ST GEORGE'S HOUSE ANNUAL LECTURE 2003

SCIENCE AND THE HOPE OF PROGRESS
BRIDGET M. OGILVIE, DBE, SCD, FRS

To deride the hope of progress is the ultimate fatuity, the last word in poverty of spirit and meanness of mind". The Nobel laureate, Sir Peter Medawar, made this characteristic, positive thinking remark in his Presidential address to the British Association for the Advancement of Science in 1969. In this lecture, Peter Medawar commented on the prevailing attitude of negativity resulting in a perverse willingness to believe that the advances of science and technology bring with them some essential malefaction. This view, he went on to say, can only be sustained by systemically disregarding all the benefactions of science and thinking only of its harmful effects, real or imagined. People in this mood seem almost to welcome evidence of some new ecological miscarriage or misadventure of technological origin.

Since 1969 little has changed except that now there are those that believe scientific advance should stop altogether. Thus, as I am with Peter Medawar in believing in the hope of progress for the benefit of mankind, my talk today will highlight some of the huge benefits which we have already derived from the biological revolution, and will discuss some of the potential benefits we might see in the future. But my talk will also highlight the growing threat to science from those who seek to oppose it. Unless we, scientists and non scientists, work together to counter this threat, we could put in jeopardy the health and well-being of millions of poor and vulnerable people and of future generations.

In this year, 2003, the scientific community is enthusiastically celebrating 50 years since the publication by Jim Watson and Francis Crick of the structure of the molecule that is responsible for inheritance in all organisms, DNA. They described the structure of DNA as a double helix the 2 strands of which complement each other. They correctly inferred that either strand of the helix could act as a template for the other, allowing the molecule to replicate itself. Their conclusion to this seminal paper was that "It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material". With these rather coy words, Watson and Crick ushered in a biological revolution which is now progressing with ever-increasing speed and will undoubtedly continue to be a major influence on the future of mankind.

My talk today not only marks the anniversary of the onset of this biological revolution but is also, I suggest, entirely appropriate for St George's House and its community, attempting as it does "to be a place where people of influence and responsibility in every area of society should come together to explore, develop and communicate their ideas and anxieties". I therefore thank your Royal Highness and the Dean and his colleagues for inviting me to give this year's St George's lecture on the theme of this extraordinary revolution.

In the 50 years since Watson and Crick's paper was published, scientists have developed many techniques that permit us to study and manipulate DNA. Watson and Crick and many others since have been awarded the Nobel Prize for their contributions to these advances. In this talk, I shall focus on how our knowledge of DNA makes us able to identify individuals, identify genetic defects, enhance food production, and deal with infections and other diseases. I shall also address some of the social changes and ethical challenges it is producing.

Perhaps the best known, and most widely accepted, practical application of these advances in the technology associated with DNA is genetic fingerprinting invented by Alec Jefferies in Leicester in 1985. This technique enables us to identify individuals – whether human, animal or plants – with an exceptional degree of accuracy and reliability using tiny numbers of cells – i.e. a single human hair root or the minute number of cells we leave on a cup or glass when we drink from it. For a time, people worried about its potential for incarcerating the wrong criminals, but nowadays its use is widely accepted in forensic science. It was some time before people realised it is also often the ideal tool for identifying the wrongly convicted. In New York for instance, DNA has been used to exonerate more than 100 wrongly convicted people, some of whom were on death row. This forensic use of DNA technology is also being applied to plants and animals. It can be used to ask how much variation there is in a rare plant population? And whether populations of plants are the same or distinct? Or are any individuals within a species native or introduced? Answers to these questions are now possible and are invaluable in attempts to propagate or reintroduce rare species of plants and animals.

