Pigs with human genes have been in the news recently as Cambridge surgeons prepare to transplant their hearts and kidneys into human beings, but this is only scratching the surface of the revolution taking place in the world of genetics.

Creating superbreeds is nothing new. The first transgenic mammals were born in 1976, and more than 60,000 are now made in Britain every year, each of which contains a unique blend of genes from two or three species. Human genes have been added not only to pigs but also to sheep, cows, rabbits, mice and fish. Then there's human cloning.

It is now quite routine to splice new genes into mammal sperm, fertilised eggs, and cells from embryos, while cloning by artificial twinning has also become an established breeding technique. The same cloning method has been found to work in humans too after experiments by Dr Jerry Hall at George Washington University and earlier attempts in Britain (all identikit embryos were destroyed).

British Association delegates recently heard predictions of apples with antibodies against tooth decay and crops which glowed when thirsty or diseased. But German scientists in Basle have already made fruit flies with extra eyes on their wings, antennae and legs, and scorpion poison genes have been added by Oxford geneticists to cabbages to kill caterpillars (what about people?).

New genes are big business: Monsanto has developed potatoes with bacterial insecticide genes to destroy colorado beetle, and ESCA Genetics has made coffee beans with low caffeine, high aroma and pest resistance.

Zeneca is working on slow ripening bananas, while DNAP Tech is doing the same with pineapples and others are creating bio-melons together with new strains of peas to make "designer starch". Some 2,000 field trials are now taking place in different countries of new plants, of which 80 are in Britain. Maybe even roses will be changed.

Consumers will probably notice little difference because most retailers are very reluctant to label modified meat, fruit or vegetable products, fearing a massive consumer boycott as with

irradiation. However labelling may be forced on them after a crucial vote in the European Parliament later this Autumn.

Computers linked to the internet now dominate the search for genes, with more than 10,000 gene sequences sent every day from dozens of countries to the National Centre for Biotechnology in Bethesda Maryland. Each is matched against other known fragments in the GenBank with results sent back in minutes.

This growth of knowledge is exponential. By July 1995 scientists had unravelled 1.8 million base pairs of DNA encoding all 1,743 genes from the bacterium Haemophilus Influenzae. By January 1996 the 12.5 million base pairs making up 6,000 genes in the yeast Saccharomyces cerevisiae were also decoded, and 100 million base pairs of a nematode worm will be fully analysed by 1998.
By 2005 the entire human genome will be available as a giant computer listing of 3 billion base pairs at a cost of some £2 billion. Of course mere strings of code are useless unless we know what they do.

One way to find out is to insert vast numbers of gene fragments from one species into another to see what happens, or to analyse a protein and then work out the gene sequence to make it. That is how researchers from Genentech taught a bacterium to make human insulin in August 1978.

Instead of having to design and build a giant biochemical complex employing hundreds of staff, the entire production was condensed into the nucleus and cytoplasm of a single cell: the ultimate in miniaturisation. That cell reproduced itself millions of times over, in a culturing process similar to that in a brewery, and by the late 1980s the mutant strain was supplying thousands of diabetics.

Now hundreds of "marker genes" have been identified, with obvious effects linked to the presence of other sequences. These markers will help locate the approximate position of other target genes - say for a tendency to schizophrenia, obesity, diabetes, extreme shyness, extraversion, creative ability or even intelligence and athletic ability. But such knowledge without a clear moral framework could destroy us.

Intelligence is influenced by a wide variety of factors. However, certain genes have already been found which affect mental ability, such as the Fragile X gene. It is possible that certain combinations of marker genes may turn out to be associated with higher than average intelligence, Olympic winners or even preference. Or perhaps musical ability...
A fierce dispute continues over whether there is any genetic influence on orientation, as claimed by Dr Hamer at the US National Cancer Institute recently. His data has been challenged, but his comments about a possible test on foetuses caused uproar not only among pro-life groups, but also among gay activists, both horrified at the potential for abuse.

Every time a new gene is identified, a new test can be developed, but when do you use it? Prophesying illness sounds like a good idea except that knowledge can be a burden and tests can be wrong.

Genes for Downs syndrome, Huntington's chorea or cystic fibrosis are one thing, but what about genes carrying an increased risk of Alzheimer's, breast cancer, asthma, heart disease or depression? Is a twice average lifetime risk sufficient to justify a termination for those content before to abort only those with major defects?

Widespread gene screening for insurance purposes is almost inevitable as postal tests become more widely available. Last month University Diagnostics began advertising a £65 test for unknown carriers of the cystic fibrosis gene and others will surely follow.
Insurance screening will be necessary to prevent massive fraud by people taking out huge policies after privately discovering that they carry genes for such things as breast or bowel cancer, but screening will also mean that some become uninsurable.

Human cloning of foetuses for spare parts, human-monkey hybrids perhaps with some language capability, and designer children are all today's possibilities with the tools that dictators like Saddam Hussain may already have, applying exactly the same methods as now used routinely in animal research and specialist breeding programs.

China has already resolved a breeding dilemma. In October 1994 it was decreed that all those with unhealthy genes would be banned from having children. Thus the genetic dream has already become a nightmare for a fifth of the entire world population.
In the West, the dominant forces of the market-place are driving our own genetic revolution, with 1,250 biotech companies jostling for venture capital in America alone. Hence the fighting over patents for creatures designed to suffer such as the cancer-growing oncomouse (EU patent

0169672), or to patent human genes. Hence also the calls to follow America by reversing legislation, making Britain a safe haven for companies on the run from countries like Germany, where attitudes are far more conservative.

Biotechnology is accelerating ahead of debate. The House of Commons Committee on Science and Technology has taken until July this year to recommend that a Human Genetics Commission be established, but even that would not cover animals or plants, nor such urgent concerns as British germ warfare research using mutant viruses. Such agents could be awesome weapons in terrorists hands. The genetic revolution will continue to pose some of the greatest dilemmas society has ever faced, and finding answers for the longer term will not be easy, despite the current tendency to drift on a tide of pragmatism, justifying almost anything that might relieve human suffering or save lives. There is no doubt that we urgently need this technology to cure cancer, cystic fibrosis, AIDS and a host of other illnesses as well as to feed a growing population, but we are rushing headlong into a new era without any parallel whatever in the history of human existence.

We cannot just sit back and let events unfold. A comprehensive Gene Charter is needed, and a Global Summit on Biotechnology, agreeing world-wide safeguards, standards, monitoring and controls. The alternative could be a profound, irreversible alteration of life on earth within a hundred years. Super-human and sub-human could yet take on a whole new meaning. Either we control the technology, or the technology will redesign us.

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