

But as the days of Noe were, so shall also the coming of the Son of man be. (Matthew 24:37)

And it came to pass, when men began to multiply on the face of the earth, and daughters were born unto them, That the sons of God saw the daughters of men that they were fair; and they took them wives of all which they chose... There were giants in the earth in those days; and also after that, when the sons of God came in unto the daughters of men, and they bare children to them, the same became mighty men which were of old, men of renown. And GOD saw that the wickedness of man was great in the earth, and that every imagination of the thoughts of his heart was only evil continually. (Genesis 6:1-5)

And there was yet a battle in Gath, where was a man of great stature, that had on every hand six fingers, and on every foot six toes, four and twenty in number; and he also was born to the giant. (2Sa 21:20)

And yet again there was war at Gath, where was a man of great stature, whose fingers and toes were four and twenty, six on each hand, and six on each foot: and he also was the son of the giant. (1Ch 20:6)

And whereas thou sawest iron mixed with miry clay, they shall mingle themselves with the seed of men: but they shall not cleave one to another, even as iron is not mixed with clay. (Daniel 2:43)

UN official urges rich nations not to block life-saving modified crops

MEXICO CITY, July 10 2001(AFP) -

A top UN official on Tuesday urged rich nations not to block the development of genetically modified organisms (GMOs) which he said could save the lives of millions who would otherwise die of starvation. "While the risks are as yet unproven, there is a very proven risk from malnutrition: 850 million people in the world go to bed every night hungry," said Mark Malloch Brown, the head of the UN Development Programme (UNDP). "Unproven scientific fears should not lead to the unnecessary loss of tens of millions of lives to hunger," he said at a news conference in Mexico City, after presenting a UN report that urges rich countries to put aside their fears of GMOs. At a ceremony to present the report, Malloch Brown said "it would be wrong for rich Northern consumers, faced with overflowing supermarket shelves, to block development of these technologies that hold so much promise to help feed the poor."

He said there was a huge potential to create more nutritious, drought- and disease-resistant crops, which could also help reverse desertification in many developing countries. "The developing world has for far too long been victimized by creeping double standard by which rich nations, having benefited from revolutions in pharmaceuticals, agriculture and information and communications technologies, are questioning their utility for the poor," the UN official said. The UNDP's annual Human Development Report said the potential of biotechnology, which accelerates the process of cross-breeding by transferring genes from one plant species to another, has barely been exploited. The report acknowledged that fears about risks to human health and the environment had fuelled mistrust of new technologies in rich countries, particularly in Europe.

Malloch Brown stressed the report did not suggest glossing over concerns about the potential risks of GMOs. "We are as rigorous as groups such as Greenpeace in saying there must be the highest level of regulation in terms of food safety and environmental protection," he said. But the environmental group Greenpeace harshly criticized UNDP for promoting GMOs. "Rather than advocate the export of unsafe and risky genetic technology toward countries of the South, agencies like UNDP should concentrate on promoting and disseminating proven and sustainable methods to improve agricultural practices," said Greenpeace Mexico activist Raul Benet, interrupting the formal ceremony.

The UNDP report also states that inadequate public funding, market distortions and unfair intellectual property rights deny the benefits of high-tech advances to Third World countries. It called for greater international funding for research and development, and differential pricing of medicines and other high-tech products between rich and poor nations. "It is past time to put to rest the sterile debate over whether new technologies are a luxury or a necessity for the poor," said Malloch Brown. Mexican President Fox, who attended the ceremony at the presidential palace in Mexico City, praised the report. "It invites us to ensure that science, technology and research be available to confront the challenges posed by poverty, marginalization, exclusion and the lack of opportunities," he said.

Biotech 'Frankenstein Crops' May Yield Food to Poor

By Evelyn Leopold

Monday July 9 2001

UNITED NATIONS (Reuters) - Genetically-modified crops, under attack in the West, may provide an answer to cutting malnutrition in poor nations by developing seeds resistant to drought, a new U.N. report says. Despite somewhat unpredictable results, the report -- to be released on Tuesday by the U.N. Development Program -- argues against a blanket rejection of genetically-altered crops, saying they could produce a higher yield in countries with poor soil and where populations are desperate for food. The so-called "Frankenstein foods" have been put on hold in European countries, and are under attack in the United States and Canada because of fears over potential health and environmental hazards that genetic engineering could produce.

"The current debate in Europe and the United States over genetically modified crops mostly ignores the concerns of the developing world," said the annual 265-page Human Development Report 2001, to be officially released in Mexico City by UNDP.

The successful Western campaign to ban the pesticide DDT, for example, has produced a new breed of malaria-carrying mosquitoes in many tropical countries.

`` BALANCED APPROACH''

"Instead of changing the environment to fit the seed, the seed could be changed to drought-resistant crops," said Kate Raworth, co-author of the report, in an interview. "We are calling for a more balanced approach."

Mark Malloch Brown, head of UNDP, pointed to an effort by Japan to develop new varieties of rice in West Africa that have 50 percent higher yields, are more tolerant of drought and richer in protein.

Yet UNDP is cautious, with Raworth saying research into potential health hazards, biosafety measures and labeling has to be part of the technological revolution. Australia, Brazil, Japan and Britain require such labels and 80 percent of the consumers in the United States want them as well.

Harvard Professor Richard Lewontin says it is still impossible to determine the consequences of biotechnology, although the negative consequences have yet to emerge.

However, many studies in the United States are not based on government data but provided "by the very parties who are asking for approval to distribute the new variety in the first place," he warned recently in the New York Review of Books.

NORWAY FIRST IN "HUMAN DEVELOPMENT"

The report, the 11th annual survey of more than 160 countries, produces a broad human development index, aimed at showing that "progress" is not dependent on income alone but health, education, adult literacy and life expectancy.