I suspect these uses of DNA fingerprinting are nowadays an aspect of scientific progress that is acceptable to virtually everyone. Its use in another context, the identification of paternity, has major social consequences. Never before has it been possible to know exactly whether or not a child has been fathered by a particular individual. Until this DNA revolution, matrilineal family trees as exist in some societies have been far more reliable than the patrilineal model used in our society! I often recall my late father's twinkley look when he heard his friends boasting about their ancestry and his remark to me "always remember my dear that your great grandfather spent a fortune tracing the family tree and a much bigger one covering it up!" My father's remark was probably a tease but reflected the reality of the pre DNA era that putting store on our patrilineal ancestry was always a bit of a gamble! It illustrates too the reason why DNA has been described as a unique molecular link with the past and the future.

The field of reproduction research involving human embryos developed rapidly in the 1970's with progress in our ability to maintain and grow embryos and cells outside the body, in the test tube = in vitro culture, a technology where advances have been very important for medical research generally and the application of our knowledge of DNA. This field is of course fraught with ethical and moral issues. Nonetheless, this year marks not only the 50th anniversary of the discovery of the structure of DNA but it also marks the 25th birthday of Louise Brown, the first child successfully born following in vitro fertilisation. Since then over a million such test tube babies have been born world-wide. Last year more than 5500 much wanted babies were born in Britain following in vitro fertilisation. It is instructive to remember that when this technology was being developed in the 1970's in this country, it was highly controversial and, as with stem cell research involving embryos currently, not permitted in the USA using Government money. The moment Louise Brown was born, attitudes changed completely and studies of assisted reproduction were soon permitted in many countries including USA. This is a classic illustration of the principle that when the community sees real benefit in a new technology, it is accepted. The DNA revolution has enabled us to identify genetic defects and other genetic characteristics in embryos before implantation or very early in development, leading to embryo selection or abortion early in pregnancy if the embryo has a serious genetic disorder. Despite considerable and continuing controversy about this type of research and medical intervention, the majority of the community in Britain supports it.

There are problems as well as benefits associated with this technology. To achieve success with in vitro fertilisation, more than one fertilised embryo may be replaced in the uterus and so test tube babies especially in the early days were often multiple births which have their own risks. Sex determination in early embryos with subsequent abortion mainly of female embryos has resulted in serious sex imbalances in the children of some communities where male children are specially sought after. Screening of embryos can present huge ethical dilemmas e.g. tests for diseases with no cure or screening for disabilities. I am sure all of us, including the scientific community, are glad we live in a country where research and medical interventions in this field are tightly regulated, not the case everywhere. Britain has also decided to permit stem cell research using human embryos up to 14 days of age again under carefully controlled legislative conditions. Cells derived from very early human embryos can grow and multiply in the test tube in an unlimited manner, and develop into many specialised mature cell types upon command. This highly controversial research could eventually benefit many chronic medical conditions where organs or cell types within organs are damaged or destroyed. However, ethical and moral issues aside, there are numerous technical challenges to be overcome including possibly, but not certainly, obtaining stem cells from adults rather than embryos. But once they are overcome, the ability to generate unlimited numbers of specialised cell lines from healthy or diseased tissues where the disease has a genetic basis would transform drug discovery in, e.g. rare diseases such as motor neurone disease or more common diseases such as diabetes and heart disease where the key cell types that are damaged are hard to obtain. These cell lines could be used to study the processes that go wrong in diseased cells and design high throughput screens to identify molecules that halt disease progression and develop them into medicines.

Religious faiths differ greatly in their views about the sanctity of the human embryo and many people of no or little faith also feel uneasy at what is seen as a utilitarian approach to the human embryo. It remains to be seen whether results of obvious benefit come from this research in time to dispel the widespread unease in other countries concerning research of this kind. It is, I have to say, already clear that research of this type will certainly be pursued in some countries that do not share our Judeo-Christian heritage whatever we in Europe or the USA decide. If such research became illegal in Europe or USA but continued elsewhere to the successful development of treatments for serious diseases for which there is currently no treatment, we would then be faced with another ethical dilemma, which is should we benefit from research that we had decided was unethical? My guess is most of us would decide to do so.

