The Genetic Revolution

Having looked at the enormous benefits we have already seen in agriculture and medicine as a result of genetic engineering, we now need to ask about the possible dangers before then thinking about law changes or other regulations.

Understandably there has been an enormous amount of concern about the risks (1600): "we have to be aware of the high risks and responsibility of everybody who is involved in these new systems, especially the scientist who produces genetically engineered organisms" (1600b).On a purely practical level let us consider some of the things that could go wrong.Virulent new infections threatening to wipe us all out is the substance of science fiction films such as Star Trek, but what is the reality?

1. New organisms going out of control

The idea that an organism could do great damage if released in the wrong place is based on bitter experience.Those concerned for the environment can point to a large number of times where plants introduced from one country into another have unexpectedly become a nuisance.Therefore there has been enormous concern over what could happen if a genetically altered species were released into the environment with unexpected results (1610).

An example is the current plague of rhododendrons in Snowdonia and other parts of the UK.This plant was imported from India for the first time in the eighteenth century by wealthy land -owners who liked the evergreen bushes with their dark fleshy leaves, that grow well in woodland and have magnificent flowers.

The bushes grow very densely, cutting out all light beneath.They grow tall and then flop over, suffocating nearby plants or young growing trees.They also disturb the balance of the soil, turning it more acidic.You might think this would not matter too much - after all we all appreciate country walks through wild woodlands rich with the beauty of these flowers.

The problem is that the plants are just too resilient.Some 250 different types of insects, fungi, or small creatures live off an oak tree.This ecological system maintains a rich balanced environment and keeps oak trees from totally dominating the countryside.

The rhododendron is an unfriendly plant.The leaves are juicy but unpleasant to eat so even in a deer park they may be left alone. The leaves have virtually no food value even if they are eaten. There are very few other creatures that thrive on rhododendron bushes - no fruits to eat or nuts to collect or sap to drink.

The bushes are spreading steadily, escaping from where they were planted out.When cut down they just grow up again.In places like Snowdonia they have become a ferocious weed which conservationists are despairing at, yet no-one could possibly have predicted this when they were planted there over 100 years ago.

It is one thing to move a naturally occurring organism from one country or area to another, but what about introducing an organism the world has never met before - anywhere? (1620).

What would be the effects of new plants created in the laboratory and released into the environment?How can we be sure that a particular cereal plant does not turn into a nuisance?How can we be sure a genetically engineered fish does not multiply so fast that other types of fish are starved and driven out or even eaten by them?

The area that possibly gives most cause for concern is the invisible one of new strains of bacteria or viruses finding their way out of the gene factory and into the soil, water supply or the bodies of animals or humans with disastrous results. These new strains are now becoming available commercially and as they do control will become even more difficult (1625).

You may remember when we looked at how bacteria are used as chemical factories we started by using bacteria which grow naturally in the human gut and which can be found elsewhere.What would be the effect of creating by accident a new version of E.coli which turns out to release substances causing bowel cancer if they get into the human gut.It may be that this same strain has some other genetically engineered feature such as producing a hormone to increase cow milk production.

E.coli organisms pass all the time between humans despite normal standards of cleanliness - just as well that they do or newborn babies would suffer through lack of them and people on anti-biot -ics would have permanent bowel problems afterwards if E.coli were killed.It is impossible therefore to control the spread of a strain of E.coli through a town or city.We see this in the spread of resistance to antibiotics.If you treat a certain percentage of a town with certain antibiotics, before long you can find there are resistant E.coli in the gut of those who have never been on antibiotics in their lives.Fortunately resistance is usually lost with time, unlike a genetically engineered organism which could remain dangerous for a very long period and be hard to detect or control.

What about water supplies or soil?Soil organisms are also used in genetic engineering and tampering with the genetic code of a non-soil organism could produce one which was able to survive in the soil quite well, or could turn a harmless soil organism into a global hazard (1630).Are we producing domesticated bacteria or potential "andromeda strains"? (1640)

Suppose such an organism turned out to survive very well indeed, and to multiply fast - or suppose it travelled further in an agricultural spray than it was meant to.We know very little about how genetically engineered bacteria might be carried in a strong wind from - say - a small crop spraying airplane or helicopter.

