

Genetic Modification and the New Creation: fact fiction and faith.
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Introduction

The advent of the new biology, involving DNA analysis, translation, manipulation and transfer has opened up a new era, in which the Biological sciences have come of age in terms of their commercial application and potential for understanding and influence. The secular world has embraced biblical imagery in describing the potential of genetic engineering of plants, animals and humans, both in terms of the New Creation and in the apocalyptic language of judgement. In the early 1980's scientists, keen to attract popular attention and government funding, talked up the potential benefits of the Human Genome Project, Genetic Engineering and DNA analysis (sometimes called genetic screening). The response from within the Christian community was slow, then enormously varied. Few have responded with unequivocal optimism, most with varying degrees of caution, distrust, or outright condemnation. Some of the responses, both within the Christian community and beyond have been deliberately sensationalist, woefully ill informed, or both!¹ It is entirely appropriate that this Institute, with its chosen theme of New Creation, should allocate some time specifically to Genetic Engineering, especially as I expect that the topic will be touched on in a wide variety of other working parties.

Understanding of our colleagues' assumptions and background often eases debate; so at the outset let me share with you a little of "where I come from". I am the son of a chemical engineer and studied Natural Sciences at Cambridge University. My final undergraduate year was spent in the Department of Applied Biology, (what had previously been the School of Agriculture) studying Plant sciences – Breeding, Physiology and Pathology of crops. A year's post-graduate study was followed by teacher training and a decade of teaching Biology at secondary school level. A convert to Christianity in my final's year, I married into Methodism, began Local Preaching in the mid-eighties in the Bahamas, and trained for Presbyteral Ministry at Wesley House ten years ago. Through a desire to link science and theology I spent my final year at Theological College producing a dissertation on "The theological and ethical issues raised by Genetic Engineering". Through this interest I have been involved in our Connexional "Genetics Working Party" helping to resource British Methodism in our response to these pressing issues.

I have heard British Methodists speak of "The Methodist Quadrilateral" of Scripture, Tradition, Reason and Experience. As the report of the Church of England on Marriage and Family life indicates, this is not an exclusively Methodist approach!² These four resources are not independent of each other, and in tackling issues raised by modern technology may be mutually contradictory. They do however provide the nexus within which to address any given issue. Disagreements between Christians often flow from the different weight being given to each of these sources, as well as from the different interpretations of scriptural material or a given tradition. You may understand from my background why I tend to give considerable significance to the "reason" dimension of this quadrilateral. If, as Polkinhorne suggests, both Science and

¹ See for example: Dixon P(93) The genetic revolution - today's dream ... tomorrow's nightmare? Christian and Ho Mae-Wan() XXXX

² "Something to Celebrate" The Church of England report on Marriage and family life. PXX

Theology are attempts to describe reality³, then I see any assumption that scientific fact is to be subject to scriptural assertion as prejudice. We will see later on that this is not to give primacy to reason, still less to “science”, it is however to indicate at the outset that shibboleths like “the primacy of scripture” need, by each generation, to be interrogated rather than blindly adopted.

When we come to address the ethical issues raised by any novel technology the realities of the practices involved need to be grasped before engagement with informed debate can be possible. The New Genetics and Genetic Engineering are sadly areas where Christians have often rushed to condemn before properly grasping the science involved. In complex and nuanced issues accurate information is a prerequisite for contribution to the debate, especially if that contribution is to be a critical one. Prophets need understanding as well as courage. We do our Lord disservice if we claim to speak in His name but do so from ignorance. In a plural society differences of opinion can easily be sidelined as driven by belief and therefore invalid; critique needs factual accuracy to have any bite. Wesley may have professed to be “homo unum libris”, but even an amateur historian like myself can see that he expected his preachers to be widely read. His keen mind, breadth of reading and saturation with both scripture and Prayer Book provide a role model for interpretation of scripture and response to contemporary issues. In reading material on the issues around the New Genetics one is struck by the simplistic assumptions of “sound bite” driven media, and by extreme reactionaries (or at least those who find a platform in print or other media.) If some of what follows seems to be simple grade school Biology, I make no apology; it is. From those for whom it can be taken as read I ask indulgence and critique where I over simplify or gloss over other interesting but less relevant science. From those for whom science is a strange territory, I ask patience and honesty. If some of what follows seems arcane or unnecessarily complex, bear with me, as some of the “Fictions” that need exposing are only recognisable as such when one has a better grasp of “the way it really is”.

There has always been a tension within the Christian Church over the extent to which nature can be taken to reveal the nature of God. There are those who assert that creation reflects the Creator, and that “general revelation” is a valid resource for theological reflection. In tension with this is the approach that stresses the fallen nature of creation, and that only the revelation of God in His Word is reliable⁴. The Fall, it is asserted, damages our human ability to “read” creation; I would wholeheartedly agree with this. However, this school of thought would also assert that the Fall so distorts the image of God in creation that any theology derived from reflection on nature must necessarily be so flawed as to be unusable. British Methodism would seem to me to walk more in the former path than the latter, reflecting John Wesley’s confidence in the universal grace of God. In my general acceptance of large sections of scientific understanding I am locating myself firmly with those who expect creation to reflect, at least in part, its creator.

Having introduced the weasel words “at least in part” I need immediately to move on to assert that the revelation of God in creation is ambiguous. As Hick indicates, the “message” of creation is ambiguous⁵ It is only through the eye of faith that the cruel, power driven, chaotic and senseless aspects of creation are interpreted as reflecting creation’s “fallen-ness” and the

³ Polkinghorne J. Lecture Cambridge School of Divinity 1991

⁴ Barth would be the champion of this approach. See below, Section 3, where an inclusive logos Christology is used to hold these two poles in tension.

⁵ Hick, *Evil & the God of Love* p279

same faith identifies its self-sacrificial, loving and purposeful aspects as significant in reflecting a loving, purposeful and self-sacrificial God. The challenge of holding to the Christian faith “despite the evidence” as one scholar has put it⁶ is one that far greater minds than mine have wrestled with.⁷ In the end, scripture and tradition are important in controlling what we might call “the hermeneutic of creation”. In less high flown language, it is from the perspective of hope-filled Christian faith that we interpret the world around us.

Section 1. GM: some facts.

Turning therefore to the science underlying the practices of Genetic Engineering or Genetic Modification (GM) (I should note that I shall be using these two terms interchangeably.⁸) It is always helpful to begin with a definition, and so I would suggest that genetic engineering is “the alteration of the heritable material of a given species by human beings taking specific actions.” This is deliberately broad, and reflects the first point that I would want to emphasise, namely that this is not a new phenomenon. As the handout indicates⁹, humans have been altering the inherited characteristics of our domesticated animals and crop plants for thousands of years. We have been doing so as a conscious and intentional act for at least two hundred years, and these “conventional breeding” techniques have been remarkably successful. In the 1990’s Monsanto took out full-page advertisements in the British national press rightly to assert this point. What our knowledge about DNA structure and molecular biology has enabled is a novel technique to apply to this deliberate alteration of the heritable characteristics of organisms. In glossing over this Monsanto’s advertisements were somewhat disingenuous.

