Keith Roby Memorial Lecture in Community Science (1987)

“The Engineering of Reproduction: Is it Heading off the Rails?”

Lecture delivered by: Dr Ditta Bartels, School of Science and Technology Studies at the University of New South Wales, on 14 October 1987 at Murdoch University

Introduction

It is a great honour for me to be here at Murdoch University to give the Fifth Keith Roby Memorial Lecture. Unfortunately I did not have the opportunity to know Dr. Roby personally, but through contact with some of his friends and colleagues, in particular with Professor Charles Birch, the inaugural Keith Roby Memorial Lecturer, I feel that there are some indirect links between my outlook and that of Dr. Roby and the group he built around him.

Quite a number of years ago, Professor Charles Birch in fact introduced me to the topic I wish to share with you, namely the social, political and ethical issues that arise from the technologies of genetic engineering and in vitro fertilisation (IVF). In early 1981, just after I completed my Ph.D. thesis on the history of genetics, I began to read some of the literature on the then quite new techniques of genetic engineering and IVF, and I felt that the social analysis of these techniques might be the direction into which my research would go. But I felt that there was no need for me to make a decision about it just then, since after almost five years of concentrated effort, I was planning a major holiday trip to Europe with my family.

As it happened, just a few weeks before I was to leave I was invited to a dinner at which Professor Charles Birch was a guest. I can't quite remember who said what about genetic engineering, but I guess that I must have made some sense, because by the time coffee was served, Professor Birch had asked me if I would like to participate in a forthcoming workshop of the World Council of Churches on the social consequences of genetic engineering. The workshop was to be held in a little village near Haarlem in the Netherlands, in June 1981. I was absolutely delighted, but also somewhat apprehensive, since I had never participated before in such a high-powered international gathering.
The workshop discussions, which were conducted under the guidance of Professor Birch and Dr. Paul Arbrecht, were later published by the World Council of Churches in the form of a booklet called *Manipulating Life*. This workshop determined the direction of my research from then on. Through it I had found an area in which the excitement of learning about the latest scientific breakthroughs could be combined with a social concern about the application of these technologies. But moreover, here was a domain in which it was possible to become politically active in regard to how the applications of a new science should be channelled. It seems to me that the social, ethical and political assessment of genetic engineering and in vitro fertilisation is now very much at the core of the field which was so important to Dr. Keith Roby, namely the design of a model - indeed of a vision - of how science and society can interact to their mutual benefit and advancement. I shall always be grateful to Charles Birch for having steered me in this direction.

Since that World Council of Churches workshop in 1981 I have continued to examined the ongoing scientific, clinical and industrial developments in genetic engineering and IVF, and the many connections between them. I would like to share with you an appreciation of these developments, so as to give you a sense of where these sciences have arrived at and in particular, where they are heading. I believe that public discussion on the current advances in the biomedical sciences is vital, since without such public discussion decision making in these areas becomes institutionally isolated and far too technocratic. There is a great danger that the agenda for research and development is set according to judgements of what is "technically sweet", to use the phrase coined by Robert Oppenheimer for describing the drive behind the development of the atomic bomb. This means that research projects are executed and put into practice just because scientists find the work intellectually stimulating, and not because there is a broad-based public endorsement of the scientific and technological advances.

**Overview of problematic aspects of IVF programs**

We generally think of IVF in terms of a stereotype, in terms of the individual woman who has tried for years to become pregnant but fails to do so. What could possibly be wrong with a technology that simply unites her egg and her husband's sperm and thus allows them to have a baby? But unfortunately in practice, IVF consists of much more than this unproblematic individual stereotype. What it amounts to is much less idealistic:

First, IVF has become a massive world-wide enterprise, much of it run on a commercial basis, with competition between the separate IVF centres. As a consequence there is a distortion of success rates, in order to attract clients.
Second, IVF programs involve a great deal of public expenditure, which comes at the expense of other community health needs.

Third, there is a significant danger to women on IVF programs, in particular a danger of cancer from the superovulation treatment.