Microcomputer programmes are being developed to try to predict what could happen but there are an enormous number of variables including particle size, wind speed and direction,

turbulence, evaporation, sedimentation, and bacterial survival time (1650).Survival time and what the organisms release into the soil are the two critical factors.Suppose we make a mistake, when one organism in 100,000 in the spray mix turns out to be a second undetected mutant but with quite unexpected and terrible results.

Studies are being carried out to see how well bacteria survive in agricultural sprays. In a greenhouse, bean and oat plants were sprayed with bacteria in an attempt to simulate what might happen in a field. Damp air (high humidity) and low temperature made bacterial growth on the plants up to 65 times more likely after spraying. Bacteria also survive better if the spray contains larger droplets rather than small (1656). Drifting downwind was noted but the strain being used tended not to establish itself unless concentrations on the plants were high (1658).

Studies are also continuing to see how well genetically engin -eered bacteria survive in soil (1660).Do they get washed through by rainwater?Will they land up in streams and rivers or pollute our reservoirs?Such studies are difficult and time consuming.They have to be done in artificial conditions - after all the whole point is to check first before release into the environment.How well will such studies match up to conditions in the outside world?

The pressure is growing therefore to allow small scale introduc -tion of genetically engineered micr-organisms into the soil. The company Monsanto has developed a new strain of bacteria which is fleurescent to monitor the passage of the bacteria through soil more easily. This strain has been used first in a pre-release growth chamber and then in a limited field test. The tests were approved by the US Environmental Protection Agency (1665).

Suppose that such bacteria release acids or other chemicals into the soil that make the soil unusable (1670).Suppose that such organisms are carried in dust on car wheels, on shoes, by strong winds, on the feet of animals or by insects.The effects could be devastating on an area, a country or a continent.This is perhaps one of the most worrying scenarios since it would be totally impossible to put right. After all you cannot sterilise the entire planet.

Further studies are looking at the survival of genetically changed bacteria in lakes. The experiments were done in special flow chambers where the water was constantly changing to

simulate as closely as possible natural conditions after release. They found that the strains of altered bacteria they tested tended to survive as well os the originals from which they were changed (1672). Clearly survival could be greatly improved or lessened depending on how the organisms are modified.

Even where there are strict regulations, unauthorised release of new organisms is already happening (1680), sometimes this has been carried out by those who believe the risks to be minimal (1690), and just a natural extension of evolutionary principles and an expansion of the process of domestication of species (1690).

Viruses are also a potential source of huge problems.As we have seen there have already been suggestions that the AIDS epidemic caused by HIV could have started as a result of a laboratory accident.Although we have dismissed this theory as being very unlikely we are faced with the fact that in the 1990's we have the ability to create tens of thousands of new viruses, many of which may have unpredictable results.Some of them will produce milder disease and will be suitable as vaccines (1700), others may turn out to be more lethal or more infectious.In the case of live HIV variants, the only way to find out is on humans.

Viruses can and do escape.Why else did the World Health Organisation insist that the last surviving specimens of smallpox were destroyed?The threat became a reality in 1982 in Birming -ham University when a sample escaped from a damaged container and a laboratory worker became infected. She died and a major outbreak of smallpox was only prevented because there were enough people who had been vaccinated in the past so she could be looked after safely.More worryingly this was not the first such accident: in 1973 a smallpox outbreak at the London School of Hygiene and Tropical Medicine killed two people (1710).

smallpox has now been completely eradicated worldwide by a global vaccination programme.Because of this the vaccinations have stopped.If smallpox virus were to escape in an accident in ten or twenty years time, most of the world's population will by then be younger non-vaccinated people and a vast epidemic could result.

Fortunately (if we believe the laboratories concerned) all last remaining viruses have been destroyed.Perhaps they have not been.The temptation to keep such a powerful virus from extinction is great for those who might want to tamper with it genetically.Scientists are also untidy and disorganised people sometimes: in 1985 the London School of Hygiene and Tropical Medicine was involved in yet another smallpox scare when sealed ampoules of virus

were found by accident in a fridge in the medical microbiology department - inside a biscuit tin where they had been since 1952! (1710)

However if it can happen with smallpox, know to be one of the most infectious and dangerous viruses ever discovered, could not accidents happen quite routinely with viruses thought to be relatively harmless (1720) ?