I will now turn to my particular interest in the potential of the DNA revolution which is its use in two fundamental aspects of life, the provision of food and the prevention and treatment of disease. Ensuring food security for the human race and our ability to deal with the escalating threat of disease in plants and animals caused by new or drug resistant organisms are continual challenges which pose serious risks to the future of mankind. Our survival in a biologically hostile world depends, as always, on scientific and technological ingenuity and our skill in managing risks.

Here is Europe we are food secure because of the scientific and technological success of previous and current generations of scientists and farmers. By the use of fertilisers, herbicides, fungicides and pesticides and the development of highly productive varieties of plants which are genetically far removed from their original ancestors, crop yields are enormous. Our highly productive crops are not only very changed genetically but they are also genetically homogeneous which makes them extremely vulnerable to diseases. Thus, we are engaged in a type of race between the ecological situation we have developed to meet our

food requirements and evolutionary changes in the predatory competitors that feed on our crops and infect us, animals and plants. Our advantage lies in the wonderful new technologies scientists have invented. You might think we and our plants could adapt to this threat but the odds are heavily stacked against us. Without the help of science, we cannot compete with micro-organisms that multiply 100 or 1000 times over periods of days. In the hope of progress in the race against microbial genes, our best weapon is our wits, not natural selection on our genes and the genes of domestic animals and plants. It is for this reason that scientists are worried by the attitude of many environmental campaigners who seem to think we can continue to feed the human race without further scientific progress i.e. by continuing to rely on old, much less precise and slow working technologies than those now available thanks to the DNA revolution. This attitude is well illustrated by the cult of organic food. Because we are a rich nation, we can afford to be very fussy about what we eat and because agriculture in the western world is so highly productive, it makes good economic sense to encourage many of our farmers to produce food for the luxury market. Organic food is a luxury and eating it a lifestyle choice. If its supporters left it at that, I would have no quarrel with them. But it is wrong of organic farmers to try to increase their market share by making assertions about the superiority of organic over conventional food that don't fit with the facts. It is obvious that we are not poisoned by pesticide traces in foods as claimed by organic ideologues, the opposite is more likely. We live longer and farmers who are more exposed to pesticides than other groups have much lower rates of cancer than the rest of us. A diet high in conventional fruit and vegetables containing these supposed poisons actually cuts cancer rates considerably. If we went organic with its high fruit and vegetable prices, consumption of fruit and vegetables would fall, as we know it is very price sensitive and premature cancer and other causes of death would increase.

How were the plants that organic farmers describe as "traditionally bred" and sellers of organic food describe as "natural" actually developed? A very common technique in crop development over the past 50 years has been to artificially bombard plants with irradiation to produce mutations. This form of genetic modification alters chromosome structure and genome sequence in ways no other technology can, and it has been used especially to obtain pest resistant crops. Indeed, there are more than 2000 commonly available plant varieties currently that have been produced using this crude, uncontrollable technology. It is ironic that because organic farming specifically chooses to use pest resistant varieties in order to reduce pesticide use, of all forms of farming, the organic approach is the most dependent on varieties generated by irradiation. In so doing they accept a form of genetic engineering that has never been assessed for food safety and is less predictable and more random than GM which they claim to be hazardous. Why people should think that food plants developed by irradiation should be OK to eat whilst those produced by the more precise mechanisms of induced mutation by GM are not or that putting a fish gene into a potato should make that potato dangerous to eat when fish and chips is the nation's favourite dish, I cannot imagine!

Let me give you a few specific examples of varieties produced by irradiation - "Golden Promise" malting barley used in organic beer, on sale in Waitrose and blessed by the Soil Association, and durum wheat used in Italy for pasta production, particularly interesting in view of Italy's wish to protect the international sales of their "pure natural pasta". Many of the plant varieties you have in your gardens were produced by irradiation – begonias, roses, tulips, azaleas, chrysanthemums – the list is very long. And don't forget too that chemical mutagens are also used to develop new varieties – these mutagens are all carcinogenic and unpleasant to handle as they are related to chemical weedkillers and mustard gas. So

"traditional" plant breeding does not conform to the image promoted by organic farmers and their allies.

