story that will interest their readership or listeners, which will help to sell their product whether it is a newspaper, a magazine, or a radio or television programme. Furthermore, since print space and airtime costs money, they require the facts in as brief a form as possible. Despite what some scientists might speculate, accurate reporting of the science is of the essence, even if their presentation style focuses more on selling the ideas than scientists would do in traditional publications and oral presentations. The needs of the scientists are also quite simple- they require their achievements to be presented in a form that does not affect their scientific accuracy nor lose sight of the major findings or points being communicated.

So if the needs of both parties are simple, shouldn't communication between them also be simple and without problems? Unfortunately not; there

are a wide range of issues that affect efficient communication and, therefore, the publicising of agricultural science to the public. Scientists complain that science reporters don't understand their work and over-edit their contributions or misinterpret information supplied so that it loses its meaning and scientific correctness, and might even discredit the scientist in the eyes of their colleagues. They also complain that sometimes they are not given the opportunity to review or comment on final drafts before publication. Other editing problems appear to include changing the title of the article so it no longer reflects its content, dramatizing or changing the tone of an article, distorting factual information and conclusions, over-simplifying information, over-emphasising minor points at the expense of major points, changing inferences to firm conclusions and removing qualifications that have been placed on conclusions (Sindermann, 1982).

The media on the other hand complain about lack of cooperation from the scientist, either because they don't have time or because they don't see communicating with the public as a priority for their job. Other problems encountered by the media include a lack of interviewee skills and confidence to interact with them, excessive use of scientific language, long-windedness and verbosity, rather pedantic, unable to say yes or no without qualifications, and unwilling to take firm stands (Sindermann, 1982). They are also concerned about the (albeit) isolated occasions that scientists might use them to disclosure major, groundbreaking research findings that haven't yet been subjected to the rigors of peer evaluation. It is essential that the community of scientists first evaluate and approve for publication any new scientific results before they are disclosed to the public. This avoids embarrassment and discredit of the scientist and any negative effects on public opinion and the integrity of science.

DISCUSSION VIEWPOINT

In this chapter I have suggested that the agricultural scientist is required to acquire extensive interdisciplinary knowledge and a wide range of skills and competencies in order to practice effectively and ethically in the rapidly developing world of agricultural and life science. As our science has forged ahead to create an intricate knowledge system that is synthesized and fermented to further science as the human endeavour, the demands on the scientist have increased. Our increased impact on the environment has in recent years caused a cry for caution in addition to a call for more resources. In order to both protect and use the resources available it is imperative that the term "sustainability" precedes consideration of any new technology. It is an agricultural scientist with all the above competencies who will be able to

look at each new innovation and assess it for its use in a manner in which sustainable development can be forged to the benefit of all people.

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