It was my privilege to have known Keith Roby, whom this lecture commemorates, since his undergraduate days in Sydney until his death almost exactly a year ago. We lived in the same college together, he as a student when I was vice-master. We belonged to the Student Christian Movement and the Science Association in the University. I saw him less after he graduated and moved on to other universities for post-graduate and post-doctoral studies. But we kept in touch and came together again for the ten-year programme of the World Council of Churches on Science Faith and the Future. We worked together in planning the World Conference on that subject at the Massachusetts Institute of Technology in Cambridge, Massachusetts, in 1979. At Cambridge we visited Professor Everett Mendelsohn, of the Department of History of Science, on which occasion Keith invited him to visit Murdoch University, which he did later that year to present a Counterpoint Forum with me on the subject of Science and Ethics. That was the last time I was with Keith, though I corresponded with him until his death.

What do I remember most? His smile. There was something about his smile. It was beckoning, anticipatory, certainly welcoming, confidently it seemed to say - yes we can do something about that. It spelled out enthusiasm for life. What was its source? You will find the clues in some of Keith's writings for students. He had a passionate conviction about the meaning of life. It was both an intellectual and an emotional commitment which he found best articulated in the writings of Paul Tillich and A. N. Whitehead. Everything else in his life was like the spokes of a wheel radiating out from that central hub of meaning and commitment.

Let me share with you something I have treasured since we were last together in Perth. I had spent some days with Keith and his group in Murdoch. We had seminars, lectures, dinners, interviews and what have you. This group seemed to be involved together all the time. It was an unusual academic experience, for most of us spend most of our time
alone with our thoughts. Going back to Sydney on the plane Everett Mendelsohn said to me, "Charles, these people really enjoy each other's company. That's really something." Yes it is. There had gathered around Keith Roby, particularly in Murdoch University, a group of enthusiastic young people committed to similar values and similar hopes. They were going places together.

The commitment of this University to community science as part of its ongoing programme, and this lectureship established by Keith's friends and admirers, is a commitment to carry on the work that Keith was instrumental in promoting here.

Keith Roby was a live spirit; he was a Christian, scientist, inter-disciplinary scholar, international, ecumenical, friend to many, father and husband. His spirit lives on today amongst us and in the University which nurtured it. For that we rejoice.

**Sorts of Science**

An implication of the title of this lecture is that there is not just one sort of science and technology. We have a choice. What kind of science a society chooses is a product of ideology, economics, politics and philosophy. We can choose our science and technology, much as we may choose a philosophy or a religion. The modern industrialised world has made its choice that one in every two scientists and technologists is engaged in perfecting the instruments of war. That is a tragic choice which brands scientists and technologists as amongst the most destructive people in the world today. That is one reason for the public disenchantment with science lest, to use Churchill's words, the dark ages return on the gleaming wings of science.

There is no scientific or technological imperative that determines the direction of science and technology. This is a matter of public policy. Human progress has never come on the wings of inevitability. It is probably true that a society that chooses, let's say, the nuclear energy option, will find it difficult to change direction after huge investments have been made in that technology. But, even then, we are not in the grip of technological determinism that closes our options for ever. Science had its birth in ancient Greece. It was born again in the 16th Century. It's time it had a second rebirth. Hence my title - Born Again Science.

**Community Science**

This lecture commemorates the Murdoch University staff member who established here a programme of teaching and research in a particular sort of science and technology, which he imaginatively called community science. Community science is defined by its
objectives. The definition I like best was given to me by one of Keith Roby's students, Chris Ledger. "Community science is science and technology for a sustainable society." But what is a sustainable society? Let me say first what it is not. Many of us believe that the world as at present organised, politically, socially and economically, is not conducive to the long-term survival of humanity nor the short-term survival of particular regions. The reasons have to do with the impossibility theorem which says that if all the world's people used resources and polluted the environment at the rate of the developed world we would run out of resources and destroy the life-support systems of the planet within the foreseeable future. This is the argument of the limits to growth. The word "limits" refers to growth in numbers of people, economic growth in material goods and growth in deterioration of the environment. The argument of limits to growth is that a world based on the unlimited growth in the use of resources has a limited life. Hence the argument for zero population growth and zero growth in the production and consumption of material goods.