It is for reasons such as these that the scientific community is at odds with the campaigners who have so ferociously and ruthlessly turned the community in Western Europe against the valuable and increasingly precise technology known generally as GM. The new technology of GM has been politicised to an unprecedented degree, although as a process it does not warrant the alarmism campaigning groups have induced. To condemn an entire technology instead of assessing its use on a case-by- case basis has to be irrational. It is undoubtedly the case that the manner of introduction of the new technology of GM to crop production in Europe was over enthusiastic and ignored cultural sensitivities. This led to the current widespread loss of community confidence that has been so exploited by non-representative groups and activists for their own political ends. That is, many parties have behaved badly in this debate by their insensitivity, overstatements or exaggerations. It is time to look at the realities not the imagined situation that GM represents.

In many other countries GM has been welcomed and is being used enthusiastically to produce new plant varieties especially with enhanced pest resistance to the great benefit of those communities. Throughout the developing world, ever increasing use of pesticides is necessary to combat pesticide resistance. This is associated not only with declining crop yields but also rising numbers of cases of people poisoned by exposure to these chemicals. China has been growing GM crops since 1988, and between 1997 and 2000, the height of the GM furore in this country, Beijing approved the release of 100 GM crop varieties. A major reason for this activity was because, for example, in China cotton growing had almost stopped because of ever increasing resistance in its major pest, boll worm, to pesticides. Now GM cotton varieties with enhanced pesticide resistance are widespread and indeed GM cotton is grown all over the world – we are all probably wearing or owners of clothes made of GM cotton. Likewise, cabbage and cauliflower are staple food crops in China and yields were dropping fast as pesticide resistance made them highly susceptible to destruction by pests. GM is being used on these crops to increase yields. Thus, whatever we decide in Western Europe, this wonderful new technology is being used with great success and great benefit in many other countries, despite the activities of European-based campaigning groups who are trying to tell people in other countries that GM is dangerous. This new form of colonialism is as unwelcome as the original! We need to let other people decide for themselves as the Chinese, Vietnamese, Indians and many other nations are already doing. If we in Western Europe decide to cripple ourselves and reduce the hope of progress in dealing with plant disease by rejecting new technologies, so be it. But all of us should be aware of what is happening. We should also note that if Britain rejects growing GM crops, it will seriously affect African attitudes.

To my mind, the debate about GM induced by opponents of this technology is unreasonable because opponents are not only absolutist in their demands that this technology should be forever banned but they are complacent about the present situation in other parts of the world especially Africa where crop yields are at the level seen in Britain during Roman times. Much is needed to be done particularly politically to help improve the agricultural situation in Africa, but most African scientists think GM is a necessary part of the solution. It is our business to help them, not impede them with scare stories based on false dogma.

Many environmentalists claim that they have nothing against new technology as such, but they distrust its ownership by big corporations – i.e. the anti GM movement is inextricably

bound up with the anti capitalist movement and it is undoubtedly the case that foolish behaviour by a big US based company provoked the anti GM storm in Europe. Yet the actions of activists do not fit with this statement. When presented with a biotechnology developed in the public sector and made freely available to all in the developing world, they still object to it.

This is the case with "golden rice". In the 1990's Ingo Potrykus genetically engineered some strains of rice to contain a natural Vitamin A precursor because he was distressed by the fact that 0.5 million children go blind each year in the developing world for lack of Vitamin A. He gave up his intellectual property rights, and persuaded agricultural companies to waive their patents so the rice can be given away free in poor countries.

But this crop is years away from regulatory approval as a "drug" because of precautionary regulations urged on developing world countries by environmental groups. These people argue that this rice should never be used because a person would need to eat 9 kgs a day to get enough Vitamin A and because there are better ways to get vitamins to the poor. The first statement is wrong, current varieties of golden rice will provide enough Vitamin A in 200 grams (about a cupful of rice). As for the second, if these objectors know a better way of getting vitamins to the poor why don't they do it?