This year Norway is in first place, followed by Australia, Canada, Sweden, Belgium and the United States dropping from third to sixth place. Raworth, however, says that the index is basic so all countries can be measured and that the top nations are statistically close.

At the bottom of the list are countries in sub-Sahara Africa, with Sierra Leone in last place.

This year UNDP invented a new technological index that ranks 72 countries according to leaders in the field, potential leaders, dynamic adopters and those who are marginalized.

Finland, which has the highest percentage of citizens using the Internet, leads this list followed by the United States, Sweden, Japan, South Korea (news - web sites), Britain, Canada, Singapore, Germany and Norway.

Ironically, India, which has one of the world's most dynamic technological hubs, ranks 63rd, behind Zimbabwe, Syria and Paraguay and well below China, according to the survey.

This is because Bangalore, where much of India's new technology is concentrated, is a small enclave in a nation where the average adult receives only about five years of education and there are only 29 telephones per 1,000 people.



Cloning: *Are Humans Next?*

The first clones (genetic duplicates) of an adult pig were born on March 5, 2000. Scientists at PPL Therapeutics, Inc., in Edinburgh, Scotland, created the five pig clones using genetic material taken from a body cell of an adult female pig. The researchers said, in the future, clones of genetically modified pigs might serve as sources of organs for human organ transplants.

The pig cloning was only the latest of many cloning breakthroughs achieved by scientists at various institutions since 1996, when Scottish researchers associated with PPL Therapeutics created a sheep named Dolly, the first clone of an adult mammal. Besides pigs and sheep, scientists have also cloned other animals, including cows and mice. A number of scientists said they believed it was only a matter of time before human cloning would become a reality. However, this prospect raised ethical concerns among many people.

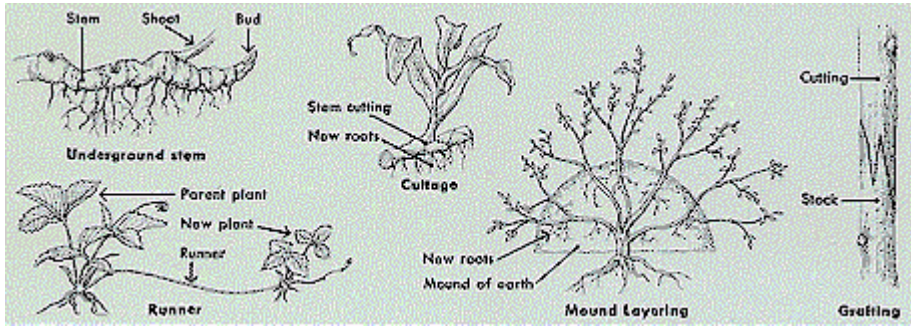
World Book editors have compiled background information on cloning adapted from content in World Book.®

What is a clone?

A clone is a group of genetically identical cells. For example, tumors are clones of cells inside an organism because they consist of many replicas of one mutated cell. Another type of clone occurs inside a cell. Such a clone is made up of groups of identical structures that contain genetic material, such as mitochondria and chloroplasts. Some of these structures, called plasmids, are found in some bacteria and yeasts. Techniques of genetic engineering enable scientists to combine an animal or plant gene with a bacterial or yeast plasmid. By cloning such a plasmid, geneticists can produce many identical copies of the gene.

The term clone also refers to a group of organisms that are genetically identical. Most such clones result from asexual reproduction, a process in which a new organism develops from only one parent. Except for rare spontaneous mutations, asexually reproduced organisms have the same genetic composition as their parent. Thus, all the offspring of a single parent form a clone.

Single-celled organisms, such as bacteria, protozoa, and yeast, usually reproduce asexually. Clones of these organisms are useful in research. For example, various drugs and other compounds can be tested on bacterial clones. All the test bacteria have the same genetic makeup. Therefore, any differences in effectiveness among the different compounds result from the compounds themselves and not from the bacteria



Many plants reproduce by vegetative

propagation, a form of natural cloning. Plants that develop from runners or underground stems are clones of the plants that send out the runners and stems. Gardeners use such techniques as cuttage, grafting, and mound layering to produce clones of favored plants.

World Book illustration by Marion Pahl

Algae, fungi, and such simple plants as club mosses can reproduce asexually as well as sexually and can be cloned. Higher plants usually reproduce sexually and form seeds. However, many--if not all--higher plants can also reproduce asexually through a process called vegetative propagation, and so they can form clones. Plant clones are useful for measuring the effects of various environmental factors or chemical compounds on genetically identical plants. Breeders use cloning to collect plants with certain desired traits. Farmers and gardeners raise apples, potatoes, and roses by means of clones.

Hydras, flatworms, and other animals can be cloned through asexual reproduction or the process of regeneration. But most higher animals form clones naturally only when identical twins or other genetically identical multiple births occur.

An experimental process

An experimental technique has been developed for cloning certain higher animals. This process involves destroying the nucleus of an egg cell of the species to be cloned. The nucleus is then removed from a body cell of an animal of the same species. This donor nucleus is injected into the egg cell. The egg, with its new nucleus, develops into an animal that has the same genetic makeup as the donor. If a number of eggs receive transplants from the same donor, the resulting offspring form a clone. Scientists used this technique to clone such amphibians as frogs and salamanders as early as the 1950's. In 1996, a group led by Scottish scientist Ian Wilmut used the procedure to clone a sheep. This event marked the first time a mammal had been cloned in this way.