The argument is familiar to most of us. When first propounded it sent shock waves through both the rich world and the poor world. The rich world saw its survival as dependent upon economic growth in the production and consumption of material goods. The poor world saw its survival as dependent upon economic growth even to keep the poor alive. The rich world has had its turn now it's our turn, said the poor world. So there was great opposition all round to the so-called steady-state society or the equilibrium society. And we need hardly be surprised. There is little that all the nations agree upon. But there is one policy that is the same for all. Without exception all nations want increased economic growth. I was at a conference in Bucharest in 1974 called by the World Council of Churches to discuss these matters and the role of science and technology in the future. I was in a working group on limits to growth. We were getting nowhere with the third world delegates. Jorgen Randers (an author of The Limits to Growth) and I had to write the report of our group.

I recall Randers saying to me that part of our trouble was that all our expressions were negative: limits, equilibrium, steady-state and so on. We needed a positive phrase! And he suggested "science and technology for a sustainable society", i.e. a society that could be sustained, ecologically, indefinitely. In other words the sustainable society is one which does not destroy the soil in which it grows. It sustains the sources of life. Let me add that Keith Roby was a valued part of the team of the World Council of Churches which subsequently investigated the implications of the sustainable society. His special interest in the programme was sustainable energy for the future.


**Crisis in Knowledge**

If community science is to be taken seriously its proponents will find themselves challenging, and being challenged by, the proponents of the dominant model of science and technology in the western world. Today there is a crisis of knowledge, but not because the quantity of knowledge is doubling every ten years or so. It is another, more serious crisis. Today's crisis is a crisis of experts. The dominant model of knowledge is a jig-saw puzzle model. Consider what it does in our traditional universities. We divide knowledge into compartments called disciplines: physics, chemistry, economics and so on. When you get a discipline you get a department.

The idea of a discipline is that the information in it is relatively independent of the information in other disciplines. Disciplines are regarded like the blocks of a jig-saw puzzle. Stick the bits together and you get the picture, i.e. knowledge. Blocks of knowledge are like bricks that are independent of each other. Knowledge is treated like substances. This is the substantialist prejudice of the western world. People who are trained in disciplines are called experts. Sometimes they cross boundaries in what is called inter-disciplinary studies. Mostly they do not. The general idea has been that if society has well-trained experts in all the disciplines the experts would guide us in the truth and to right action. It has not worked out that way. Instead it is the sea of data from experts in which we are all drowning. What went wrong?

Knowledge cannot be divided into separate compartments like commodities. Knowledge is not like the blocks of a jig-saw puzzle at all. The title of Arthur Koestler's last book is *Bricks to Babel*. In it he wrote "we seem to be compelled to shape facts and data as we know them into hard bricks and stick them together with the slime of our theories and beliefs". The result - a tower of Babel. Our knowledge lacks any fundamental unity. It is as though we build a great cathedral, laying each stone and brick next to one another with great attention to detail, but without any sense of the whole cathedral let alone its purpose. This way of thinking, which is called substance thinking, loses the unity which no fragment can grasp.

It follows that the experts must always be wrong. They have tunnel vision rather than a panoramic outlook. A French Prime Minister is reported to have said that there are three common ways for a man to ruin his career: chasing women, gambling and trusting experts. Of these, he said, chasing women is the most pleasant, and gambling is the quickest, but trusting experts is the most certain.
Specialization is necessary but not sufficient. As a method of operating we no doubt still need the disciplines. But we need to do something about the training of experts in these disciplines. We need new sorts of experts. They are people who can cross boundaries. There is a difference between an expert and a thinker. A thinker sets no boundaries to his thinking. That is why the philosopher Heidegger said "science doesn't think". The scientist is not taught to think across boundaries. Those that try are politely labelled "dilletantes" or less politely "nuts".