Moreover, this danger applies not only to the women who want to become pregnant, but also to those women who are co-opted into the programs as volunteer egg donors.

Fourth in the hands of some practitioners IVF has become associated with the selective destruction of excess foetuses in the wombs of women on the programs.

Fifth, IVF leads to exploitative surrogacy arrangements based on the recently developed technique of embryo flushing.

Sixth, IVF presents us with large storage banks of frozen embryos in all of our metropolitan centres.

Seventh, IVF opens the problematic area of experimentation with human embryos and the usage of these embryos as research material.

Lastly, current developments in IVF make it possible to carry out sex selection of the embryo before it is implanted. From amniocentesis we already know that the identification of the sex of the foetus often leads to the abortion of female foetuses. New developments in IVF embryo research make sex selection much more feasible, and on this basis we can predict a change in the sex balance of future generations.

Let us now examine some of these problematic features of IVF programs in more detail.

**High public costs of IVF programs**

In Australia as well as overseas, the clinics that carry out IVF programs do not provide figures for how many IVF treatments they perform in a year. Clearly, without these figures it is very difficult to calculate what is spent on IVF programs out of the public purse. But recently, in order to assess the commercial potential of IVF technology both here and in the United States, the *Business Review Weekly* has carried out an investigation to provide a rough estimate of how many treatments are currently conducted in Australia every year. The range they came to is between 10,000 and 20,000 treatments. I have tried to substantiate these estimates, and with calculations based on IVF pregnancy rates reported by the National Perinatal Statistics Unit, I arrive at about 7,500 IVF treatments in Australia for 1985 alone.
(566 chemical pregnancies, ratio of treatments to chemical pregnancies of 13 to 1). Since 1985 this yearly figure has increased considerably, probably to above 10,000. Now each of these treatments costs around $3,700, with Medicare benefits paying over $2,600. On this basis the yearly direct government expenditure on IVF programs in 1985 was over $20 Million.

What is not included in this estimate are the high set-up costs involved in putting the skilled IVF teams in place as well as their expensive equipment. Furthermore, we have mentioned only the government contribution to the cost of the IVF treatments themselves. If pregnancies result from these treatments, they are often problematic, with a quarter of them being twin or triplet. As a result, the babies born are often premature and need to be looked after in neonatal intensive care units. As we know, these are very expensive to run and again involve vast government expenditure. So what the government currently spends every year on IVF treatments, on the set-up and maintenance of the laboratories, and on the intensive care of ensuing babies, exceeds $20 Million by a considerable margin. (About 420 IVF babies in 1985.) We know that our total health care expenditure is not going to increase in the foreseeable future. This means that the many millions of dollars spent yearly on WE programs have to be at the expense of other health services.

**Superovulation and multiple pregnancies**

In passing I have mentioned the problem of multiple pregnancies and premature infants. Unfortunately this problem is part and parcel of IVF programs and hence unlikely to go away in the future. It derives from a particular technical feature of IVF technology to which I would like to turn now since it raises a number of social and ethical problems. In IVF programs women are treated with hormone preparations - generally those called Clomid and Pergonal - so that in their ovaries not just one egg matures as is normally the case, but rather a larger number of eggs sometimes as many as 20. This process is called superovulation and it is an integral part of the IVF treatment, since without it there would be a very low chance of picking up eggs to fertilise outside the body. But superovulation is not without difficulties, since potent, and possibly dangerous hormones are involved. Indeed, recently it was reported in the British medical journal *The Lancet* that on three separate occasions women who were treated in this way developed cancer of the ovaries. Obviously the side-effects of superovulation, both short-term and long-term, should be monitored closely. So far this has not been happening.