It is in fact early days for this new, very precise DNA based way of developing new plant varieties. When new types of crops are produced with GM technology that the consumer believes are advantageous to them, attitudes will swiftly change as they have in other countries. Imagine the effect it would have on the average UK citizen's view of GM plants if someone was able to produce by GM a tomato with the properties of Viagra!

Whilst people in UK and Europe may have been persuaded that the fruits of the DNA revolution should not be applied to plants, even to develop varieties able to resist new highly damaging plant diseases, the same population of people is highly enthusiastic about its application to the development of new medicines. Here indeed people do hope for progress by the application of science! The development and use of vaccines and antibiotics against many dangerous bacterial and virus infections over the last 50 years has transformed our lives.

These successes led a senior US health official to claim 35 years ago that we could "close the book on infectious diseases" i.e. he and others decided little more was needed to combat bacterial and viral threats to human life. But as we have come to realise, this was a false dream.

Nowadays infectious diseases are once again a threat for 3 reasons.

Firstly, the rise of drug-resistant organisms – so called "super bugs" that the common antibiotics can't kill. Secondly, new and re-emerging pathogens – since 1976, 30 serious new infectious organisms, including some of the most deadly ever seen, HIV/AIDS and the Ebola virus, have been identified and finally, the threat of pathogens released or created as weapons of man's destruction and terror, including anthrax and the smallpox virus.

These threats have jerked us out of the complacency induced by the success of the development of antibiotics and vaccines in the third quarter of the 20th Century which resulted in major reductions in research activity in infectious diseases everywhere in both

academia and industry. Now there are 250+ medicines being developed worldwide against infectious diseases. However, most are not yet available and we need them urgently, because we are not winning the battle against these new threats from infectious organisms. The DNA revolution is a great help in speeding up the identification of potential new drugs as I see first hand in one of my current activities, the development of new medicines for malaria where drug resistance is also an escalating problem. I hope for progress in this area but I wish I were more certain we can achieve it quickly because the threat of antibiotic resistant infections is so serious.

There are in addition many infections against which both vaccines and drugs have proved impossible or difficult to develop. Scientists have known for many years that most if not all infections of the human race came from other animals initially, and that infections can suddenly leap from animals into humans and change rapidly. Influenza is a good example of this type of infection. This is why a network of laboratories exists world-wide to assess changes in the influenza virus bearing in mind the devastation caused by Spanish flu at the end of World War I when somewhere between 20-70 million people died. Something similar could happen again. This situation i.e. that new variants of existing infections or brand new infections can suddenly appear has been made clear to the population at large by the arrival of HIV/AIDS in the early 1980s and now Severe Acute Respiratory Syndrome (SARS) this year. Here the DNA revolution and other technological advances are the main hope of progress in dealing with these real threats to mankind. Because of these advances, both HIV and now the coronavirus responsible for SARS were identified and characterised rapidly, in months in the case of HIV in the early 1980s and in weeks in the case of SARS. You may take this for granted – to me it is an extraordinary scientific achievement. Equally extraordinary, at least to me, is that in the 20 years since HIV/AIDS was identified as a virus, 64 new medicines have been developed against this lethal disease and its associated conditions and over 100 are in the pipeline. We cannot eliminate this virus but it can be controlled though only through continual medication involving a cocktail of drugs. Because HIV is continually changing, we need to continue to develop new drugs against it. There is much talk of a vaccine but we need to be cautious in hoping for progress there because vaccines against infections that change rapidly as HIV, influenza, etc. do have never yet been more than partly successful.

There is real reason to be concerned about the potential effect of infections such as HIV/AIDS and SARS on the future of the human race. The ever-increasing size of the human population is associated with the development of mega cities where people and animals live in close proximity and provide ideal environments for the transmission of infections. It is just as well we have had such a revolution in our technological capacity to detect, analyse and seek how infections are vulnerable to attack by drugs or vaccines. Here the hope of progress is undoubtedly dependent on the application of science. Controversy in this subject relates to the availability of drugs, a topic I will not address today, but one in which I am much involved.