There is also the possibility of industrial accidents as the number of factories growing genetically engineered organisms continues to increase. For bacteria, filamentous fungi, yeasts, mammalian cells and viruses the risks can be quite separate and different. For example, with bacteria, the main risk to factory or laboratory workers is infections of various kinds. For cell cultures the main risk is considered to be from dormant viruses although good management of cultures should eliminate these. A recent report evaluating the range of risks came to the con -clusion that they were small but also had to admit that such conclusions remained theoretical in the absence of any reported occupational accidents or diseases attributed directly to genetically engineered organisms. The study concluded that " only long term observations can confirm this assumption (low risk) and consequently the highest feasible containment measures should still be used in years to come" (1725).

A further worry has been accidental infection of patients with viruses causing cancer as a result of injection with genetically engineered substances obtained from human cells growing in flasks.These cells are usually cancerous in origin (or else they tend not to go on dividing in the laboratory).Could viral material be injected accidentally with increased risk of cancer in the future?Viral contamination of products continues to be an active concern (1730).

Transgenic fish could also cause vast problems: new fish species have already been created.What happens if they are released into rivers or the sea where they become more successful than anticipated in competing for the food chain leading to extinction of many other species (1740).

2. Germ warfare using new organisms

Germ warfare research has been carried on in secret for some considerable period of time.In the 1980's the world was shocked by the assassination of two well known Bulgarian dissidents,

one in Paris and the other in London.Both were killed in an identical way.A special umbrella was used by someone following each of them.In each case a tiny metal pellet was fired into the leg of the person just a metre or so in front.It felt like an insect bite.Neither realised much had happened until a few hours later when the wax coating on the pellet dissolved and an unknown biological weapon began to leak out of microscopic holes in the pellet surface.Within hours each was in hospital dying.

The fearsome spectre of germ weapons being used on a large scale was raised by the Gulf War in early 1991 when it was revealed that Iraq possessed huge amounts of anthrax spores which could be spread over the desert using shells or helicopters, rendering large areas dangerous to humans.
anthrax
survives for a long period in normal conditions.

In the 1940s a small Scottish Island was made totally uninhabit -able for 50 years following experimental release of anthrax spores on the Island to see how effective they would be in germ warfare.

Genetic engineers open horrifying possibilities to the manufac -turers of weapons.How about designing a new virus that produces death or severe illness in half those exposed to it in less than ten days?At the same time of course large amounts of vaccine are prepared to ensure that all the troops on your own side are fully protected.

The best virus type would be one which can be passed to a large number of people easily either in a fine mist or in the water supply but which does not pass easily from person to person so the infection is contained in an area.A fine mist of smallpox virus from a single helicopter in a single attack would be deadly to an unprotected army but would also create a disaster across a whole continent.The agent needs to be carefully engineered.

Germ warfare is extremely difficult to test - after all who are your volunteers for testing?Viruses are usually species specific so you cannot reliably test new viral weapons on animals.Viruses have unpredictable effects on large groups.For a start very time someone is infected there is a chance of a mutation or adaptation.New viruses would therefore be difficult to control although that might not deter a dictator wishing to harass or intimidate a hated minority group in a sparsely occupied area.

Viruses being made by secret weapons research will of course be tested - for without testing you have no weapon.Where and on whom such tests will be carried out is uncertain.All that is certain is that it will not be on volunteers who know what is really being done, nor will it be in a lawsuit and media dominated Western nation.What will be the results of the tests? Could one experiment cause an illness to spread out of control?

The answer to all these questions is that these things could happen and doubtless we will see from time to time unexplained new diseases appearing suddenly in small groups before hopefully disappearing again.We will never know the origin.After all the secret service of a country is hardly likely to admit to trying out germ warfare on humans of another country in peacetime - or maybe even during a full scale war.

Variations on germ warfare include targeting viruses at the crops or animals that the other side depends on for food.Here the testing is very straightforward and can be carried out in the animal houses of any of the major biological warfare research centres.Again there is the potential for things to go very badly wrong.

The next century is perhaps more likely to be dominated by terrorism than major wars.The collapse of the Eastern Bloc has already produced a number of independent states in which conflicts similar to those in Northern Ireland are developing. These conflicts arise as a result of people movements so that a nation has a sizeable group within it who have a very different culture and identity.Integration is not an option for the minority who feel their identity would be destroyed.