Early scientific attempts at cloning

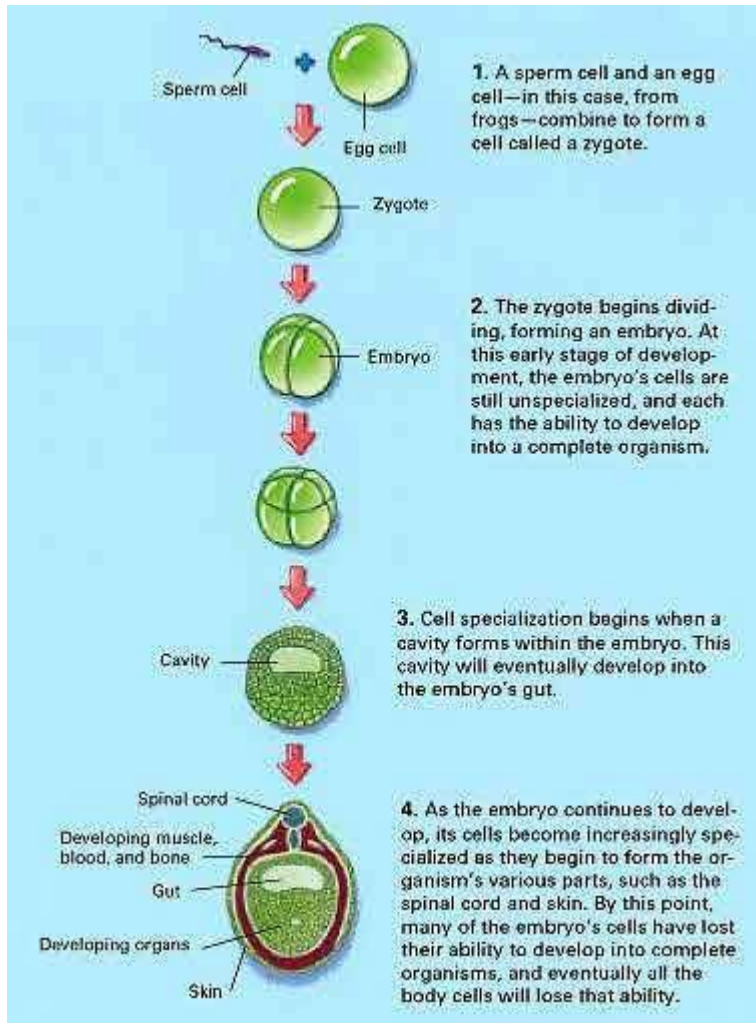
Scientists have long been intrigued by the possibility of artificially cloning animals. In fact, people have known since ancient times that some invertebrates (animals without backbones), such as earthworms and starfish, can be cloned simply by dividing them into two pieces. Each piece regrows into a complete organism. The cloning of vertebrates, however, was much more difficult. The first leap forward in the cloning of these more complex organisms came in the 1950's with work done on frogs.

Beginning in 1952, Robert Briggs and Thomas King, developmental biologists at the Institute for Cancer Research (now the Fox Chase Cancer Center) in Philadelphia, developed a cloning method called nuclear transplantation, or nuclear transfer, which was first proposed in 1938 by the German scientist Hans Spemann. In this method, the nucleus--the cellular structure that contains most of the genetic material and that controls growth and development--is removed from an egg cell of an organism, a procedure known as enucleation. The nucleus from a body cell of another organism of the same species is then placed into the enucleated egg cell. Nurtured by the nutrients in the remaining part of the egg cell, an embryo (an organism prior to birth) begins growing. Because the embryo's genes came from the body cell's nucleus, the embryo is genetically identical to the organism from which the body cell was obtained.

In their experiments, Briggs and King used body cells from frog embryos. From these cells, they were able to produce several tadpoles.

The mystery of cell specialization

Briggs and King used embryos consisting of only a few thousand cells as the source for body cells and nuclei, because at that stage of development an embryo's cells are still relatively unspecialized. As an embryo develops into a completely formed organism consisting of billions of cells, its cells become increasingly specialized. Some cells become skin cells, for example, while others become blood cells. Skin cells can normally make only more skin cells. Likewise, blood cells can normally make only blood cells. By contrast, each of the unspecialized cells of an early embryo is capable of producing an entire body. At the time of Briggs's and King's experiment, researchers were not sure whether specialization occurs because different cells get different assortments of genes or because genes that are not needed in a particular kind of cell become inactive.



During the development of an embryo, the embryo's cells divide and become increasingly specialized. Specialization means that cells destined to be part of the organism's skin, for example, can normally give rise only to more cells of that type. For many years, cell specialization frustrated scientists attempting to clone animals.

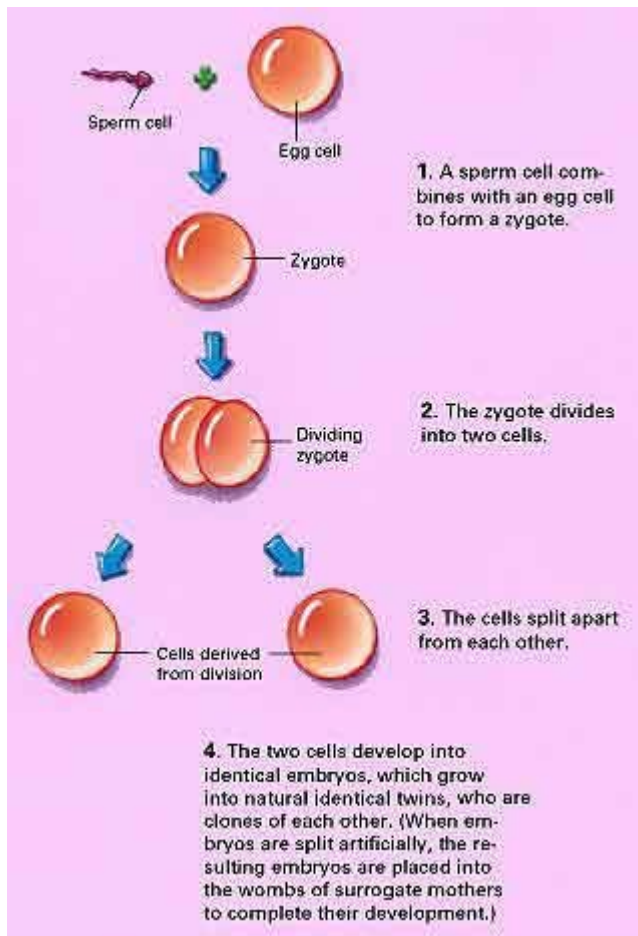
World Book illustration by Roberta Polfus

Additional research on nuclear transplantation was conducted in the 1960's and 1970's by John Gurdon, a molecular biologist at Oxford University in England. In 1966, Gurdon produced adult frogs using nuclei from tadpole intestine cells. This experiment proved that even cells that have undergone a great amount of specialization remain totipotent—capable, under certain circumstances, of directing the development of a complete organism. Totipotency implied that all of a fully developed organism's body cells contain a complete set of genes and that specialization occurs because certain genes are active in some cells and inactive in other cells.