It is helpful at this point to use the illustration of what have been sensationally dubbed “Frankenstein’s Pets”. These are extreme breeds of cats, dogs and other domesticated animals. (see illustrations 1&2) Examples include the sphinx cat, naked and highly dependent on its keepers for specialist care, the “munchkin” cat with legs so short and spine so long that it can not safely jump, the Shar Pei breed of dog with its rolls of fur so tight that individuals often go blind due to the fur scratching the cornea. These are the products of “natural breeding”, and have nothing to do with the techniques of DNA manipulation I am about to describe. I believe them to be obscene, and the Kennel Club of Great Britain and the British Cat Society will not permit these breeds to be “shown” competitively. This illustrates the fiction that “natural” is good and “unnatural” is evil or bad, even before we tackle the almost impossible task of defining “natural”!

If we were a conference of Biologists we might spend days on defining “species”. For our non-technical purposes we can adopt the simple approach that if two individuals can mate to produce fertile offspring then they are of the same species. Thus Dachshund and Rottweiler can produce fertile cross-bred puppies, as they are of the same species (*Canus domesticus*),

⁶ Calvert D (99) Advent Lecture in Southam Parish Church (unpublished)

⁷ See amongst others Pailin D A (92) A gentle touch

⁸ I believe that there is an issue here in terms of the way language shapes our perception and attitude to the world around us. “Engineering” engenders an assumption that the biological systems we are dealing with are mechanical, determined, inorganic. This is a mis-perception of these dynamic and plastic systems and processes that is increasingly being challenged.

⁹ “Milestones”: see appendix

but horse and ass produce the sterile mule, indicating they belong to different species. We will see that GM is novel in allowing the transfer of heritable material between species that could never interbreed, producing “transgenic” individuals that are fertile.

Heritable characteristics are those characteristics that can be passed from one generation to another. Often authors and speakers move immediately on to discuss DNA and molecular biology at this point; before following their conventional approach I would like to make a small but vital aside. Humans are different, if not unique, with regard to what we pass on to our offspring. I have handed on to my daughters far more that is coded for by my DNA, by my genetic material. We are social beings with complex linguistic and cultural heritages and traditions. We pass from generation to generation knowledge, attitudes and beliefs that have little or nothing to do with “genes”. On this point (if little else!) I would agree with Dawkin’s recognition of the concept of “memes”, his invented term to describe supposed cultural equivalents of the physical genes. As one set of UK authors has put it in the title of their book significant aspects of our human existence are “Not in our genes”¹⁰

And so we turn to the basic biology. This “heritable material” is of course the DNA, and a little background may go a long way to dispel some false fears and fiction about GM. When I taught secondary school Biology we were still allowed to ask pupils to scrape the inside of their cheek, smear the resulting “gum” onto a microscope slide, add a drop of stain, and view their own cells under the microscope. What they saw was similar to diagram 1. The bulk of the cell is made up of relatively amorphous “cell stuff” or “cytoplasm”. The darker staining nucleus was even less structured and ordered. Even after people began to investigate cell structure in the 1930’s at much greater resolutions by using beams of electron instead of beams of light, the nucleus, unlike the cytoplasm, remained relatively amorphous. (Diagram 2) That was mostly true, except for the period in which the cell when through cell division. Then, visible under the light microscope and in living tissues, thread like structures condensed within the nucleus, lined themselves up in pairs on the equator of the dividing cell, and then were separated so that each daughter cell received one complete set of these “chromosomes”. The number of such chromosomes is characteristic of the species involved. The garden pea has seven pairs, the fruit fly, four pairs, human beings twenty three pairs. “Karyograms” were produced by photographing dividing cells, cutting round the outline of the chromosomes, and pairing the sets of chromosome pictures. (Diagrams 3 & 4) Much could be ascertained from just this gross observation of chromosomes. Thus the karyogram in diagram 3 enables us to say that the individual concerned is female (two X chromosomes) and has Down’s Syndrome (three copies of chromosome 21). We can say something about her metabolism, her facial characteristics, her cognitive development and her personality: something but not everything!

For the early decades of the last century scientists barked with increasing accuracy up the wrong tree. Their mistake was understandable. The chromosomes fitted the evidence as being the structures that passed information about characteristics from one generation to the next. There is an enormous amount of information needed, even for the simplest of organisms. A complex coding material would be needed. Chromosomes have two major chemical components, namely proteins and nucleic acids. (Diagram 5) Both are polymers, long chain molecules build up from basic units, building blocks or “letters”. Proteins are built up from an alphabet of some 20 or so letters called amino acids. Nucleic acids are very dull having, for DNA, only 4 such building blocks. For decades attention focussed on the more promising and

¹⁰ Lewontin Rose et al. “Not in our genes”

more complex proteins. It was a seminal experiment by Hershey and Chase in 1945 that redirected research to the Nucleic acids (see hand out). Thereafter, looking in the right place, science proceeded apace.

Des-oxyribo-Nucleic Acid has the structure outlined in diagrams 6,7 & 8. With a backbone of 5-carbon sugar molecules linked to phosphate molecules there are organic bases sticking out from the sugar molecules. These bases are of two types, purines that are long and pyrimidines that are short. Each type can be present in two forms. Each base is an exact match in size and electrical charge, to its "complementary base". Watson and Crick were given their Nobel prize for interpreting X-ray diffraction patterns created by DNA as indicating that the molecule is in fact two strands, running in opposite directions, each a "mirror image" of the other in molecular terms. This double helix structure is directly linked to DNA's function, and has become an icon of the late twentieth century. The double strand can "unzip" and complementary bases will self-assemble on each original strand. This ability of biological systems to self-assemble from the molecular level upwards undermines the assertion so beloved of creationists that the likelihood of creating a fully formed human by random chance events is as low as that of a tornado creating a 747 as it sweeps through a junk-yard.

So DNA is a very long very thin molecule, made up of a string of letters, A,T,C, and G repeated in varying sequences. The statistics are staggering. In just one nucleus from a human cell the total DNA is about 1 metre long, yet only one millionth of a centimetre wide. There are something like three thousand million "base pairs" or sets of letters along the double helices that make up the human genome, or all the DNA in a human nucleus. Although the Human Genome Project has significantly reduced the estimated number of genes coded for by our DNA, there are probably some 30-80 thousand "genes" or lengths of DNA that code for one particular function or another. Modern molecular Biology may significantly alter the context but not the content of the Psalmists cry that "I am fearfully and wonderfully made"¹¹

Diagram 9, the chart of letters, may not look like it, but is the most exciting slide I will display today. It is the code cracked; the secret of DNA laid bare. It gives us the ability to "read" a sequence of DNA, to convert a string of ATC&G's into a sequence of amino acids, which then gives us the structure of a protein, and proteins are either the framework from which living things are built or else the controlling tools to build them. And the startling fact is that this code is virtually universal.¹² Whether from a pig, a pea plant or a pomegranate, the DNA code will be the same. Thus DNA from one place in nature should, in theory, code for the same product in another totally different setting.

As abstract conversation around this topic tends swiftly to become unintelligible, let me introduce a real, concrete example from not so recent science history.