Superovulation leads not only to a large number of eggs, but also to a large number of embryos. This raises two related questions: how many embryos to insert into the woman's uterus and what to do with those which are left over. It is now known that when three
embryos are inserted, the chance of one of them implanting in the uterus is higher than if only one embryo is introduced. Insertion of four embryos raises the chance even more. But if all the inserted embryos happen to implant in the uterus, a triple or even a quadruple pregnancy can occur with a whole host of obstetric difficulties. Most IVF practitioners opt for a trade-off: they insert three embryos and hope that only one or two will 'take'.

But one of the top IVF practitioners in Britain, Dr. Ian Croft of the Humana Hospital in London, argues that it is worthwhile to insert as many as six embryos if they are available. He has perfected a technique whereby he can pierce the hearts of foetuses and thereby destroy them. So if too many embryos implant, he eliminates the excess foetuses. Dr. Croft justifies this selective in utero destruction of foetuses on the basis of the general acceptance of abortion. But Dr. Croft's practice has shocked the British IVF fraternity, and he has been asked by the British regulatory body, called the Voluntary Licensing Authority, to discontinue his practice of inserting more than three embryos. It should be mentioned, however, that this regulatory body is voluntary; it has no legislative control over any of the IVF practitioners.

**Embryo experimentation**

If no more than three embryos are inserted, a store of frozen embryos quickly builds up. These can be kept for later use by the patients if their first IVF treatment does not succeed; alternatively, the embryos can be 'donated' to another couple who might be unable to produce their own embryos; or thirdly, the couple has the choice to allow their embryos to be used as research material.

In Victoria, WE legislation is now in place under which a Government Committee, chaired by Professor Louis Waller, has to review all proposed experiments with IVF embryos. Scientists who fail to obtain permission for their experiments, or who go beyond what has been approved by the Committee, face criminal charges with gaol terms up to four years. The Victorian law also distinguishes between embryos generated in the course of infertility treatment and embryos which are produced especially for research purposes. This latter production of research embryos is prohibited.

But in other Australian states the Victorian example of legislating WE procedures has not been followed. Indeed, the National Health and Medical Research Council is opposed to such legislation. This means that outside of Victoria, if any restriction of embryo experimentation is practised, it is only on the basis of self-regulation.
In Britain WE legislation has also not yet been passed, even though it was proposed as an urgent requirement by a government-appointed committee as long ago as July 1984.1 quote from the report of this committee, generally referred to as the Warnock Committee:

Everyone agreed that research using human embryos was a matter on which there must be legislation, and that whether and to what extent embryos should be used must be a decision for the law ... All members of the Committee wanted the criminal law to be invoked in this matter ... The difference is whether some work involving live embryos should be licensed or none.

I quite agree with the recommendation that research with human embryos should be governed by special legislation. Such experiments should not be allowed to remain an area that is self-regulated by scientists. There are broad ethical considerations involved in decisions as to what type of experiments can be performed with human embryos and which experiments should not be done. These decisions must involve the values and judgements of people who are well outside the group of IVF practitioners and their clients.

A further point arises in regard to embryo experimentation which is not generally highlighted sufficiently. This is that embryos used as research material are often not generated as a side product of infertility treatment at all. In their demand for this research material, the IVF scientist often turn to women who far from wishing to become pregnant, are actually seeking sterilisations for purposes of birth control. Women like this are asked to co-operate in the interest of science and allow themselves to be treated first by superovulation and then have their eggs collected at the time of their sterilisation operation.

But as we have seen, superovulation can endanger the health, and even the lives of women. Nevertheless, many women have already gone along with this kind of treatment so as not to impede the research interests of their medical practitioners. In Britain, Professor Baird at the University of Edinburgh, Dr. Braude at Cambridge and Professor Templeton at Aberdeen have been particularly outspoken about the desirability of using volunteer women to donate their eggs. What they wish to see is a separation between clinical IVF treatment and research using human embryos. On the other hand, the Victorian IVF legislation prevents the collection and fertilisation of eggs from women who do not aim to become pregnant. Because of the serious dangers involved for women in superovulation and egg collection, I believe that this should be the legal position in all of Australian.
**Surrogacy arrangements based on embryo flushing**

Women have been under pressure not only to donate their eggs for research purposes, but also to give up embryos conceived within their bodies and babies born to them. Here we come to a discussion of surrogacy, and what I would like to draw to your attention especially is surrogacy based on the handling of embryos outside the body. IVF technology has taught scientists how to handle early human embryos in vitro, and animal husbandry has shown how the technique of embryo flushing can be perfected. In the technique of embryo flushing, fertilisation actually takes place inside a woman's reproductive system, but before the embryo has a chance to implant into her uterus, it is flushed out, examined and then transferred into a different woman's uterus. This technique has been patented and commercialised in the United States.