Community science calls for scientists who will be different from those turned out by faculties of science in traditional universities. The advance statement on the proposed Diploma in Community Science of Murdoch University says that its students, in assessing a project or policy, must be able to consider social, political, environmental, philosophical and ethical issues. That is what I call crossing boundaries. But that will not happen without an alternative model of knowledge to that dominant in our society. I have called the dominant model the substance or mechanical model. The alternative I call the ecological model because it emphasises relationships rather than substances. The dominant model reflects substance thinking.

The ecological model reflects event thinking. In substance thinking an entity is what it is in relative independence of other entities. It has only external relations, such as the petrol that drives the motor car. But plants and animals and humans and other entities are not commodities. To understand what they are you have to understand them in terms of relationships and, in particular, internal relationships. They are what they are by virtue of their internal relationships. We understand the meaning of that best in ourselves. I am what I am by virtue of my internal relationships or feelings to other people, for example. I am not the same person today as yesterday. My internal relationships change me. Event thinking or relational thinking is making its way in physics before biology. Physics has discovered the impossibility of thinking deeply about fundamental physics in terms of particles regarded as substances. For as David Bohm says, "There are no particles". Biology, and along with it environmental science, has a long way to go to move in that direction. The rules of substances, i.e. mechanics, are not the only rules that govern the activities of organisms.

A man made same counterfeit $18 dollar notes. He took them to a shop and asked for change. Which do you prefer, said the shopkeeper, three sixes or two nines! If we work with a counterfeit model of nature we get counterfeit answers all along the line.
Implications of the Crisis of Knowledge

By opting for the substantialist prejudice the whole of society operates out of a profound error that is destroying much that is worthwhile in ourselves and in the world. Experts are always wrong. The best informed are often the most confused. That is why Bernard Shaw, in the Doctor's Dilemma, said "The professions are all a conspiracy against the laity". The effects are far-reaching. The crisis in knowledge has helped plunge the world into its present global crisis of management. The Club of Rome talks about the world problematique, by which it means to convey the idea that we are confronted with a lot of problems simultaneously and that we cannot solve any one of them one at a time. All are interconnected.

For hundreds of years we could grow in each part of the production system; more food, more petroleum, more tractors etc., all separately pursued. But in this transition period in which we find ourselves the goals have become intertwined and interdependent. Concerned with pollution, we design motor cars that use more petrol; we raise chimney stacks in England - and produce acid rain in Europe. Consider the complex relations between advances in hygiene, medicine, population growth and food shortages. Even technology, crime and freedom are intertwined. No important question can be answered at the level it is asked. You cannot do only one thing.

Yet the way of the world has been to go to experts. We get partial answers that do not fit together. I can tell you how to control inflation, says the economist, but I cannot help you with unemployment. Economists tend to say it's a case of jobs or environment, when actually if you do not look after the environment there will be no jobs. My friend Paul Ehrlich says economists are the most dangerous of the experts because they are listened to. Experts are fond of regarding life as a zero-sum game. If you gain something here then you have to lose it there. But what about the possible symbiosis of desirable goals; environment and jobs? Or do we have to forever live with a system of trade-offs?

Our task is to find a new approach to the world problematique in which we can think synoptically about economics, politics, science, technology, industry and ethics in an ecological model that encompasses all life. The ecological model has as its goal an ecologically-sustainable and socially just global society. Or to put it more simply - healthy people with healthy relations to a healthy environment. When the experts say it cannot be done, I remind myself of the story of Leo Szilard, the Hungarian polymath, who helped to make the first nuclear chain-reaction in Chicago. When Szilard appealed for research grants he always proposed to do experiments that he had in fact already
done, so that he could use the money for research whose outcome he could not predict. The system worked perfectly, until one year his application was rejected on the grounds that the proposed experiment was impossible.

The sort of science and technology we choose will very much depend upon our basic attitudes to the future, both to what is known and what is unknown.

**Attitudes to the Unknown**

What do we really know about the future? "Precious little", says economist Kenneth Boulding, "but that little is precious". Various attitudes to the unknown are captured in the century-old story of *The Lady or the Tiger*.