If your pancreas stopped making a hormone, a hormone that is one of those protein compounds, then you would become a Type 1 diabetic. For over a century people have been able to control their blood sugar levels, despite being diabetic, through the injection of the hormone, insulin. The insulin was isolated and purified from pancreas material recovered from the cadavers of pigs or horses, but in a number of cases people began to become intolerant of

¹¹ Psaln 139: NKJV

¹² "virtually" because there are minor differences between some of the DNA code triplets for prokaryotic cells (mostly bacteria) and those for eukaryotic cells (organisms with a nuclear envelope)

porcine or equine insulin. This was primarily due to the human body detecting the non-human sections of the protein and rejecting it. If we could make "human insulin" then perhaps these problems could be overcome. That is exactly what was done in the late 1970's, and "humulin" (human insulin produced by genetically modified bacteria) was one of the first commercial products of GM to come on to the market. The procedure, in outline is relatively simple. (see diagram 10)

Firstly the human gene, the length of DNA that carries the message "make human insulin" needs to be identified, and located within the 3×10^9 base pairs that make up the human genome. "Molecular scissors" need to be available to cut out this length of human DNA. These were discovered in the late 1960's as scientists identified two types of enzyme that break down DNA. One type, the exo-nucleases, simply remove the terminal bases repeatedly, reducing DNA to its constituent bases. The more useful enzymes for GM do something quite different; they latch on to specific sections of DNA where a given sequence of a few bases occurs. At those points, and those points only, the endo-nuclease breaks the DNA double helix. Some enzymes break the chain straight across, others leave one or two of the specific sequence of bases unpaired. These "sticky ends" will be complementary on the ends produced by such an enzyme. If incubated with one particular endo-nuclease a length of DNA will be reduced, not to its constituent bases, but to a set of fragments, all of different lengths. If your DNA is different from mine, and it is, then your set of fragments will be different from my set of fragments, because of the different positions of the recognition sequences for that endo-nuclease through out my DNA and yours. This is the basis of "genetic fingerprinting". If the fragments are dragged through jelly by an electric potential difference (gel electrophoresis) the small fragments will move further than the large ones. After a given time we can stain the gel and reveal different "stripes" or bands of DNA fragments. Such patterns are reminiscent of the bar codes used by supermarkets to identify products. If bar codes are compared and found to be identical, then the probability that the DNA comes from different individuals is very low.

So the gene must be identified, cut out from the human genome, then isolated from the rest of the human DNA.

Cells generally destroy naked DNA; it is usually bad news, being associated with viral infection amongst other matters. To introduce the human insulin gene into a bacterium therefore needs a "Trojan horse" of some description. Such things exist, in fact the more people have looked for them the more they have found. Circles of DNA called plasmids spend their time joined into the genome of bacteria, and periodically "drop out" and infect other bacteria. By cutting the plasmid with the same endonuclease as the human DNA and then mixing the two forms of DNA, it is possible to create "recombinant DNA"

Made up of the plasmid plus the desired human gene. (see diagram 11) These can be introduced in to the suspension of bacteria and will hopefully be taken up and incorporated in to the bacterial genome. It is then necessary to identify and isolate those organisms in which the transferred gene is functioning. For bacteria this is normally done by including an antibiotic resistance "marker gene" and using a strain of bacteria that are antibiotic susceptible. Those bacteria that grow must then have taken up the plasmid, and should be producing insulin.

These processes were successfully carried out in 1973 using frog materials, and commercially applied to the example quoted in the late 70's. Humulin came on the market in 1982.

Lest the impression be given that all is plain sailing, it would be good to outline some of the difficulties involved, beyond those inherent in the process described! (see diagram 12) The first relates to regulator genes. Up to this point I have used a general idea of a gene as a length of DNA. One of the reasons that “Dolly” the sheep was so significant was that for the first time research had demonstrated in a mammal what scientists increasingly believed, but had not been able to prove, namely that all cells are “totipotent”. A moment’s thought will show that we all developed from one cell, a fertilized egg. All the information to provide the genetic input for another you or me is present in every cell. It is vital therefore that in most cells for most of the time most of the DNA is not allowed to function. There must therefore be sections of DNA whose function is not to code for proteins that are going to be produced (gut enzymes, hair, haemoglobin etc) but rather act as switches turning such “structural genes” on or off. Such regulator genes exist, but are not neatly packaged next to the structural gene they regulate, and thus a much greater length of donor DNA needs to be transferred than just the structural gene.

The second difficulty came as a great surprise in the 1970’s, when people discovered that one cannot assume that the information is in one complete sequence along a chromosome. One might begin to read “make hu...” and then read a nonsense sequence of two bases repeated hundreds of times, before returning to the structural gene. These “introns” interrupt the structural gene sequence, breaking it up in to a number of “exons” or executive sequences. Obviously this greatly lengthens the structural gene, and increases the chance that our random scissors will cut before the final exon has been reached.

The third problem arises from the random nature in which the vector or Trojan horse inserts the donor DNA. It is quite possible that the inserted section may disrupt an existing gene and cause damage to the recipient organism. Whether the “Beltsville pigs” were the result of such disruption to a developmental gene is, I believe, still a moot point.

The final difficulties relate to the flights of fancy that some have entertained with regard to human GE. These do not relate to obscure details of how the genome is constructed and functions, but rather relate to the way the world is. The first of these issues arises from the fact that Gregor Mendel was very lucky. You may remember that this Bavarian monk was the first to record the statistics relating to the characteristics of his garden pea plants. Thus he was able to follow and describe the patterns of inheritance for all higher organisms. However, he chose several characteristics that, like flower colour, for example, are controlled by just one allele. Thus the gene for flower colour is present in one of two forms, giving true breeding red or true breeding white flowered pea plants. But for many characteristics there are several genes involved in influencing a given characteristic. For such multifactorial characters several genes would have to be engineered into the recipient, increasing the risks of damage or failure with each additional transfer.

Secondly, for many of the interesting or contentious characteristics of human beings, agreeing a definition of the character is in itself problematic. Take intelligence, for example, where most are agreed that in absolute terms IQ tests test for the ability to perform on that particular IQ test! Similarly “criminality” is defined not in absolute but societal terms. The chance of identifying a length of DNA that is linked to such “fuzzy” characteristics is slim. To move from identification of a length of DNA to the definition of the causal relationship between a piece of DNA and such complex human behaviour is another giant leap. Whether one might then be able to engineer such hypothetical causal lengths of DNA to create, enhance or reduce the ill defined character

trait or behaviour is, at this stage, still in the realms of science fantasy rather than science fiction.

Thirdly there is a distinction to be made between genetic influences and genetic determinism. Some characteristics are genetically determined. Some of these are of major significance, for example Huntington's Disease, a progressive degenerative disease of the nervous system that leads to increasing loss of function, and eventually to coma and death. This is caused by a single gene, and a dominant gene at that. The presence of the gene will cause the disease in later life. For many recently reported genetic influences the matter is much less clear cut. A mutation in the BR CA 1 gene may significantly raise the chance of developing breast or ovarian cancer. It is rare for such a mutation to be purely deterministic.

The final of these "the way things are" issues is summarised on diagram 12. In technical language "genotype does not determine phenotype". In more accessible terms, the way an organism turns out, its appearance and function, or its phenotype, is a product of the interaction of its genes and its environment. Thus the average height of Japanese males has significantly increased over the past fifty years. This is due not to changes in their genotype, not to genetic evolution, but rather to changes in the environment (diet, medicine etc) that have allowed existing variety within the gene pool of Japanese males to be expressed. If this sounds like an upmarket version of the Nature versus nurture debate, it is!

I trust this whistle stop tour through the realm of molecular biology has provided a bedrock of fact from which to examine some of the various reactions to this novel technology. GM is possible, and it has developed rapidly since the collective pause that scientists imposed upon themselves at Asilomar in 1977. The responses to these developments has been mixed, and it is to this variety of response that we now turn.