Our understanding of all diseases, not just infections, is being transformed by the DNA revolution. Cancer is a disease caused by mutations or alterations in DNA. We know that cells become malignant only once they have been subject to several genetic mutations. Cancer in its many forms is as variable as infectious disease – this is why progress in developing therapies is incremental, but progress there is and this is very dependent on the DNA revolution. Patients are just beginning to benefit from the first designer drugs – drugs that have been designed around an understanding of what has gone wrong in the DNA of cancers. These therapies will be much more effective and selective than the blunt instruments

of chemotherapy or irradiation. It is a bit like mending a broken car – it is much easier if you understand the mechanics and electronics and can deal with the faulty component. Our knowledge of DNA is allowing us to identify the faulty molecules in cancer cells and devise smart ways to fix them. However, new designer drugs are only part of the change in the way we will deal with cancer in the future. Already our understanding of DNA changes in cancer cells is helping us to diagnose and choose treatments for cancer - these are the areas that are likely to bring most immediate benefit to cancer patients. If we can identify changes in DNA that occur early in cancer progression, we can diagnose the disease earlier when it is easier to treat.

We also know that even cancers that we think of as belonging to the same type – like breast or colon cancer – are really a mixture of different diseases that probably need to be treated quite differently. Lumping these cancers together and trying to treat them the same clearly doesn't work very well. If we go back to our broken cars, it is like trying to mend all Fords by replacing the fan belt and fixing all Vauxhalls by replacing the battery which is what we do with chemotherapy and irradiation.

By looking at the DNA we can now generate a detailed genetic fingerprint of each individual cancer and this eventually will enable us to tailor the most effective treatments for each person. This is a very active area of research in cancer currently.

DNA can also help us predict who may be at risk of developing cancer so that we can monitor them or advise them on life style. The ultimate goal of course is to stop people getting cancer. All of this is within our grasp, but only because of our knowledge of DNA and our ability to study it.

Let me now turn to one of the greatest impediments to the hope of progress in implementing the new research tools the DNA revolution has provided us with, the activities of single issue and campaigning groups to which I have already made some reference. In medical research, chief amongst these are the animal rights campaigners. They are also the oldest as they began their activities in the 19th Century. They are extremely well financed and increasingly clever and, in some cases, ruthless in their methods. Their campaign has had two major foci – to get at the hearts and minds of our children, most of whom have highly anthropomorphic views of animals thanks to urbanisation, Disney and writers such as Beatrix Potter. They also aim to make research involving animals so inhibited by bureaucracy and expense that it is almost impossible. They have been very successful in both these aims. However, the recent violent and intimidating behaviour of a small group of animal rights extremists against HLS and their customers and professional advisors together with an increase in the activities of groups who want medical progress plus a change in mindset by the current Government administration has had a positive effect on community attitudes to the need to use animals in medical research.

This is constantly monitored by those of us responsible for funding medical research. The most recent opinion poll showed a marked increase in the percentage of people who agree that it is acceptable to use animals to develop new medicines, now approaching 90%. Opinion polls aside, the most telling evidence of community attitudes is that people are not deterred by the activities of animal rights groups from giving money to medical research charities all of whom are known to support the use of animals in research.

We all need to recognise the techniques used by pressure groups of which the animal rights campaigners are but one example. They carefully select evidence and examples that suit their preconceived viewpoint when producing reports, and take advice from organisations already opposed to the scientific matter in hand rather than from the research community. They do not use proper scientific assessment and have no mechanism for independent scrutiny to achieve the public interest they claim. They are exceptionally skilful in their use of the media – and getting a negative report or criticism into the press seems to dictate how society responds. That is, people in positions of influence whether in business, the city, politics, medicine or whatever seem to run scared quite unnecessarily at the slightest negative comment on scientific matters, whether animal testing for medicines, GM crops, stem cell research etc. Those of us who have lived with the animal rights campaigners all our professional lives have been totally bemused by the way city firms have immediately caved in when confronted with their activities. Some of us were brought up to believe that appeasement is not a dominant British characteristic, but it certainly is in this case! It is a matter for concern because the methods developed by animal rights groups can so easily be copied by others. They use modern technology very effectively to achieve blockade by email and telephone. In fact, many of the activist groups are just an individual with a PC and a total commitment to oppose. It is not just scientific research in medicine that is being affected by these methods and the community as a whole needs to be alert to what is happening. Environmental campaigners are already resorting to verbal abuse and bullying intimidation towards anyone prepared to disagree with them as perusal of the journal The Ecologist clearly reveals.