The young man could open either door he pleased. If he opened the one, there came out of it a hungry tiger, the fiercest and most cruel that could be procured, which would immediately tear him to pieces. But if he opened the other door, there came forth from it a lady, the most suitable to his years and station that His Majesty could select among his fair subjects. So I leave it to you, which door to open?

The first man refused to take the chance. He lived safe and died chaste.

The second man hired risk assessment consultants. He collected all the available data on lady and tiger populations. He brought in sophisticated technology to listen for growling and to detect the faintest whiff of perfume. He completed checklists. He developed a utility function and assessed his risk averseness. Finally, sensing that in a few more years he would be in no condition to enjoy the lady anyway, he opened the optimal door. And was eaten by a low-probability tiger.

The third man took a course in tiger taming. He opened a door at random and was eaten by the lady.

To interpret this story, we respond to the unknown by trying to retreat from it, by trying to comprehend it or thirdly by trying to control it. To retreat from the future is the Arcadian approach. It is directed backwards to a mythical golden age, to a state of innocence in a pastoral world where peace of mind is not threatened, intellectual aspiration is not called for and virtue is not at risk. Arcadia is a world without strife, without ambition and without material accomplishment. This approach is evident in longings for a return to a simpler risk-free life that never was. But a world without science and technology is not a choice possible for us. Four billion people cannot survive without some form of science and technology. We
can choose between technologies, but apart from that there is no option open to us. It is the case of Henry Ford's offer to prospective buyers of the first Ford motor car, "You can have any colour you like as long as it is black".

A second approach is to attempt to comprehend the future and these days that means a risk/benefit analysis. Measure the probabilities and the trade-offs, calculate the social risk/benefit ratio and the common good will be defined. But it is not. A risk/benefit analysis was made of a project to remove crossing lights in front of an old folks home. The analysis resulted in the crossing lights being removed. What value are old people in old folks homes? The choices of risk assessment methods are themselves biased by underlying cultural assumptions or those of the analyst. You need only consider the controversy following the well-known Rasmussen report on risk/benefit analysis of nuclear reactors. The assessment, management and adjustment of risk in industry is estimated to cost in the region of 300 billion dollars in the U.S. each year. That is about 15 per cent of the GNP. The underlying question is how safe is safe enough and that involves subjective judgements which vary with the analyst. And we have to remember that we can always be eaten by a low-probability tiger.

A third approach is to control the future. This is the approach of the tiger-tamer. Historically, I suppose, it could be said to be represented by the Utopian vision that began to be taken seriously from the 17th Century onwards. One of the writers at the time was a man called Foigny who, like Francis Bacon, placed his Utopia on an island in the southern seas which he called Terra Australe and whose inhabitants he called Australians! In Utopia man creates the world anew and improves it through his own exertions. He begins as a tenant or lodger in the world and ends up as its landlord. And as his environment improves so, it alleges, will he. Men look forward, never backward and seldom upward.

This is the dominant tradition of professional engineers, scientists and technologists in general. It serves us well up to a point. But as some engineers have been the first to point out, it has met its match and more in the complex, unmanageable world it is called upon to address. There is, despite its benefits, one long-recognized weakness in utopian speculation: the inadequacies of man and the unlikelihood that he can live up to his own ambitions. It is for this reason that utopian thinking has led some of its modern practitioners, such as Arthur Koestler and Carl Sagan, to consider ways of "improving" man through genetic engineering or by some other sort of biological manipulation.

The utopian vision leads us to a paradox well put by historian and philosopher, Karl Jaspers, who wrote: "Today we are conscious of standing at a turning-point in history. . . . It is the Age of Technology. . . . We see ourselves in our technological ability as creators of salvation
on earth without parallel - or we see ourselves as equally without parallel in our spiritual perplexity."

The man who trained himself to become a tiger-tamer finds himself confronted with a carnivorous lady. Why? The unknown is not a wrinkle to be ironed out of the social fabric. Not only do we face the inadequacy of man, but the unknown grows as we grow in knowledge and in our ability to control. Or to put it another way, there is a law that says as knowledge increases arithmetically, ignorance increases geometrically.