Section 2: Some GM Fictions challenged

From being hailed as the hope for the future of world food production and the solution to all of humanity's medical ills, to being reviled as destroying biodiversity, oppressing the poor and reviving the horrors of Nazi eugenics, the responses to GM have been often extreme, and dramatic. There are significant issues to be addressed around the applications of the new biology, but some of the anxieties are, I believe, unfounded or misplaced.

One example which illustrates the power of media hyperbole is that of GM foodstuffs in the UK. In February 1996 the supermarket chains Sainsbury and Safeway both introduced for sale the tomato puree from tomatoes genetically modified by Zeneca to ripen but not soften or over-ripen on the vine.¹³ This GM product was clearly labelled as such, the supermarkets carried background information leaflets, and the puree sold well. The area of GM soya beans grown in the USA increased in 1997 fivefold, and producers claimed it was impractical to segregate GM from non-GM beans during distribution. Given the very widespread use of soya protein to raise protein content in processed foods, the material was introduced widely in an enormous range of foodstuffs during 1998. In the USA there was little reaction, but in the UK a media furore erupted in early 1999. "Frankenstein foods" were reviled as the products of irresponsible

¹³ Bruce & Bruce p51,2 &161,2

scientists, pressure grew to go “GM-free” and in due course both the Supermarkets withdrew the GM tomato puree. The paste was, up to withdrawal, still selling well.

What are we to make of this? Firstly we should note that for the foodstuffs involved, the product from GM crop plants is virtually indistinguishable from non-GM varieties. The tomato involved, unlike the commercially unsuccessful “Flavr Savr™” produced by Calgene (and later bought up by Monsanto), was not based on an “antisense” gene, but rather on the introduction of a repressor gene that inhibited the use of the gene for and therefore the production of, the enzyme that causes tomatoes to go soft after ripening. The soya involved had been engineered to be resistant to one particular herbicide, and the “product” of the gene involved is a digestible protein, difficult to detect in the milled and processed soya flour. But for the highly contentious and questionable case of Dr Pushtai’s research on GM lectin-rich potatoes, there has been no major research to indicate that these GM food products are unsafe. Yet the mistrust in “scientific experts” engendered by the mis-management of BSE in the 1980’s prepared the way for a popular rejection of GM foods. There is, as several commentators have indicated, an issue around labelling and information¹⁴. The introduction of GM soya necessarily had an impact on a much greater proportion of consumers than a specialist product like tomato paste. Little thought or effort was given to inform the public until the producers were doing so defensively. It is ironic that as a result of campaigners trumpeting “freedom of choice” for those objecting to GM foods those who had no objections are now denied the choice to buy the tomato paste involved!

The issue was made more complex by the associated issue of the unknown environmental impact of the GM crops from which GM foods are produced. As many will know three years of field trials of GM crops are coming to a close in the UK. Those campaigning against the use of GM crops and these trials have gained considerable media attention through carefully orchestrated “eco-terrorism” destroying the crops at various trial sites. In a global setting a curiously insular approach is being taken, which will, I believe, be shown to be mistaken. For five years now in the USA, in Canada, in Asia and in Latin America there has been widespread commercial cultivation of GM soya and Oil Seed Rape (“canola” to non-UK residents). To date there has been little evidence reported of concomitant widespread ecological impact. One wonders how long the eco-terrorist can continue to cry “wolf”.

As before, I would like to illustrate some of the principles involved by considering a specific example. In 1993 Prof Dean Hamer published a tentative conclusion based on a statistically small sample of men. Some 40 or so males were involved, half of whom identified themselves as homosexual in orientation, half as heterosexual. Samples of DNA were taken, and the X chromosomes analysed as described above and the resulting gel plate patterns compared. In all 18 homosexuals there was a stripe on the gel plate present in a position where there was none in the 18 heterosexual men. This indicated the presence of a DNA fragment. Within days of the scientific publication the tabloid press carried banner headlines “Gay gene discovered”. Homosexual males sent copies of the article to parents as evidence that it was the parents who were to blame for the child’s orientation. In the years following this unhappy period no scientist has been able to replicate the experiment. In 1999 a Canadian study based on homosexual brothers directly challenged the results from Hamer’s paper. Published at a statistical level of significance of 99% it would appear that the small scale of the survey allowed a false conclusion to be drawn that the fragment of DNA was correlated with the sexual orientation of the men.

¹⁴ Bruce & Bruce p180 et al

Be that as it may, and it is vital caveat to subsequent discussion, the mis-use of the published data by the mass media is an ideal case study. For clarity of expression in what follows I will write as if the now challenged result was valid. What had supposedly been identified was a length of DNA. What was proclaimed in the less reputable media was that “a gene for homosexuality” had been discovered. The string of assumptions is breathtaking. It had been demonstrated that there was a *correlation* with self-professed sexual orientation: any *causal* link had not been demonstrated, i.e. that the length of DNA did, in some way, influence sexual orientation. If such a causal link were to be established it is yet another assumption that such a length of DNA was deterministic in its effect, i.e. that the presence of the gene necessarily causes homosexual orientation. Finally, even if causal and deterministic effects were to be shown, “lifestyle”, family relationships and interpersonal relationships are also subject to personal choice. The desire for public interest in science and in one’s own research also tempts scientists at least to oversimplify, and at worst to sensationalise their results. As an example of the difficulty of reasoned debate in media driven by the sound bite this is a frustratingly clear cut. The underlying issues of genetic determinism, and of single “genes for” any given characteristic, however complex, are also evident.

Another fiction arose from the international attention focussed in 1997 on the cloned sheep, Dolly. For the first time cloning had been successful for a mammal. The nucleus from a mammary gland cell was transferred into an enucleated sheep’s egg. Of over 200 such transfers, only Dolly came to birth and developed into a healthy lamb. As well as a large proportion of embryos that spontaneously aborted, there were a number that developed abnormally and a few with birth defects. The potential application to produce genetically standardised experimental animals was highlighted by Prof Wilmut of the Roslin Institute at the time and in subsequent publications.¹⁵ The mass media however seized on the implications of potential cloning of another mammal, human beings. Much was made of the fear that some unscrupulous dictator, usually in the demonised form of Saddam Hussein, who could by the application of this technique “make copies of himself”. The fiction of genetic determinism and reductionism is prominent here. Even if we put to one side the ethical issues raised by a success rate of less than 1%, and the risk to the children born with the various defects present in Dolly’s siblings, such a cloning project could never “copy” an adult in the way being portrayed. The key issue is the link between phenotype and genotype. A cloned person grows up some decades after the adult nuclear donor. The environment is significantly different. Just as identical twins (“natural clones”) are not the same person, although similar in many ways, so cloned individuals would be similar but different from the adult from whom they are derived. I should note here that my point is to expose the false assumption behind the media hype. The ethical issues around cloning of humans are an entirely different question.¹⁶

To conclude this section of my paper I would like to outline some areas of concern that I would argue are worthy of attention.

The first of these relates to GM crops and world food supply. If UN statistics are correct the problem of exponential growth of population but geometric growth of food supply will increase the pressures on agricultural productivity over the next few decades. The transnational agrochemical industries have promoted GM crops as the potential solution to this crisis. This

¹⁵ Briuce & Bruce p71ff

¹⁶ See for example Messer

needs to be carefully challenged. There is hope that crops may be genetically modified to enhance their nutritional content, to increase the range of environments in which they may not only survive but also be productive. The “golden rice” variety with enhanced Vitamin A is one well-publicised potential example.