Despite the demonstrated totipotency of body cells, scientists were repeatedly frustrated in their attempts to use nuclear transplantation with nuclei taken from the cells of adult vertebrates. In the rare cases in which offspring resulted from such experiments, the young never survived to adulthood.

Embryo splitting

A different and simpler cloning procedure, called embryo splitting, or artificial twinning, was developed in the 1980's and was adopted by livestock breeders. In this procedure, an early embryo is simply split into individual cells or groups of cells, as happens naturally with twins, triplets, and other multiple births. Each cell or collection of cells develops into a new embryo, which is then placed into the womb of a host mother animal, who carries it to a full term. Although this technique permits the production of multiple clones, the clones are derived from an embryo whose physical characteristics are not completely known rather than from an adult animal with known characteristics—a serious limitation for practical applications of the procedure. By the early 1990's, embryo splitting and nuclear transplantation using cells from embryos had been used to clone a number of animals, including mice, cows, pigs, rabbits, and sheep.



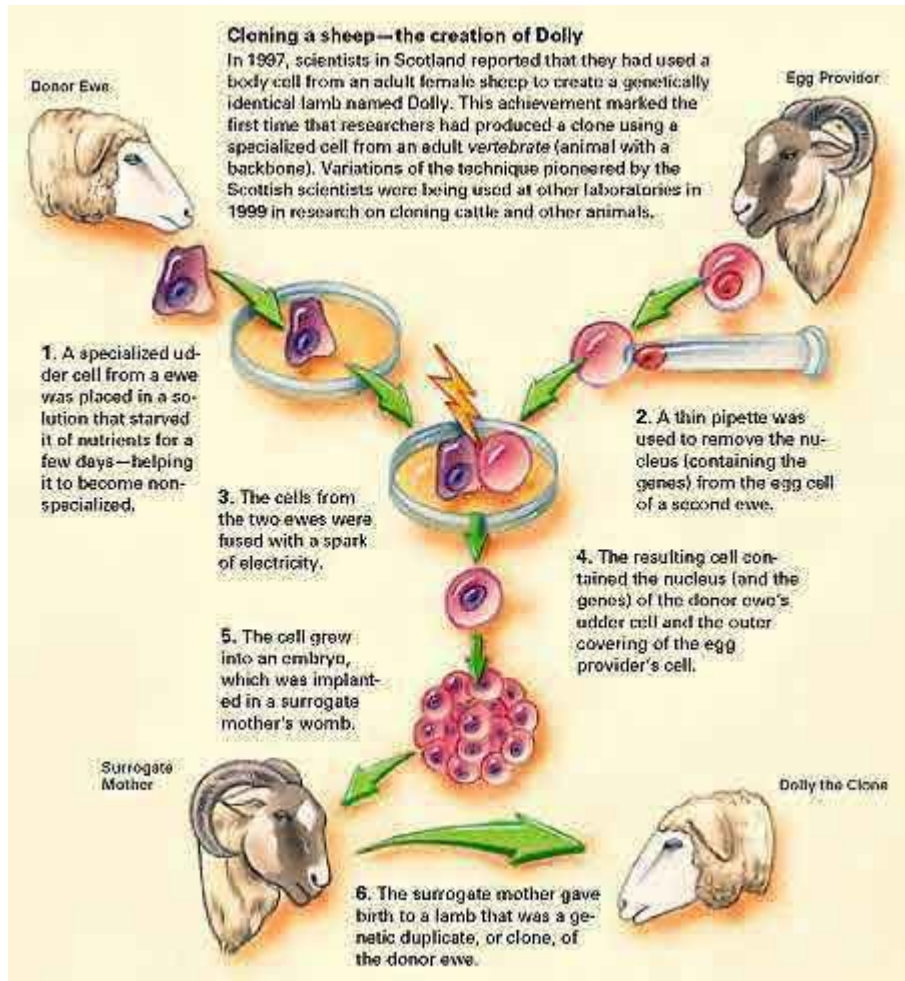
Nature has its own cloning methods, such as when a fertilized egg divides to create identical twins or triplets. Scientists duplicate this natural cloning process artificially with animals by dividing early embryos into separate cells or groups of cells--a procedure called embryo splitting.

World Book illustration by Roberta Polfus

Dolly and other cloning breakthroughs since 1996

The failure of cloning techniques to work with cells from adult animals after many years of research led most scientists to conclude that the cells of mature organisms are simply too specialized to be cloned. In 1996, however, researchers led by embryologist Ian Wilmut of the Roslin Institute near Edinburgh, Scotland, found a way to do the seemingly impossible.

Wilmut and his colleagues took mammary-gland cells from an adult sheep and placed them in a solution that essentially starved them of nutrients and caused them to stop growing for a few days. Then, with a spark of electricity, they fused each mammary cell with an enucleated egg cell. The resulting cells were allowed to grow into embryos, which were then transplanted into surrogate mother ewes (female sheep) to complete their development. Nearly 300 attempts at this technique resulted in failure for the scientists. Some eggs did not accept mammary cell nuclei, embryos that were produced died, and lambs that were born were abnormal and died. But one lamb, apparently healthy, survived the procedure: Dolly, who was born in July 1996.