There is an alternative to these approaches to the future. It accepts the inevitability of incomplete knowledge, it accepts the challenge of the surprising world around us and it accepts the imperfections of man. The fundamental question is not how to calculate, control and even reduce risk, important as they are in certain situations. It is how to increase our risk-taking abilities. How can we attain the intellectual and moral maturity to live fully and safely in a complex world. How brave is our new world?

Every creative step forward in human civilization has involved an increase in risk taking. A. N. Whitehead said: "The major advances of civilization are processes that all but wreck the societies in which they occur. It is the business of the future to be dangerous." Advances in civilization were never throwbacks to some garden of Eden with a restoration of primitive innocence. They have always brought a maturer fulfillment of human life. With every new advance into life there is a cost. Every new liberation in technology, politics, education or sex, produces new forms of enslavement. The price paid for neolithic culture and for urban civilization was enormous. So too was the price paid for the agricultural revolution with soil erosion and the like, and later the industrial revolution with its dark, satanic mills. In each case the new brought new creative possibilities and new hopes and new experiences, but also new possibilities of evil and suffering that did not exist before.

Willingness to take risks is a condition of biological progress. Life could have stayed in the slime of a shallow tropical sea where it probably originated. It did not. It ventured up rivers, onto dry land into the air. It conquered every habitat on earth, from the deepest depths of the oceans to the highest peaks of the mountains, from pole to equator. One could imagine the first marsupials arriving on this continent saying to themselves - this particular spot is the place for us. No, they ventured forth to every corner of the continent, diversifying as they went until Australia found itself with the world's greatest array of marsupials.
How did life increase its risk-taking abilities? By mutating. That is to say by changing to meet the new future. Even that first molecule of DNA in the ancient sea could have stayed the same, just replicating itself for ever. But it did not. It had built into itself the capacity for change. That is the basis of evolution as we understand it today.

The question for us is do we have the capacity for change that will enable us to increase our capacity for living in the future. And for humanity we mean not primarily changing our biology, but changing our culture, our politics, our economics, our science and our technology. The sustainable and just global society of the future will be full of risks. But they will not be foolhardy risks that could lead to our extinction such as was the fate of the dinosaur. To think that the future is simply a continuation of present trends is to have the dinosaur mentality. That future is one of certain extinction.

The question I put to myself is this. Had I stood back at the edge of history, say at the brink of the industrial revolution, how would I, with hindsight, have steered its course? Would I have feared the risks involved in forging ahead? How could I have accepted the challenge and taken the increased risks, while at the same time refusing to accept the enormous cost that history claimed. That is the question I now ask of myself at this turning point of history. Perhaps we could have skipped some of it, as suggested in a cartoon depicting a group of tribesmen way back who were consulting the future. The caption of the cartoon read: "So by a vote of 8 to 2 we have decided to skip the industrial revolution and go right into the electronic age". A nice idea but not a possible one.

What are the cultural mutations we would have to make to ensure a future on this earth which is sustainable and which promotes a full life?

**Features of a Science and Technology for a Sustainable Global Society**

It will be informed by an ecological model of organisms and institutions and their interrelations, as opposed to an exclusively mechanical model which is the dominant model of science and technology today. The emphasis will be on relationships, that is to say on event thinking rather than on substance thinking.

It will be less manipulative of nature and more in harmony with nature. Medicine will emphasise preventive medicine in contrast to the present emphasis on curative and manipulative medicine. Industry will be more concerned with preventing poisons from getting into the air and water than in trying to clean up after the damage is done. All manipulation that is needed will be done in the context of respectful attention to the strategies of life and ecological interdependencies. Technology will opt for soft
landings, not hard landings, i.e. superstar technology will give place to the so-called "softer" options of appropriate technology. Not everything that could be done will be done. Our faith in technology will be tempered. As Leontief, the economist, said, "It's the people who don't know anything who think that everything is possible!"

It will write the person and all living creatures into the equation in a way that most risk/benefit analysis ignores. Nature will be valued not solely in terms of its instrumental value but in terms of the intrinsic value of its creatures as well. A new ecological ethic will have to weigh up both instrumental value and intrinsic value in assessing the relative merits of any action.