Embryo flushing can be used in several different types of surrogacy arrangements. First, let us take the hypothetical case of Mr. White and Mrs. White who would like to have a child, but the problem is that Mrs. White's ovaries do not function well. Through an agency they are put in touch with a Miss Black, who for a small fee is prepared to undergo superovulation and to be artificially inseminated with Mr. White's sperm. The idea is to flush out of Miss Black's uterus any resulting embryos and to insert these into Mrs. White, so that she can give birth to what will become her baby.

Unfortunately problems can arise easily. If not all the embryos are flushed out in the procedure, Miss Black becomes pregnant. Furthermore, if the embryos are not all flushed out as intended and one of them is pushed up into the Fallopian tubes, Miss Black ends up with an ectopic pregnancy which is a great danger to her life. Even if the condition is detected in time, the Fallopian tube with the implanted embryo has to be removed surgically. This will probably leave Miss Black infertile.

Of course these complications are not highlighted to Miss Black by the contracting agency. What she believes is that she will be paid handsomely for just a few days of minor inconvenience. In fact, however, the complications arise frequently, like in the case of Alahandra Munez, a 21 year old woman from Mexico, who was smuggled across the border to California so as to act as an embryo donor for her affluent second cousin, Mrs. Harrow. As it happened, the embryo did not flush out of Alahandra's body during the procedure, and she gave birth to a baby girl. By then she wished to keep this baby, but she was not permitted to do so by the contracting couple. Alahandra now lives in the US illegally, with fear of deportation, but at least she can see her baby once a week.
Next I would like to turn to a type of surrogacy which concerns me even more. Let us again consider our hypothetical couple Mr. and Mrs. White who wish to have a child. But now, while Mrs. White's ovaries are functioning well, her uterus is not. In this case the treatment is to have Mrs. White impregnated with Mr. White's sperm and have the embryo flushed out of her body. The embryo is then inserted into the uterus of Miss Black, who for a certain sum promises to hand over the baby when it is born. The argument that has been put forward in favour of this kind of arrangement is that Miss Black would not be emotionally attached to the baby, since genetically it is not hers at all. I don't accept this argument, but let us pass over that and move on to our third hypothetical case.

Here we have Mr White and his wife Dr White, who has functional ovaries as well as a functional uterus, but for career reasons Dr White does not wish to go through with a long and possibly arduous pregnancy. She therefore arranges to become impregnated with her husband's sperm, has the embryo flushed out, and inserted into Miss Black's uterus. The baby is born, and for a certain sum it is handed over to the Whites. The interesting point here is that the technology of embryo flushing has made it possible to employ underprivileged women, possibly coloured women from third world countries, to bear the babies for the affluent white women of the West. The babies will look exactly like the parents who have commissioned them and not like the women who have given birth to them.

The technology that is required for such transactions is already with us; indeed it has been patented in the US. And that this technology has enormous potential for the exploitation and denigration of women cannot be denied.

For these reasons I feel that it is urgent to legislate now, so that surrogacy arrangements of all types are outlawed. Again, the Victorian law serves us as a good model.