World Book illustration by Peg Gerrity and

Roberta Polfus

The most important technical point of this research was that the nucleus of a specialized body cell from an adult animal could be reprogrammed to direct the development of a new organism—that is, the cell could be restored to totipotency (the capability, under certain circumstances, of directing the development of a complete organism). The cell-starvation technique used by the scientists was based on the theory that cells that are not growing become easier to reprogram. The programming of a nucleus is an interactive process between the cytoplasm (the cellular substance surrounding the nucleus) and the genes in the nucleus. The cytoplasm sends to the nucleus signals that determine which genes are turned on or off and therefore which proteins—the end product of genes—are produced by the cell. As the cell becomes specialized and loses its totipotency, it becomes unable to produce many proteins.

In nuclear transplantation, the longer the cytoplasm has to work on the transplanted nucleus before protein production begins, the more likely it is that the nucleus can be reprogrammed to direct the normal development of an embryo. Contributing to the success of the Roslin scientists was the fact that protein production begins relatively late in the development of sheep embryos, compared with, for example, mouse and human embryos. Therefore, there was a lot of time for the nucleus to be reprogrammed.

Further advances

An apparent advance on the Roslin technique was reported in August 1997, when scientists at ABS Global Incorporated in DeForest, Wisconsin, a biotechnology company specializing in livestock reproductive services, said that they had produced a calf using a cloning procedure more efficient than that used with Dolly. The Wisconsin scientists began by performing a nuclear transplantation to produce an embryo from a body cell of a 30-day-old bull fetus (a more fully developed embryo). Then they added another step. They took one of the cells from the embryo they had produced and performed a second nuclear transplantation. The embryo resulting from the second transplantation was then placed in a surrogate mother. The double nuclear transplantation helped make the nucleus even more susceptible to reprogramming and increased the success rate of the procedure. The scientists said that only 15 attempts were required before success was achieved with the birth of the calf, named Gene.

Although ABS Global researchers used a fetus as the source of the nucleus used to produce Gene, they said they were also experimenting with nuclei from the cells of adult cattle. The scientists hoped that their procedure would eventually enable animal breeders to produce an unlimited number of identical animals with superior traits.

Transgenic animals

In July 1997, Ian Wilmut and his colleagues announced that they had combined their cloning procedure with genetic engineering techniques to produce lambs with a human gene for a particular blood protein in their cells. First, Wilmut's team inserted the

human gene into a sheep fetus cell. This cell was then allowed to divide into many cells, each of which was then used in a nuclear transplantation to produce an embryo. Of three identical female lambs born with the human gene, two--named Polly and Molly--survived and were introduced to the press in December.

Animals engineered to carry genes from other species are called transgenic animals. The human gene that Polly and Molly were born with causes their bodies to produce factor IX, a human blood-clotting protein useful for treating hemophilia, a disorder in which blood clotting does not occur normally. The protein is secreted into the animals' milk and can be extracted to create a drug for treating hemophilia.

In January 1998, scientists at the University of Massachusetts and Advanced Cell Technology, Incorporated, a biotechnology firm in Worcester, Massachusetts, announced the birth of three transgenic calves created through a method similar to that used with Polly and Molly. Although these calves carried only an experimental gene that had no effect on the animals, the scientists said that other calves they planned on creating were to carry a gene to produce human serum albumin, a protein needed by people who have lost large amounts of blood.

Hawaii mouse cloning

Despite the importance of the various cloning accomplishments announced in 1997 and early 1998, none of them had achieved what the Roslin Institute researchers claimed to have achieved--the creation of an animal clone from an adult body cell. Because of this failure to duplicate the Dolly achievement, some scientists remained sceptical as to whether Dolly was in fact a clone of an adult animal. Much of this doubt was finally laid to rest in July 1998, when biologists at the University of Hawaii announced that they had created more than 50 mice using adult cells in a variation of the cloning procedure used with Dolly.

There were two major differences between this mouse technique and the Dolly technique that allowed the Hawaii scientists to achieve such remarkable success. The first difference was that the Hawaii researchers used naturally dormant cumulus cells (cells that surround eggs in ovaries) in their procedure. Because these cells were not growing, they could be easily reprogrammed inside enucleated egg cells without starving them in a special solution, as was necessary with the udder cells used in the Dolly procedure. Secondly, instead of electrically fusing a body cell with an enucleated egg cell, as was done in the Dolly technique, the Hawaii researchers used an extra-fine needle to inject the nucleus from a cumulus cell into an enucleated egg cell. Because this technique did less damage to the egg than did electrical fusion, it increased the chance that the resulting cell would develop into a healthy embryo.

Scientists said because there are important similarities between mouse and human development, the success of this mouse research made it more likely that humans could be successfully cloned.

Uses of cloning

Researchers said the cloning of animals, especially those that have been genetically modified in certain ways, could have a number of medical, agricultural, and industrial applications. For example, cloning could result in the mass production of genetically modified cattle that secrete valuable drugs into their milk. But the cloning of animals indicated that it may also be possible to clone humans. Much of the public expressed revulsion toward the prospect of human cloning, and some politicians vowed to outlaw it. Its proponents, however, saw human cloning as a way to help people, such as by allowing infertile couples to have children.

Animal cloning

Transgenic animals (animals engineered to carry genes from species other than their own) can be made to produce a wide variety of proteins that could be sold as drugs, as well as other proteins, called enzymes, that could be used to speed up industrial chemical reactions. Although the creation of transgenic animals began in the 1980's, cloning was expected to make it possible for such animals to be mass produced. Large numbers of transgenic animals could produce vast quantities of needed drugs and other useful substances more efficiently and at much lower cost than is possible with bioengineering methods. As of mid-1998, most genetically engineered proteins were being manufactured in bioreactors, large steel vessels in which billions of genetically modified microorganisms produce proteins that are then extracted and purified.