It will measure life in terms of richness of experience. The focus of the dominant model is on possession and consumption of goods and services. Patrick White recently wrote to the Labor Party in Australia: "If we don't search our conscience in the months to come and realize that there is more to life than money, minerals and missiles, we run the risk of offering ourselves for destruction as well as helping to destroy the world." Richness of experience relates to people not only as consumers but as producers as well.

It will be accessible to non-specialists, participatory, non-specialists. One of the authors of *Limits to Growth*, when asked ten years later how he would have changed the book were he to write it now, replied, "We didn't tell the people that the power to change things rests with them." But that assumes that people will take the trouble to understand the issues. The temptation we face when we recognize the urgency of issues is to become activists in an immediate way. I feel about them much as I feel about experts. The problem is that activists are too likely to assume what the problem is and then to get an expert to tell them how to solve it. As science and technology become more participatory there will be a growing awareness that whole classes of science and technology may be incompatible with democratic forms of government such, for example, as nuclear power, certain forms of data processing and some forms of genetic engineering aimed at positive eugenics as distinct from negative eugenics.

It will promote community in contrast to breaking up community, such as happened during the green revolution in the developing world and as is happening now in the so-called development in the frontier regions of Brazil. How can communities be saved? By empowering ordinary people to take their own development into their own hands. This is called self-reliance. "The meek shall inherit the earth." That's what the graffiti writer put up on the wall. Someone wrote beneath. "If that's alright with the rest of you." Since then someone had added a third line. "The meek won't want it!"
It will emphasise the possible symbiosis of desirable goals; jobs and environment; deflation and employment; ecological sustainability and social justice.

It will put an emphasis on transcending. Individuals are constituted by their relations to others but they transcend the others to which they are related. To be alive is to rise above the present experience of life. Life is novelty. A healthy society is one whose members are encouraged to transcend the given pattern not to conform to it.

It will be planetary rather than local and national. Science and technology in the service of national goals alone will not be conducive to a sustainable global society. It must transcend national boundaries. In his famous talk at the M.I.T. "strike" in 1969, George Wald recognized that the problems were global requiring global solutions. "The thought that we are in competition with the Russians and the Chinese is all a mistake and trivial.... We are one species with one world to win."

It will be non-violent. Swords will literally be beaten into ploughshares. The one million dollars spent every minute on military activities and weapons will be seen to be the suicide that it is. Scientists and technologists will be ashamed that every one in every two of its practitioners is now engaged in destructive activities. Defence there no doubt will be, but it will not be thought in terms of the sort of massive overkill that the present nuclear arms race presents.

When a new kind of man and a new kind of culture is emerging it is not likely that the old man will willingly disinherit himself. He will try to make a new life out of a dying culture through desperate simplification. He will insist on hearing the old records played and replayed. The return to simple basics is a return to the worn out ways of the past. Mr Reagan and Mrs Thatcher and Mr Fraser are not the wave of the future. They are part of our economic and political malaise. Their's is a rear-vision view of the world. Be it politics, economics, religion or morality the present plea to return to old-fashioned basics is a call to reinforce the status quo and prevent change. There is a popular appeal in the plea for simple basics. But remember that saying: "For every human problem there is a solution that is simple, neat and wrong!"

I have hope in the future because I do not believe that the resources of human possibility and transcendence have yet been exhausted. There are yet values that have not visited this planet, but are waiting to be appropriated by a society organised to ecological sustainability and social justice. The greatest power in the world is still the power of ideas.
We need in a very special way to have hope and faith and love. Reinhold Neibuhr put it this way: "Nothing worth doing is completed in our lifetime; therefore we must be saved by hope. Nothing true or beautiful or good makes complete sense in any immediate context of history; therefore we must be saved by faith. Nothing we do, however virtuous, can be accomplished alone; therefore we are saved by love. No virtuous act is quite as virtuous from the standpoint of our friend or foe as from our own standpoint. Therefore we must be saved by the final form of love which is forgiveness.

Be realistic - plan for a miracle!