However, the commercial pressures on the development of such crops indicate that it will be high yielding commercially lucrative varieties of western crops that are developed and marketed. It is notable that the major crops with GM varieties in production or on trial are soya, maize, tobacco, cotton, oil seed rape and rice. With the notable exception of the latter, these are not the crops of choice for sub-Saharan Africa or India. This is not so much an issue of genetics but of economics and world capitalism.

Similarly the kudos associated with high tech solutions militates in favour of the expensive development of inappropriate GM techniques in some developing countries, mirroring the inappropriate nature of some of the developments in the developed countries. There may well be low tech solutions that give a much higher and more sustainable return than GM crops. Mulching with organic matter produced a dramatic change in the productivity of one African valley, with little input beyond agricultural education workers, and time spent with local farmers¹⁷. Christians will see links to incarnational models for development here, as opposed to distant abstract high tech solutions imported from outside a situation.

The final point to make about this issue was well put by the UK Minister for Overseas Development, Claire Short. She rightly indicated that the world currently produces more than enough food for every human being to receive an adequate diet, and yet people are dying of starvation. The problems are of political and economic nature. One might add that at the same time as some starve, others suffer medical problems linked to obesity. The issues here are of lifestyle, self-restraint and, ultimately, of love for neighbour.

A second set of issues around GM crops relates to their potential as tools to exacerbate the financial inequalities between nations and groups. The issue of patenting GM crops is a thorny one. Seed companies have always had Plant Breeder’s Rights enshrined in law to allow them to regain the development costs and generate profit from the sale of their varieties. Patent Law strengthens the control possible over the farmer, not so much by restricting the retention of harvested seed for a second year’s sowing without a second year’s purchase of seed, but by restrictive contracts linking farmer to herbicide and seed supplier for a number of years. Once again I would contend that the issue is not one of genetics but of commercial practice. To tackle the latter through the media’s appetite for horror stories about the former is, I would contend, both irresponsible, and ultimately self-defeating. The purported development of “Terminator gene” technology and the response of some Christian campaign groups is a case in point.¹⁸

A final set of issues that I would identify as substantive are those relating to proposed application of these techniques to human beings. I have already indicated cloning as an area of concern. Another is the growth in both popular and scientific communities of assumed genetic determinism, and assumed reductionist approaches to human beings. The former is illustrated by the Stephen Mobley case in the USA, and the so-called “genetic defence”; the latter by some

¹⁷ *The Biologist* (1998) XX

¹⁸ *Selling suicide* Christian Aid report

of the responses to our ability to “screen” of the presence of certain genes or their genetic markers in both embryos and adults.

Stephen Mobley was arrested and convicted of murdering John Collins, who worked for Domino Pizza company running his own pizza delivery business. The fact that Mobley shot Collins was not in dispute. When it came to appealing the death penalty imposed by the court, Mobley’s lawyers Taylor & Summer, chose to suggest that the sentence be commuted to life imprisonment because of a genetic predisposition to violent and anti-social behaviour. A number of examples were cited from Mobley’s male relatives to indicate that several had been in trouble for violent or anti-social acts. The case received widespread publicity, and the defence went in to abeyance in the late 1990’s. This issue of genes determining behaviour, however is still live.

There is evidence from the animal kingdom that some behaviours can be not only genetically influenced but also genetically determined. This ranges from the “hybrid vigour” in success rates for training guide dogs for the blind (cross bred Alsatian-Labradors do particularly well) through the pattern of song sung by chaffinch chicks reared in isolation to the “instinctive behaviour” of dancing honeybees and the mating displays of fish and birds. Increasing evidence is accumulating that human behaviours may well have genetic influences. As is often the case, progress is first made through examining those with diseases or abnormalities, and the complex of mental health issues around schizophrenia do seem clearly to have a genetic component. The move from the fact that genes have an influence on human behaviour to the implication that genes determine [all] human behaviour is a major one, and one that many scientists challenge as invalid. A philosophy that raises the influence of genes to being all determining is both disturbing and wrong. That genetics will continue to deliver knowledge, power and the ability to influence creation for good and ill should not deter the Church from challenging over blown claims and ideologically driven assertions.

A final issue is the capacity for expensive GM techniques to draw significant sums of money away from less “glamorous” yet more cost effective treatments. The potential benefits of gene therapy would only become available in the long term, and yet significant funding is available to GM projects whilst health promotion schemes struggle with under funding.

There is much we have not touched upon. The whole range of ethical issues around assisted reproduction, the details of animal experimentation, potential ecological impact of GMOs and xeno-transplantation may be raised in our discussions. The breadth of the subject matter is daunting! It is time at last to turn to some theological reflection on what has been outlined so far.

Section 3: Faith responding to GM

There is a wide variety of responses to this technology, ranging from the absolutist rejection of Fox through varying degrees of scepticism to careful optimism.

Fox argues that there is a *telos* or end inherent in each species that is violated by transgenesis.¹⁹ Given evolution by natural selection and the influence of humans through selective breeding Fox’s stance seems indefensible. The extent to which writers oppose GM of non-human species relates in part to their assessment of the human condition. Thus the trenchantly

¹⁹ Fox M 1990 p31-51 in Wheale & McNally (eds) *The Biorevolution Cornucopia or Pandora’s box?*

negative Thompson thunders against GM: "... scientists [are saying] that we can do better than nature (or as Christians would say, better than God.)"²⁰ His approach is conditioned by a traditional doctrine of the depravity of man (sic) and a pneumatology that sees the Church as at least the main, if not the only, locus of the work of the regenerative and redemptive Spirit of God. As the final paragraphs of this section will indicate I would take issue with such an understanding of God's ways in the world, drawing on some of the Methodist scholars of the late 20th century.

Rahner²¹, unlike Thompson, argues that we have been manipulating humanity for a much longer period than the last two decades of genetic engineering might suggest, and that the change involved in applying the new technology is one of degree rather than substance. The process of the genetic manipulation of human cells would thus be seen not as a blasphemous usurping of God's role as creator but rather a continuing struggle to use responsibly the freedom granted to humanity. Reiss & Straughan²² review a range of theological responses and locate themselves as optimistically cautious.

The use of human power to "dominate" creation through technology has been the source of debate for centuries. The ecological movement of the last century has seen Christians affirm the responsibility of humankind to God to care for god's creation. In general terms there is little debate when texts such as Ps 24:1 are enunciated; the interpretation of how the ultimate ownership of creation by the creator is cashed out in practice leads to fractious debate. The fault lines through the Christian community revealed by such debate on orthopraxis tend in recent decades to run less between denominations and more between theological perspectives, a point that we may well illustrate during our time together at this Institute.

It would seem that one of the crucial starting points is the interpretation of God's role in creation & redemption, and God's partnership with, use of, or independence of human beings in that process of redemption. As Schrotten has observed²³ when humans appropriately "play God" and act as God's agents on earth, the issue is "which god do they play?" Such language is metaphor, and has the characteristics outlined by McFague.²⁴ The traditional doctrinal meta-narrative of Christianity is, I would contend similarly metaphorical in its characteristic four "moves", namely:

1. Perfect creation includes the morally free primordial humans.
2. Rebellious disobedience on their behalf causes a cataclysmic Fall, either in the "heavenly realms" by Lucifer or on earth. This Fall has wide reaching effects on the whole created order, and is in part used to defend God in various forms of Theodicy.
3. Jesus the Christ, comes as Redeemer, establishing and signifying the power and presence of God's kingdom, and dying to atone for the sins of the world. Through

²⁰ Thompson B (86) "The ethics of Genetic engineering" *Journal of the Alabama Christian School of religion* p9-17

²¹ Rahner (65) *The Experiment with Man Theological Investigations Vol9*

²² Reiss & Straughan (96) *Improving nature*

²³ Schrotten (1991) in discussions on *Genetic Engineering* held at Luton Industrial College. He was when commenting on the use by the authors of a *secular* report to the government of the Netherlands of the phrase "playing God".