Researchers involved in cloning envision a number of other practical applications for their work, including the creation of genetically modified animals that could provide organs for human organ transplants; the mass production of faster-growing and leaner livestock; and the perpetuation of endangered species.

Human cloning



The same procedures used to clone sheep and cattle could theoretically be used to clone humans.

However, human cloning would probably be more difficult than sheep or cattle cloning, because the cells of human embryos start producing proteins at a relatively early stage. Thus, there would not be as much time for the egg cytoplasm to reprogram a transplanted nucleus. However, the successful 1998 cloning of mice, which also start producing proteins at an early embryonic stage, strongly indicated that this problem can be overcome in humans.

Geneticists foresee a number of practical applications for the cloning of humans. Infertile couples who do not wish to adopt, for instance, could use cloning to have children who are biologically related to them. Cloning could also be used to produce offspring free of certain diseases. For example, a number of disorders, including some affecting the eyes, brain, and muscles, are (at least partially) caused by flawed genes located in the mitochondria, energy-producing structures in the cytoplasm. If a woman were to carry a gene for one of these disorders, she could conceive a healthy child by having the nucleus of one of her body cells inserted into an enucleated egg cell from a woman who does not have anything wrong with her mitochondrial genes. The resulting embryo could then be implanted into the woman who donated the nucleus, and she would carry the baby to term.

Some proposed practical applications of cloning

- The mass production of animals engineered to carry human genes for the production of certain proteins that could be used as drugs; the proteins would be extracted from the animals' milk and used to treat human diseases.
- The mass production of animals with genetically modified organs that could be safely transplanted into humans.
- The mass production of livestock that have been genetically modified to possess certain desirable traits.
- The perpetuation of endangered species.
- The production of offspring by infertile couples.
- The production of offspring free of a potentially disease-causing genetic flaw carried by one member of a couple; the individual without the defect could be cloned.

Ethical concerns

Because no cloning technique had been perfected as of mid-1998, scientists expected that any attempt to clone a human would--just as in the work that led to Dolly--result in the death of many embryos and newborns before success was achieved. In addition, even if an infant clone survived, there was no guarantee that it would develop normally. The genetic material in body cells accumulates subtle molecular changes as an organism ages. Because the cell used to create Dolly came from a 6-year-old animal, Dolly's chromosomes had certain characteristics normally found only in older animals. This finding led some scientists to wonder whether Dolly, though appearing normal, might have inherited genetic damage that would eventually show up as premature aging or some other disorder.

An indication that Dolly could at least breed normally came in April 1998, when she gave birth to a lamb that Roslin scientists said was healthy. The lamb was not a clone, but rather the offspring of a natural mating between Dolly and a male sheep.

Because of the many unresolved issues, many scientists said that human cloning should be postponed until such questions were answered. Nonetheless, some people wanted attempts at human cloning to begin as soon as possible. They included a Chicago scientist who announced his intention to open a group of clinics to clone humans. In response to that proposal, the U.S. Food and Drug Administration (FDA) said in January 1998 that any such project would require FDA approval--which the agency indicated it might not grant.

Other ethical questions

The ethical debate over cloning also encompassed the possible psychological impact on the offspring. Would a human clone tend to have a diminished sense of individuality? Perhaps human clones would think that they were genetically destined to the same fate as the persons from whom their donor cells came.

Ethical questions have also been raised about cloning's effects on parenting and family life. Parents of clones might value their children according to how closely they met some overly detailed, preordained specifications. Cloning, therefore, could undermine basic elements of a loving, nurturing family, such as the acceptance of each child as a unique individual.

Cloning might have society-wide effects, as well. What would happen to a world that separated reproduction from love and other human relationships? Would society use cloning for eugenics (attempting to scientifically improve the human race according to arbitrary standards)? Ethicists have voiced concerns that cloning, combined with various techniques of genetic engineering, could lead to efforts to selectively breed children who are healthier, more intelligent, or even designed for warfare or slavery.

In favor of human cloning

Scientists and medical ethicists who argue in favor of human cloning claim that much of the public's concern is based on misconceptions. They note that, although many people believe that cloning would produce an instant carbon copy of an adult person, cloning would, in reality, produce what amounts to a delayed identical twin, several years or even decades younger than the person who donated the cell from which the clone was produced. Identical twins are genetic carbon copies, but they are separate individuals. They often look different because of different preferences in clothing and hairstyle. They may have different moral values, academic achievements, occupations, and tastes in music.

Another misconception that scientists suggest clouds the issue of human cloning is the question of how genes influence an individual's development. Human beings do not inherit a fixed, unchangeable genetic blueprint from their parents. Scientists believe that physical and mental traits result from complex interactions between genes and the environment in which an individual grows up and lives--including the chemical environment surrounding the fetus in the womb. Two people can inherit the same set of genes and turn out very differently, because environmental factors often determine how genes are expressed. A person might, for example, inherit genes for large body size, but those genes will not be fully expressed unless the person receives proper nutrition. Genes for musical ability may be expressed only if a person grows up in a family that loves music.

Would human clones be less human?

Some ethicists voice fears that human clones might be considered less than human and might be used for spare parts in organ transplants or for other unethical purposes. Legal experts, however, claim that clones would have all the legal rights and

protections of other people. They note that society never questioned the legal rights of offspring resulting from other reproductive technologies, such as in vitro fertilization (the technology that produces "test-tube babies").

Perhaps the strongest argument put forth in favor of human cloning is that cloning could provide the only avenue available to some infertile couples for producing children. In cases of fertile couples in which one member carries a gene for a disease, cloning using a cell from the other member could assure that the couple has a healthy child of its own. Some U.S. legal experts claim that preventing a couple from choosing cloning as a method of reproduction could be unconstitutional. Scientists and ethicists who favor human cloning research also argue that cloning may provide a better understanding of the nature of genetic diseases and aid in the production of embryos from which cells could be obtained to grow various organs for organ transplants.