**IVF and genetic engineering are coming closer together**

Let us now leave the domain of IVF and surrogacy, and turn to an area of new work in biomedical research through which IVF and genetic engineering are coming into close proximity. So far, clinical practice has not gone very far down this route, but as we shall see the science is ready to go. We are therefore at a stage where vital social and ethical decisions need to be made. Unless the public makes it known that its endorsement should be a prerequisite for the application of this science to the human domain, the developments will be driven ahead by the scientists and technologists involved in the absence of any societal controls.
In the remaining part of this lecture I would like to show you that IVF and genetic engineering can come together in two ways, both involving the genetic manipulation of early embryos. One route is that of genetic diagnosis, the other is that of genetic transfer.

**Prenatal diagnosis**

Gene diagnosis often—though not exclusively—takes place within the context of prenatal diagnosis of the foetus. This practice in fact goes back some 20 years, when the technique of amniocentesis was introduced into obstetrics. In amniocentesis a fluid sample is withdrawn from the amniotic sac which surrounds the foetus. Cells shed by the foetus are generally found in the sample that is collected, and these cells can then be analysed in the laboratory. The drawback with prenatal diagnosis based on amniocentesis is that the test can be performed only late in pregnancy, around week 16. This means that if a defective foetus is detected, termination of the pregnancy by abortion becomes problematic from an obstetric point of view as well as emotionally. Thus efforts have been made to develop techniques with which to bring forward into the earlier part of pregnancy the diagnosis of the foetus.

Furthermore, traditional prenatal diagnosis managed to pick up only a handful of conditions, namely those where there is a gross chromosomal defect or those where an abnormal protein is secreted. Down's syndrome with an extra chromosome 21 falls into the first category, while Tay-Sachs disease and spina bifida fall into the second. Geneticists have been quite dissatisfied with the paucity of conditions detected by traditional prenatal screening, and have strived to develop a technique whereby many more genetic diseases can be detected.

Both the obstetricians in search of prenatal diagnosis at earlier stages of pregnancy, and the geneticists in search of more comprehensive prenatal genetic tests, have come up with results recently. The first advance was that about five years ago a new technique called chorionic villus biopsy was introduced. Here foetal cells are withdrawn for analysis not from the amnion which is accessible only late in pregnancy, but rather from the chorionic villi which are accessible much earlier. Prenatal diagnosis based on the chorionic villus technique can be conducted in the first three months of pregnancy. So if an abortion is called for in the case of a foetus which is found to be defective, the abortion is much less of a problem both technically and emotionally than later on in pregnancy.

Meanwhile the geneticists have come up with an equally spectacular breakthrough based on genetic engineering or recombinant DNA technology. This is the development of so-called gene probes which are purified and radioactively labelled stretches of DNA. Depending on the conditions that are investigated, the gene probes are either whole genes or fractions of genes. Their main property is that they bind to DNA in a highly specific way, and so a gene
probe for sickle cell disease, for example, binds to the DNA of a person or foetus with the disease, but not to the DNA of a normal individual. There are now over 3,000 genetic diseases known, and in principle the new technology of gene probes should permit the detection of all of them.

Now if diagnostic kits can be produced which contain gene probes for a whole range of genetic defects, then it becomes worthwhile for large numbers of pregnant women to seek gene diagnosis of their foetuses. It is obvious that as genetic technology becomes more powerful, and many of the 3,000 genetic conditions can be detected by means of gene probes, more and more women will opt for the genetic diagnosis of their foetuses. In turn, this will increase the market for the production and distribution of gene diagnosis test kits.

On the basis of such expectations the production of gene probes has become big business in the United States. The market is estimated to be over three million pregnancies per year in the US alone. According to a recent survey of the Congressional Office of Technology Assessment, over 50 companies are involved in research and development on gene probes. Obviously, the only way these companies can survive commercially is to market their technology as widely as possible.

Thus one factor which increases the penetration of gene probe technology into the market is the number of conditions that can be screened for. In addition, there is a second factor which also determines just how extensive genetic diagnosis of the foetus will become. This is the time during pregnancy at which the diagnostic test can be performed. The more that this can be pushed into the early part of pregnancy, the greater will be the interest of pregnant women and of their medical practitioners in the technology.