²⁴ Macfague S (??) *Models of God*

Jesus' resurrection and ascension the Spirit of God is released in to the Church and the world in a novel way and the redemptive work of the Kingdom progresses.

4. The final move is the Eschaton, when God brings redemption and judgement to completion.

This outline is of necessity something of a caricature, but is probably unremarkable in outlining received tradition. Despite Darwin and 150 years of Christian reflection this framework is still widely used with little indication of any metaphorical reinterpretation.²⁵ The need to reassess this framework is pressing if the Church is to communicate with the scientific community. There never was a historical state of perfection from which all creation "fell". Such a fall of all creatures can no longer be reasonably ascribed to the action of the primordial couple. The evolving nature of the universe and of life on this planet requires us to reassess our language, particularly given the that this year's title and theme can be seen to flow the framework rehearsed above. If the Christian story as outlined is to be regarded as metaphorical, we must be explicit about our approach. As Hick puts it "such language is valid as metaphor, but becomes deprived of its symbolic power and reduced to mere factual misstatement if it is understood literally."²⁶ I am no scholar of Wesleyan history, but given his cultural conditioning, the Sermons of John Wesley seem to assume a literalism for this language of salvation and redemption that militates against their use in this area of study. General emphases and doctrinal perspectives are helpful, but only in the room for manoeuvre that they allow.

If the world is not as it should be, as summed up in the metaphor of The Fall, and if Christ's followers are called to work to set things right, then technology can be a servant of the Kingdom. Wesley's openness to and enthusiasm for experimental uses of electricity indicate an optimistic approach to what was a novel technology. This is consistent with Wesley's concept of prevenient grace and general revelation. Unless there is some inherent flaw or evil inextricably linked to GM as a technique, it is reasonable to propose that Methodists might choose to take an optimistic view of the technology and its potential for good, even if this is tempered by caution driven by our understanding of human nature as in need of redemption and sanctification.

One of the challenges for the Church in a plural society is how best to work for the furtherance of the Kingdom? This does of course beg the prior question of identifying and agreeing "kingdom values" as applied to a novel technology, The analysis of the relationship between "Christ & Culture" by Neibuhr²⁷ provides a variety of patterns, but little guidance to choose between them.

Thus although many if not most Christians would argue that the Church's voice must be distinctive, what she should say on any given issue is hotly debated. There are those that argue that the technology on which GM is based is contrary to God's natural order, and that the response of faith should be the prophetic voice of rejection.²⁸ In this they would be comfortable with Neibuhr's model of "Christ against culture."

²⁵ Walters AM (85) Creation regained ch3

The Catechism of the Catholic Church: para 390, 601,613-617, 400

²⁶ Hick J Evil & the God of love p208

²⁷ R Neibuhr (51) Christ & culture

²⁸ Fox, Dixon, Cameron

Many others see nothing objectionable in the technology as such, but argue that Christ needs to transform a self-serving and exploitative culture so that its use of the technology furthers the ends of the kingdom. In this the use of GM could become another tool for good. Thus as a way of improving the yield and nutritional value, or increasing the tolerance of crops to drought or heavy metals, and thereby bringing marginal land into productive use, GM enables human beings to continue God's creative work begun in evolution and continued through selective breeding. Similarly the production of pharmaceuticals by transgenic animals, or of plastics by transgenic plants would similarly be seen as legitimate applications of our God given and Spirit led discoveries. The painful tedium of repeated dialysis may in the future be relieved through the use of transplants of organs from transgenic pigs genetically modified to carry human immune system recognition factors. From the positive perspective this would be seen as use of human creativity to further kingdom goals rather than presumptuous meddling with God's good created order.

The fallen, finite and fallible nature of human beings requires a vigilant regulatory system, the corrective of a community that includes those different from ourselves, the acceptance of risk, and a limited precautionary approach. This reflects the doctrine of original sin, describing as it does the existential condition of humankind, alienated from God and one another until responsive to the grace of God.

The danger for the Church in Western society is either to accommodate itself to the secular assumptions and outlook of the society in which it is set, or to adopt such a critical stance that its voice is respectfully heard and then marginalized by those with the power to affect regulation and legislation. In debates around animal rights in the 1990's in the UK these two poles are perhaps exemplified by the Church of England's stance on Hunting and the approach of Linzey to the response of the Churches to UK government's consultation on GM of farm animals.²⁹

Turning from GM of non-human creation to the potential for applying the fruits of the new biology to human beings, we find two areas of concern. The first is how we understand and view ourselves, the second how we seek to modify ourselves in the light of this. Much has been written of human self-manipulation, mostly being highly critical of any such attempts. The usual line of argument is based either on deontological ethics³⁰ or on the consequences of damaging germ line cells and therefore influencing for ill future generations.³¹ One line of approach is to question the model of "perfection" that is assumed by those seeking to use the novel technology. Where there is disease or genetic damage the model used is of the undamaged state. For Cystic Fibrosis, Huntington's Disease, Thalassaemia and the host of other genetic disorders caused by point mutation, this model seems straightforward, and the justification, if needed would be as follows. All is not as it should be in the world. Some things occur that are

²⁹ Process of responding from Methodists Anglicans Quakers & URC to the initial consultation leading to the publication of "The Banner Report" MAFF (95) Report of the committee to consider the ethical implications of emerging technologies in the breeding of farm animals. Linzey attended the plenary discussion, effectively argued for a more extreme and negative phraseology than the group would have wanted, and then, after the draft submission was produced dissociated himself from the submission and tendered his own, absolutist rejection of GM of farm animals.

³⁰ Ramsey Fabricated Man

Curran: Politics medicine & Christian ethics p164-200

³¹ The Clothier report on gene therapy has a weak and consequentialist approach to underpin a temporary ban on human germ line GM

not as God wills, such as disease. We see God in Jesus tackling such wrongness through his healing ministry. To work in keeping with this ministry through medicine is seen as unremarkable; to do so through gene therapy applied to the somatic cells of a patient is directly equivalent.

All is not quite that simple however. In sickle cell anaemia the haemoglobin in red blood cells is produced from a gene with a point mutation that has two effects. It causes the red blood cells to collapse into the characteristic sickle shape, with the consequent deleterious effects on the capillary network in the body. It also confers resistance to the *Plasmodium* parasite that causes malaria. Thus where malaria is prevalent the human population carries startlingly high frequencies of the damaged gene, due to the advantage gained by individuals who are heterozygous. Given this simple and well known example of the ambiguous nature of mutation, we would do well to be cautious in judging that one gene is “normal” and desirable as compared to another that is “abnormal” and to be eliminated.

A Christian anthropology challenges these cultural assumptions at a deeper level. Given the Trinitarian understanding of the God in whose image we believe all human beings to be made, any understanding of human beings must be of them in community. The model of “perfection” in secular (and Christian) Western culture is often one of the strong individual, able to be independent of others and, through strength, to provide help for others. I believe there to be an urgent need to redefine a Christian view of the perfect person, through use of Jesus as the exemplar. Here is one who depended on rich women for his upkeep during his itinerant ministry, who relied on some one else to provide the donkey for his entry into Jerusalem on Palm Sunday and who relied on the generosity of one disciple in providing the upper room and on the work of others to prepare the last supper. Jesus asked for the help of his trusted friends in facing the dark hours in Gethsemane, needed Simon of Cyrene to carry his cross, and had to use Joseph’s tomb. We need to hear again from the L’Arche communities Jean Vanier’s observation that the strong need the weak as much as the weak need the strong.