Partition is the only other solution.This happened in India in the 1940s creating the new states of Pakistan and Bangladesh.When partition occurred, tens of thousands of people fled from one side to the other.Life is never neat and tidy.Partition usually fails because every town or village contains a variable mixture.

Every major war between countries over the last 40 years has produced large numbers of refugees: people looking for sanctuary. The result is that the world is becoming more muddled.This can be a good thing in producing large cosmopolitan multi-nation cities such as London, but can also be the seed bed for resent -ment, anger, oppression and protests including terrorism.

Germ warfare is an attractive terrorist option.After all it is hard to prove or disprove what they terrorist claims to be able to do.Because germ agents are unseen, a tiny amount of agent has the potential to terrorise and disrupt the lives of millions.

Imagine the terrorist who telephones a national newspaper to say that ten phials of nerve agents or hazardous viruses will be added to one of the thousands of distribution points of our domestic water supply.Over 30 million adults would be boiling all drinking water for weeks - especially if one or two had died already.

Germ warfare is also an attractive option for state control - particularly in a totalitarian state that wishes over a gener -ation to vastly reduce the size of a certain minority community without outside interference.A special immunization programme could be set up which injects an extra virus along with the vaccines.This virus has an identical surface appearance to the outside coating of human sperm.After the infection has been eliminated the body has produced antibodies that not only vaccinate against a repeat of this rogue virus but also now recognise all human sperm as germs to be destroyed.If the person infected is a man or a boy this auto-immune reaction will make him sterile for life.Such cross reactions between infections are well known and are the basis for most of the auto-immune diseases that we discussed in the last chapter.

There are other social consequences of genetic engineering.We already have techniques capable of providing couples with an 80% chance of having either a boy or girl (1750).Many concerns have been expressed that with families becoming smaller such choice will create great sex imbalances for the future (1760).We know the catastrophic events that followed the Chinese decree some years ago that only one child was permitted per family: very large numbers of baby girls were murdered at birth because a single child had to be a son.The second catastrophe is now a long terms shortage of girls in some areas.This could have vast social consequences in the future.

A survey of couples in New York showed that US citizens tended to choose boys and girls equally, but all 57 of the non-Americans interviewed selected boys for economic and business reasons (40%), cultural reasons (30%) and personal reason (30%) (1770).Clearly if this technology becomes inexpensive and widely available there could be a major effect on the balance of sexes in some countries.

(3) Food safety

We have already looked at the large range of new foods about to appear or already available and the absence of control mechanisms to ensure safety is adequately tested before marketing.Such testing will never be applied thoroughly without some kind of regulatory authority - not least of all because the resources required to test transgenic livestock for example will be much greater than those needed to crease them (1780).

(4) Abuse of genetically created medicines

Parental pressure and expectations for the achievements of their children could produce demands for misuse of some of the new technology.An example might be pressure to prescribe geneti -cally engineered growth hormone to children of normal physique to encourage development of a taller athletic adult.A recent survey of paediatricians in France showed great concerns about risks of inappropriate use (1790).The main indication for its use would seem to be to treat human dwarfism.

Here is a thought provoking extract from a paper published in a scientific journal in March 1990, looking forward to a geneti -cally engineered world without pain - not one that is practical as we will see but challenging the way we see our future nevertheless.

"Riley-Day syndrome, a genetic disorder in which there is an impaired ability or inability to feel pain, hot and cold, is.... evidence that the.... notion that life cannot be painless is not necessarily valid.

"...a mind capable of experiencing only varying degrees of pleasure..... the human brain would be rendered painless (with a) genetic approach. In order to expedite the relief of all kinds of suffering and the improvement of the human condition in general....prompt and concerted research should be directed towards the development of such a brain...."

Use or abuse of genetic research ? If it is any reassurance to you, the author fails to point out that people unable to experience pain do not tend to last very long without terrible injuries or even death. After all, pain is a biological protec -tive device to tell you when things are getting damaged. It is interesting that not only are burns and cuts very common, but also we see a

higher than usual rate of arthritis even in the very young. The reason seems to be that we all need subtle posture changes all the time to keep our tissues from being worn out. While I have been typing additions to this chapter I have probably altered my position a few times without realising it to keep comfortable in the pre-pain stage.

The Genetic Revolution - free book by Patrick Dixon - published 1995