As we have seen, with the development of chorionic villus biopsy, prenatal diagnosis is no longer as traumatic as it was when it was based on amniocentesis. But no sooner had this technique been developed, than a new contender is ready to enter the scene. This new, yet to be perfected technique of genetic screening, will push the diagnosis even further forward. Indeed, the effect of the new technology is to push the genetic diagnosis of the offspring to the stage before pregnancy. It is here that IVF and human embryo experimentation re-enter the picture.

**Embryo biopsy**

IVF scientists have determined that very early embryos are quite robust in the laboratory. At the stage when the embryos consist of only four or eight cells, one or two of these cells can be removed, and the remaining parts of the embryos have a good chance of surviving. This
process is called embryo biopsy, and currently it is at the forefront of human embryo research. The idea is that the cells which are removed from the embryo can be diagnosed for genetic defects by means of gene probes. In principle at least, an early embryo produced by IVF can then be tested for a whole range of genetic conditions. Only embryos which are declared devoid of all the defects tested for are inserted into the woman's uterus.

We have now arrived at an interesting position. With the development of the two technologies we have looked at, namely embryo biopsy and gene probes, IVF suddenly becomes of interest not only to infertile women. All those women who would like to feel assured right from the start of their pregnancy that they are not carrying a genetically defective offspring, become potential clients of IVF. Undoubtedly this will appeal to a large number of women, particularly to those who have left reproduction for late in life. This is in fact the market that the commercial companies involved in the development of gene probes are interested in. With around 50 companies in this business, we can be sure that the new conjunction of the field of IVF with that of gene diagnosis will be pushed ahead at an accelerating rate.

Furthermore, the gene probes which are being developed do not all relate to conditions such as sickle cell anemia or Tay Sachs, which are genetic diseases in a straight forward way. Developments in gene probe technology are also taking place in regard to conditions of susceptibility. Recently it has been found that in our genetic material there might be genes related to a predisposition to cancer, to heart disease and even to manic depression. Gene probes are being developed for these stretches of our DNA as well, and so the range of genetic tests will in future include not only straight forward genetic diseases, but also mental and emotional stability as well as longevity.

In a few more years then, our hypothetical Dr White, whom we have encountered before in regard to her surrogacy arrangement with Miss Black, can go about reproduction in some of the following complex ways. First she undergoes superovulation so as to produce a larger number of eggs. Then she has a choice: she can opt for egg collection and IVF with Mr White's sperm or alternatively, she can be inseminated with Mr White's sperm and have the resulting embryos flushed out. Either way, the embryos end up outside her body and can therefore be investigated closely. One or two cells are removed from each of the embryos and diagnosed genetically. Tests are performed for thalassemia, Lesch Nyham disease, Tay Sachs, spina bifida, cystic fibrosis, Huntington's disease, Down's syndrome, and also for susceptibility to certain cancers, to arteriosclerosis, to manic depression and to schizophrenia. One or two of the embryos might both survive the screening process and test out positively for all the conditions investigated. Dr White then has a further choice to make: does she wish
to carry the pregnancy herself or would it be preferable to have her quality tested embryo inserted into the uterus of Miss Black?

By now I am probably conveying to you the sense of what I mean by the concept "the engineering of reproduction". It should be emphasised that this is not science fiction. What I have described can be done today with animals: the technologies of IVF, embryo flushing, embryo biopsy, and gene probes have all been developed and many of them are being used routinely in animal husbandry. Their application in the human domain is clearly not far away, particularly if we take into account the commercial pressures in the area of gene probe technology. But let us return once more to Dr White's ambition to have her embryo quality tested. Surely she would like to know the sex of the embryo right from the start. Recent developments can help her in this as well.