This brings me to my final and most important topic this evening which is the issue of community attitudes to science and scientists in general. I am aware that the nature of our training means that scientists like me have minds that work in a rather different way from the mindset of the vast majority of my fellow citizens. Whilst we scientists take pleasure in the rational value and intellectual delight of greater scientific understanding, non scientists are on the whole more concerned with the social and ethical consequences of scientific advance. Scientists do not work and have never worked in a moral and ethical vacuum – indeed, we accept and often initiate formal regulation of our work particularly where the dangers are perceived to be greatest or the ethical and moral constraints most obvious (e.g. research on human embryos). I was recently involved with an international group of scientists preparing position papers for the European Science Foundation on the use of animals in research, GM plants and stem cell research. The main outcome was to urge governments right across Europe to develop legislation and regulations to control research on these topics as not all European nations have the excellent legislation and regulatory framework for these issues that exists in the UK. It is important that scientists continue to discuss the ethics and morals of their work and possible effects of their discoveries, but these are not always obvious at the time and the average person is realistic about interventions in nature and the lack of predictability of the effects of these. People ask instead whether the purposes and driving interests underlying research are valid and good and whether they justify the inevitable uncertainties which they know are implicit in scientific advance. They also ask about benefits and whether knowledge will benefit the public or only the few. We all look for evidence that we can trust the judgement and vision of the people and procedures governing decisions taken on our behalf. Scientists like me must do our bit to ensure that society does not damage itself by being driven totally by emotion and irrationality by patiently and persistently explaining what we do, but we need support in this endeavour.

We need influential people such as you, my audience here this evening, to help us to adopt a more rational approach to science. Without your support, many scientists find it difficult to defend their work for fear of being seen as self interested – " she would say that wouldn't she" … is the kind of comment I have in mind.

Campaigning groups proclaim difficulties and problems but their actions show that they do not feel it is their job to provide practical solutions to their concerns. This is well illustrated by the story I told you of golden rice. In contrast, most scientists I know wish to contribute to the public good again illustrated by the story of golden rice. What I am asking you to do tonight is to join with scientists like me to ensure the hope of progress for solutions to the world's problems. The revolution in biological science triggered by the publication of the structure of DNA by Watson and Crick 50 years ago has given us technologies to address problems that have always been with us. We need to act to do something about the fact that a child dies every 30 seconds from malaria, to prevent half a million children a year going blind from Vitamin A deficiency, to produce more and higher quality food for everyone not just the privileged citizens of Western Europe, to prevent and eventually cure genetic diseases, to deal with the ever increasing threat of infectious disease, to address the rising tides of cancer, diabetes and heart disease. I recognise – and I hope I have begun to persuade at least some of you here this evening - that the DNA revolution has not only provided us with the wherewithal to address these problems but its availability has also resulted in a real increase in our responsibility to act.

In conclusion, I said at the beginning of this talk that my mind set, shared with Peter Medawar, is to use science to ensure the hope of progress for all mankind. If you are of a similar cast of mind, please help scientists like me. Your invitation to speak here tonight is an example of what you can do and I thank you sincerely for this. Please arrange for scientists to come and speak to diverse audiences, not just the cosy gatherings of the converted we are mainly asked to address. We need help with media coverage and your support in ensuring that the rational approach to science is careful regulation rather than outright opposition that can result from the actions of pressure groups. Pressure groups surely include people who frequently deride the hope of progress and illustrate Peter Medawar's ringing statement that this attitude is the ultimate fatuity, the last word in poverty of spirit and meanness of mind.