Human growth hormone, the product of GM techniques, is available to redress the deficiency in some individuals that causes achondroplasia. Some parents have sought to buy courses of the hormone for injection into their children who fall within the normal height range, in an attempt to increase their height. The assumption that successful people are tall, slim (and white-skinned) reflects the prejudice of our age, and needs explicitly to be challenged.

A number of Christian traditions have provided fruitful avenues for exploration with regard to the new genetics, in particular existential theology and process theology.

Macquarrie develops the existential philosophy of Heidegger and develops concepts that are directly applicable to the issues around human genetics and provide a challenge to deterministic interpretations. In his analysis of human existence he draws attention to the polarities of *possibility* and *facticity*. Whilst affirming that each human “stands before potentialities for being and for action, and ... responsibly decides among them and commits ... to some definite policy” he is “careful to use such qualifying expressions as ‘within limits’ and ‘to some extent’” because human beings never face “unrestricted possibility”. “At the opposite pole of existence from possibility is facticity, and this includes all the ‘givens’ of any particular existence”.³² He goes

³² Macquarrie J (1966) Principles of Christian theology p56

on to mention heredity in passing, and it would seem that this is a most helpful analysis of the human situation.

The facticity of our genome limits and restricts the possibilities open to us; the possibilities however remain open. In that openness lies the grace of God for response and action in God's ways; there too lies the possibility to reject God's ways. For example, genes may determine that a person has early onset Parkinson's Disease; part of the facticity of that person's existence at the moment of diagnosis. The response may be, as in the case of Michael J Fox, so positive that he can say that any attempt magically to remove that diagnosis and expunge the past decade he has spent living with the disease is to be rejected.³³ Conversely Police forces in the USA that refused to employ a healthy police academy graduate until he had undergone the test for the Huntingdon's gene (he had HD in his family history) were denying the possibilities still open to him, even if he did carry the gene. This analysis is also allows a more positive assessment of mistakes, errors or mutations. The vast majority of these are deleterious. However, in the providence of God, some of the copying errors in DNA and chromosome replication open up possibilities that were previously absent. This perspective of grace opening up possibilities for change is implicit within Wiltshire's paper on "Science and Theology from an Armenian perspective."³⁴

In a similar manner, the strand of Christian theology that has been developed from the process philosophy of Whitehead and Harshorne is for some a particularly appropriate model for interpreting the world of evolutionary Biology. The process of concretisation, with the openness to the future limited by the immediate chain of past events leading to the decision for the present state of the actual entity, seems a most fruitful interpretation of the situation that coheres in active cells. There is growing evidence that the static models used to provide simple explanations of DNA structure and function are as misleading as the space filling models of atoms used to build grade school models of molecules. As an aid they are a helpful first step, but taken as a description of "the way things really are" they are too mechanical, too fixed. The indications are that the genome of any organism is rather more plastic, and more fluid than the models normally used to interpret it. "Jumping genes" horizontal gene transfer and spontaneous mutations (point, or chromosomal) all indicate this. The mechanical language of code, of engineering, and the like arises from, reinforces and forms thought patterns and approaches that assume a deceptively straightforward static model.

Theology could provide a helpful perspective here, as most of our language is, we trust, providing models of ultimate reality. If the relationship with scientists is one of partnership, as pursued by the Church of Scotland's Science Religion and Technology Project, then as critical friend we would have much to offer. As our Church history shows, human beings too readily substitute the model for the reality. Philosophers of science and science historians may readily accept that models are not reality; practitioners may need reminding.

One of the challenges tackled by the process theologians is that of God's relationship with and influence upon the world. Emphasis on God's transcendence easily leads to the deistic tendencies of the 19th century. These are challenged by the model of God's immanent presence described in pan-en-theism. Reaction to this approach has been mixed, with

³³ MJ Fox (2002) Lucky man

³⁴ Wiltshire C (88) in Jones IH and Wilson KB (ed) Freedom and grace

Peacocke being somewhat sceptical³⁵ and Ward enthusiastic³⁶, and Moltmann highly critical³⁷. Nevertheless the description of God intimately involved with and responsive to the creation fits well with many of the scriptural models of God's relationship with His world. The acknowledgement that, in relation to the created order, even God does not have unlimited freedom seems better to fit our experience than the contortions undergone by some in developing theodicies that begin with God's omnipotence understood as broadly as possible. Macquarrie, in expounding existential theology and omnipotence indicates that "God's omnipotence means that he himself, not any factual situation, is the source and also the horizon of all possibilities." The pan-psychic models of reality drawn from Whitehead seek to locate the freedom of creation in the freedom granted by God to actual entities, which are "self-determining beings".³⁸ The influence of God on evolution (amongst other processes in the universe) is proposed as being through God's non-coercive influence or lure. The use of the language of "lure" and "persuasion" by God of an actual entity, which then comes to a "final decision" which involves a creative evaluation of the various factors involved, is drawn from Whitehead's own work.³⁹

As Pailin indicates, this psychical description of reality as a whole "seems to be either meaningless, misleading or deeply obscure."⁴⁰ What he goes on to propose in place of this initially appealing but ultimately unsatisfying model ascribes less to God's direct influence and more to the interaction of chance and the physical laws of the universe. He quotes Hartshorne describing mutations in the language of "chance encounters between particles (such as cosmic rays) and the genes", and Birch's description of evolutionary change as the product of "random mutations". He then goes on to describe God's creative activity as "ensuring that the constituents of reality belong to a process which combines stability with an appropriate degree of openness to novelty, and which contains an intrinsic urge towards combination in increasingly complex patterns." God is not to be thought of as attempting to direct ... the evolutionary process to develop any specific forms."⁴¹ Whilst acknowledging the radical nature of this re-evaluation of God's influence on creation, Pailin asserts that his proposed scheme "can justifiably claim to be an understanding which is biologically tenable, metaphysically significant, theistically important, and rationally credible." It also is incompatible with the pietistic language of a God who "holds the future" and who says "I know the plans I have for you".

To move towards concluding, I would like to return to the question of general revelation and the resources for recognising and assessing God's judgment on GM as a tool for establishing a "new creation".

In the context of interfaith dialogue, Cracknell has developed an inclusive Christology that draws on the concept of the *logos* used in the prologue of John's gospel. Drawing on Pittenger, Bailie and Hanson, Cracknell reads John 14:6 not as exclusive, but as inclusive. He does this by

³⁵ Peacocke A () *Creation and the world of science*

³⁶ Ward K (1999) *God and the new millennium*.

³⁷ Moltmann J () *God in creation*

³⁸ Griffin D R (1991) *Evil revisited* p97, where he succinctly outlines six propositions on which his process theodicy rests. It seems to me that he resolves the issue of evil by relinquishing traditional concepts of all-determining divine omnipotence.