**Sex selection**

It will be recalled that the traditional way of carrying out genetic diagnosis is through amniocentesis at around the 16th week of pregnancy. In amniocentesis it is possible to determine the sex of the foetus on the basis of its chromosomal constitution: XX is a female foetus, XY is a male. Recently it has come to light that in India, but also in Britain, a large number of prenatal diagnoses are performed just so as to detect the sex of the foetus. The intention is to abort female foetuses. In India a recent study has revealed that in 8,000 abortions which were examined by the enquiry, 7,997 foetuses were female. Government legislation has now been proposed to restrict the use of prenatal genetic diagnosis because it was recognised that there is a growing problem of female feticide. But India is not the only country involved. In Britain a group of cytogeneticists have drawn attention publicly to the problem of selective abortion of perfectly normal foetuses just because they were of the undesired, namely the female sex.

Like gene diagnosis in general, sex determination is not limited to amniocentesis late in pregnancy. John West and his colleagues at the University of Edinburgh have shown that a genetic probe can be used to detect the Y chromosome in early IVF embryos. This now makes it possible for our Dr White to have only an embryo of the desired sex implanted in her uterus or that of Miss Black, her chosen surrogate. John West, who has developed the Y chromosome probe has said: "It certainly would not be ethical to use the method to choose the sex of a baby. But we could not prevent the technique being used that way". The genetic probe used by West to sex IVF embryos is available commercially.
The new eugenics

What the engineering of reproduction is thus able to offer is a quality-tested product, an embryo which is guaranteed to be free from genetic disease, from susceptibility to chronic conditions and mental instability, and is also of the desired sex. In our examination of the technologies involved we have concentrated on the attraction of these new technologies for the individual, privileged woman seeking to have a baby. But these technologies also hold considerable promise at the level of the population. Here the promise is that with these new developments we can expect to weed out genetic defects, including various susceptibilities, in the next generation or so.

But just a minute: is this not what eugenics is about? Indeed it is, but through these new technologies, eugenics has reached a far more refined level than could be contemplated in the 1920s, '30s or '40s. Moreover, there is now no state coercion in any of this, there is no pressure from the government for individuals to do what is supposedly for the good of the population. Rather, what we are encountering is that biomedical technology has advanced to the point where what is good for the population is also good for the individual. We are, therefore, at the threshold of eugenics with a human face. The goal of the old eugenics was to achieve a perfect population, a perfect race. On the whole this has given way to the individualistic goal of avoiding genetic blemish in one's offspring. But the objectives remain much the same, namely the eugenic ambition to achieve genetic perfection, with an inbuilt bias against those who are considered not to be perfect.

Conclusion

We have discussed quite a large range of biomedical technologies, the conjunction of which I would like to refer to as the engineering of reproduction. We have seen that there are distinct eugenic implications in these developments, and the question then arises: do we really want this kind of eugenics? In France, the leading IVF scientist, Professor Jacques Testart, has turned against it. He calls it a "perversion of IVF" and has declared that he will not contribute to the field of IVF any longer. Professor Erwin Chargaff, a distinguished molecular biologist who contributed to the structure of DNA but then became disillusioned with molecular biology, is quite horrified at these latest prospects. He speaks of a "molecular Auschwitz, in which valuable enzymes and hormones will be extracted instead of gold teeth". But with these few exceptions, most present day molecular biologists and IVF scientists are not perturbed. In a way they are too close to it all, and their scientific and in some cases commercial interests, drive them on. Undoubtedly, when you have your nose to the grindstone, it is hard to see the bigger picture.
I hope that I have presented to you the kind of decisions society will have to make in the next few years with regard to the new reproductive technologies. Professors Testart and Chargaff notwithstanding, if the new eugenics is not discussed in public, and if no public decisions are made, then the technology will rush ahead. For IVF scientists and for genetic engineers this territory is `technically sweet; as Robert Oppenheimer has said about the atomic bomb. Moreover as we have seen, commercial interests are involved in these technologies and they exert their own pressure to push the developments ahead. Thirdly there is a great deal of individual demand for these technologies.

Together, these various pressures will act so as to provide us in the next few years with the means to engineer human reproduction. It is undeniable that we are just about at the point of having the knowledge to do this. The question is how will we attain the wisdom to prevent the engineering of reproduction from heading off the rails?