Arguments used against and in defense of human cloning

Against

- Cloning might lead to the creation of genetically engineered groups of people for specific purposes, such as warfare or slavery.
- Cloning might lead to an attempt to improve the human race according to an arbitrary standard.
- Cloning could result in the introduction of additional defects in the human gene pool.
- Cloning is unsafe. There are too many unknown factors that could adversely affect the offspring.
- A clone might have a diminished sense of individuality.
- A clone might have fewer rights than other people.
- Doctors might use clones as sources of organs for organ transplants.
- Cloning is at odds with the traditional concept of family.
- Cloning is against God's will.

• Some aspects of human life should be off limits to science.

In defense of:

- Cloning would enable infertile couples to have children of their own.
- Cloning would give couples who are at risk of producing a child with a genetic defect the chance to produce a healthy child.
- Cloning could shed light on how genes work and lead to the discovery of new treatments for genetic diseases.
- A ban on cloning may be unconstitutional. It would deprive people of the right to reproduce and restrict the freedom of scientists.
- A clone would not really be a duplicate, because environmental factors would mold him or her into a unique individual.
- A clone would have as much of a sense of individuality as do twins.
- A clone would have the same rights as do all other people.
- Cloning is comparable in safety to a number of other medical procedures.
- Objections to cloning are similar to objections raised against previous scientific achievements, for example, heart transplants and test-tube babies, that later came to be widely accepted.

Source : Cloning : Are Humans next?

Cloning
the Big Time

Hits

Genetic copying of animals is attracting commercial interest.

When scientists at the Roslin Institute in Edinburgh reported last February that they had cloned an adult sheep, their work immediately captivated the public.

But some cautious researchers wondered whether the success might not be a flash in the pan. After all, the Scottish workers had to try 277 times before they succeeded in producing the clone, named Dolly. Unless the efficiency of the cloning process could be greatly improved, it seemed unlikely to become a common technique for producing improved strains of livestock. Moreover, Dolly's birth did not prove that cloning could be used to create animals from cells that had been genetically manipulated. Unless cloning could be combined with sophisticated genetic manipulation, the technique seemed unlikely to realize its full potential.

Just six months later, it seems clear that doubts are unfounded. While the debate focused on Dolly, a number of other corporate and academic laboratories were quietly pushing ahead with similar projects. At least two U.S. companies--ABS Global of De Forest, Wisc., and Advanced Cell Technology of Worcester, Mass.--have successfully impregnated cows and pigs using cloned cells. In addition, the work over the past six months has demonstrated that cloning works perfectly well on cells that have been genetically altered.

Both corporate contenders claim that their cloning techniques are highly efficient. And neither is making any bones about its commercial intentions. In early August, ABS Global simultaneously introduced a six month old bull named Gene and announced it had formed a new subsidiary, called Infigen, to "commercialize applications of cloning technologies in the cattle breeding, pharmaceutical, nutraceutical and xenotransplantation fields."

Separately, Neal First of the University of Wisconsin at Madison has established, at least transiently, pregnancies in five different species using cloned adult cells. First says he has developed a "universal cloning system" based on cow egg cells that he has used to impregnate cows, sheep, rats, pigs and monkeys.



HARBINGER. Last February, the Roslin Institute's lamb, named Dolly, became the first animal clone to capture public attention. In cloning procedures generally, nuclei are extracted from cultured cells that might have come originally from an embryo, a fetus or an adult organism. The nuclei are inserted into egg cells which have had their original nucleus removed, a process called nuclear transfer. In the initial work at the Roslin Institute, the egg cells along with their transplanted nuclei were then implanted directly into a foster mother, where they developed and, in the case of Dolly, resulted in a viable offspring.

Researchers at Infigen use a variation on the Roslin approach, explains research director Michael D. Bishop. Rather than transferring just the nucleus, the ABS workers fuse a whole donor cell with an enucleated (nucleus removed) egg cell, a process that is helped along with a jolt of electricity. These donor cells are relatively unspecialized cells taken from fetuses.

When the resulting embryo has divided into about sixteen cells, it is broken up, or disaggregated, into its component cells. The resulting cells are themselves fused with other enucleated egg cells. These second-generation cells are then implanted into foster mothers to develop, which many of them do successfully. The calf "Gene" was cloned from fetal cells using this technique; the company expects to announce the births of cattle cloned from adult cells shortly. By selectively making copies of genetically superior animals, Infigen's corporate parent hopes to boost its share of the lucrative market for bull semen. It might eventually begin selling cloned, genetically-altered animals, says Bishop.

Advanced Cell Technology, for its part, has initiated dozens of clone pregnancies in cows and some in pigs. The company says it anticipates the first births in the near future. For these clones, the donor cells were fibroblasts taken from fetuses. The genomes of these cells can be relatively easily and precisely manipulated through a technique known as targeted gene replacement. "Advanced Cell Technology has the ability to produce transgenic animals using fetal fibroblast nuclear transfer," claims Steve Parkinson, president and chief executive officer.

Parkinson contends that targeted gene replacement produces cells having specific genetic alterations far more effectively than the traditional technique for making transgenic animals, which entails injecting DNA into cell nuclei. He reports that Advanced Cell Technology plans to clone genetically altered animals whose neural tissue would be immunologically compatible with that of humans. Clinical trials of such tissue on patients with Parkinson's disease could start by 1999, he says.

Cloning progress is not restricted to the U.S. Since the February breakthrough, PPL Therapeutics of Edinburgh, which collaborates with the Roslin Institute, has produced five lambs from fetal cells that were genetically modified to carry marker genes and genes for human proteins. Lambs produced from the genetically manipulated cells produce foreign proteins; such animals may be able to manufacture large quantities of medically valuable human proteins in their milk. The result "brings nearer the human benefits from nuclear transfer work," says Ron James, managing director of PPL. The same company is also working on cloned cattle in the U.S. Dolly, then, was more than just an overnight sensation. Rather, cloning seems set to become a vital technology for agriculture and medicine. "I think the possibility is there that it might really move large-animal transgenic work forward much more rapidly," says Vernon Pursell of the U.S. Department of Agriculture. In other words, better forget the jokes and starting looking at the stock prices.