³⁹ Whitehead A.N. (78) *Process and Reality: an essay in cosmology* quoted by Pailin as listed below, p147

⁴⁰ Pailin D.A. () *God and the processes of reality*. P148

⁴¹ *Ibid* p152-3

arguing that the one who is speaking in John's gospel is the incarnate "Eternal Word, consubstantial with the Father, who dwelt in Jesus"⁴². Reviewing the theme of "The Way" in other world religious traditions, Cracknell explicitly refutes criticism that his purpose is "to equate the inequitable" by implying common meaning to salvation, grace spirit etc in different world traditions. However he does "affirm that what the Fourth Gospel is pointing to ... is continuity with other religious traditions as well as to a certain discontinuity."⁴³ He then concludes that section of his chapter with words that I have echoed already in asserting that creation is a valid resource for Christian theology. "The longings and aspirations of humanity are to be recognised. They reflect the universal condition of all human beings, created in and through the eternal Word of God. Since they are created in and through this *Logos* it can be no surprise that they have so often sought to understand themselves as following a way which reflects the way of God in the created order.such understandings of the human situation are in the profoundest sense 'true to reality' for 'the whole seeming maze of history in nature and in man, the tumultuous movement of the world in progress, has running through it one supreme dominating way.'"⁴⁴

As I indicated in the introduction, and reiterate here lest there be any misunderstanding, such "longings and aspirations", such "ways of understanding" are not to be granted blanket acceptance. As Cracknell concludes, these "ways" beyond the Christian community, as well as the ways proposed and embraced within it, need to be tested against the Way revealed in the path Jesus followed – "the path of rejection and suffering, of abandonment and death." "... ways which have not discerned somehow the mystery of suffering and the mystery of love are 'untrue to reality' whatever label they carry."⁴⁵ These words, grounded as they are in a characteristically generous acknowledgement of, and trust in the grace of God, are pertinent to our discussion of attitudes to GM as an instrument for new creation. The attempts to use GM techniques to continue the domination of nature in intensive agriculture, through monoculture, through ever increasing demands on the yield from land and animals; these ways are 'untrue to reality' and need to be challenged. Our exegesis of Genesis 1:26 & 28 needs to be controlled by our understanding of the "domination" exercised by God over evil through Jesus Christ. This may be deeply subversive not only of some non-Christian traditions but also of some versions of Christianity.

Conclusion

In responding to the novel technologies flowing from the new biology we need first to be informed of the underlying science and also of the assumptions regarding the nature of human beings and of creation. Given that this technology is perhaps in its late adolescence, we may make allowances for presumptuous claims that it may have difficulty ever delivering⁴⁶. We may also need wisdom to discern when this technology has crossed a significant threshold. All novel technologies hold the risk of the unknown. As knowledge develops each one moves from the time when it is appropriate for Christians to call for responsible action, implying caution, to the time when it becomes appropriate to stress the responsibility to act, implying approval. Other

⁴² Cracknell K (86) *Towards a new relationship*. P78 quoting (with approval) Pittenger

⁴³ *ibid* p84

⁴⁴ *ibid* p85. The quotation is from FJA Hort on John's gospel.

⁴⁵ *ibid*

⁴⁶ I am thinking of the bumper sticker that reads "Give a teenager a job - while he still knows everything!"

than germ line GM on humans I would suggest that there is little that Christians should find objectionable *a priori* in the techniques of GM. There are causes for grave concern, particularly given the arrogant hubris of some scientists regarding human cloning, and the commercial pressures driving the development of GM crops. There is also ground for hope, for God has structured the world in such a way that “mistakes” in the form of mutations can become the raw material for producing emerging complexity and self-conscious beings. As such we are capable of discerning God’s ambiguous presence within and beyond creation and respond to this with love for God and for neighbour. We also have the gift of reason, and the ability to join with God in setting right some of the aspects of this world that are undeniably wrong. In doing so we will make mistakes; God may find ways of using even those mistakes in the development of new creations on the way to The New Creation. In the optimism of faith we may labour to discern right action and seek strength to challenge fallen humanity where it is chasing after idols. We may also simultaneously rely on the grace of God for those times when finitude and fallibility lead humanity in to error. Is it naïve or faithful to our traditions to conclude with John Wesley that “The best of all is – God is with us”?

Selected milestones in the history of genetic engineering

Date	Event and / or comment
Pre-history	Domestication and early "selection" of crop plant varieties generated differences between wild and cultivated types.
1400's	Dutch cattle renowned for their size and milk yield.
1797	F.K. Achard improves Silesian stock beet (ancestral sugar beet)
1800's	European selective breeding increases animal size, milk yield and meat development in cattle.
1812	Lorain consciously mixes two types of maize: obtains in later generations a mixture with improved yield from one type and desirable characteristics of the other.
1859	G. Mendel publishes work on the pattern of inheritance in peas. (Rediscovered in 1900 by de Vries)
1903	Heritable factors are presumed to be located on chromosomes.
1909	W.L. Johannsen coins the term "gene".
1935°	Speman proposes the idea of nuclear transplants (ie clones)
1941	Beadle and Tatum suggest "One gene - one enzyme" hypothesis. (Nobel Prize 1958)
1952	Hershey and Chase show that DNA of virus and not protein enters the cell.

- 1953 ° Briggs & King transplant frog nucleus to frog egg which does not develop
- 1953 Watson & Crick propose double helix model for DNA structure
- 1961 Jacob & Monod demonstrate "regulator genes". Nobel Prize 1965
- 1970 Gurdon transplants frog nucleus to egg: a tadpole develops, but does not feed.
- 1973 Cohen et al. First recombinant DNA transfer: Toad rRNA to E. coli.
- 1977 International conference at Asilomar, California: scientists impose a moratorium on recombinant DNA experiments pending risk assessments and regulation.
- 1981 ° Illmensee & Hoppe claim to have cloned 3 mice by embryo nuclear transfer.
- 1982 Genetically engineered bacteria produce "human" insulin.
- 1983 ° McGrath & Solter refute the results of Illmensee & Hoppe's cloning experiments.
- 1984 ° McG. & S. discover that mouse embryos cannot be cloned after the 2 cell stage.
- Willadsen grows several sheep embryos from cells separated from one blastomere (embryo)
- These sheep are clones of each other, not of an adult sheep.
- 1986 Palmiter and Brinster: rat growth hormone gene transferred to mouse embryos. Transgenic "supermice" produced.
- 1987 "Beltsville Pigs": an attempt to repeat mouse work with pigs produces severe deleterious effects.
- 1988 US Patent Office issues the first patent on a genetically engineered higher organism: the "oncomouse" which automatically develops tumors.
- 1989 Identification and replication of the Cystic Fibrosis gene raises hopes of gene therapy to cure this inherited disease.
- 1991 C. Ventor applies for US patents on human DNA sequences (of unknown function.)
- 1992 The "Clothier Report" approves genetic engineering on humans restricting it to somatic (body) cells.
- 1993 Gene Therapy experiments using retro-virus as vector to carry CF gene into the lungs begin & are suspended in the USA (doubts over adverse side effects)
- 1994 Experiments in UK use liposomes to deliver CF gene to nasal membranes.
- 1996 ° "Megan" first mammal clone by transplantation of sheep embryo nucleus
- 1997 ° "Dolly" first successful clone of adult mammal; sheep mammary gland nucleus used.
- 1998 Dolly gives birth through normal sexual reproduction.
(continued overleaf)

- 1999 Tsien et al publish discovery of "Intelligence gene" in mouse
- 2000 Dolly gives birth to live lambs, debate over "aging" of their chromosomes
- 2001 "ANDi" the first GM primate is born

Phil Challis MR01