--*Tim Beardsley, staff writer*

RELATED LINKS:

"A Clone in Sheep's Clothing" by Tim Beardsley; Scientific American Exploration, March 3, 1997

Readers' opinions on cloning; Scientific American Forum, March 3, 1997

Interview with Ian Wilmut of the Roslin Institute from *Salon*

Cloning analysis from *Nature*

Agbiotech: resources in agricultural biotechnology

The Potential of Cloned Livestock



MEET 'GENE.' This six-month old bull is just the latest in what is fast becoming a barnyard full of cloned animals. Its developer, [ABS Global](#) is pursuing animal cloning as a means of producing superior livestock.

In addition, cloned animals carrying specific introduced genes may bring to fruition the idea of "pharming" -- using domesticated animals to produce drugs and other medically important substances. Genetically-modified sheep, goats and cattle are already being used experimentally as 'bioreactors' to produce human proteins in their milk, but cloning should simplify the process of introducing foreign genes into large numbers of animals.

According to the [Roslin Institute](#) in Edinburgh key targets include:

- Human therapeutic proteins
- Organs and tissues for transplants
- Nutraceuticals
- 'Humanized' cows milk
- Animal models of disease
- Cell therapy agents

Comparing

Cloning Techniques:

- [Roslin Institute](#)
- [Infigen](#)

Two

Cloning For Medicine

Now that genetically modified and copied mammals are a reality, biomedical researchers are starting to develop imaginative ways to use this technology.

by Ian Wilmut

.....
SUBTOPICS:

[How to Clone](#)

[Clones with a Difference](#)

[Making Human Stem Cells](#)

[No to Cloned People](#)

SIDEBAR:

[Is Quiescence the Key to Cloning](#)

ILLUSTRATIONS:

[How Megan and Morag Were Made](#)

[How to Prepare Cells to Make Transgenic Clones](#)

FURTHER READING

RELATED LINKS In the summer of 1995 the birth of two lambs at my institution, the [Roslin Institute](#) near Edinburgh in Midlothian, Scotland, heralded what many scientists believe will be a period of revolutionary opportunities in biology and medicine. Megan and Morag, both carried to term by a surrogate mother, were not produced from the union of a sperm and an egg. Rather their genetic material came from cultured cells originally derived from a nine-day-old embryo. That made Megan and Morag genetic copies, or clones, of the embryo.

Before the arrival of the lambs, researchers had already learned how to produce sheep, cattle and other animals by genetically copying cells painstakingly isolated from early-stage embryos. Our work promised to make cloning vastly more practical, because cultured cells are relatively easy to work with. Megan and Morag proved that even though such cells are partially specialized, or differentiated, they can be genetically reprogrammed to function like those in an early embryo. Most biologists had believed that this would be impossible.

We went on to clone animals from cultured cells taken from a 26-day-old fetus and from a mature ewe. The ewe's cells gave rise to [Dolly](#), the first mammal to be cloned from an adult. Our announcement of Dolly's birth in February 1997 attracted enormous [press interest](#), perhaps because Dolly drew attention to the theoretical possibility of cloning humans. This is an outcome I hope never comes to pass. But the ability to make clones from cultured cells derived from easily obtained tissue should bring numerous practical benefits in animal husbandry and medical science, as well as answer critical biological questions.

How to Clone

Cloning is based on [nuclear transfer](#), the same technique scientists have used for some years to copy animals from embryonic cells. Nuclear transfer involves the use of two cells. The recipient cell is normally an unfertilized egg taken from an animal soon after ovulation. Such eggs are poised to begin developing once they are appropriately stimulated. The donor cell is the one to be copied. A researcher working under a high-power microscope holds the recipient egg cell by suction on the end of a fine pipette and uses

an extremely fine micropipette to suck out the chromosomes, sausage-shaped bodies that incorporate the cell's DNA. (At this stage, chromosomes are not enclosed in a distinct nucleus.) Then, typically, the donor cell, complete with its nucleus, is fused with the recipient egg. Some fused cells start to develop like a normal embryo and produce offspring if implanted into the uterus of a surrogate mother [see [illustration](#)].

In our experiments with cultured cells, we took special measures to make the donor and recipient cells compatible. In particular, we tried to coordinate the cycles of duplication of DNA and those of the production of messenger RNA, a molecule that is copied from DNA and guides the manufacture of proteins. We chose to use donor cells whose DNA was not being duplicated at the time of the transfer [see [box](#)]. To arrange this, we worked with cells that we forced to become quiescent by reducing the concentration of nutrients in their culture medium. In addition, we delivered pulses of electric current to the egg after the transfer, to encourage the cells to fuse and to mimic the stimulation normally provided by a sperm.

After the birth of Megan and Morag demonstrated that we could produce viable offspring from embryo-derived cultures, we filed for patents and started experiments to see whether offspring could be produced from more completely differentiated cultured cells. Working in collaboration with PPL Therapeutics, also near Edinburgh, we tested fetal fibroblasts (common cells found in connective tissue) and cells taken from the udder of a ewe that was three and a half months pregnant. We selected a pregnant adult because mammary cells grow vigorously at this stage of pregnancy, indicating that they might do well in culture. Moreover, they have stable chromosomes, suggesting that they retain all their genetic information. The successful cloning of Dolly from the mammary-derived culture and of other lambs from the cultured fibroblasts showed that the Roslin protocol was robust and repeatable.

All the cloned offspring in our experiments looked, as expected, like the breed of sheep that donated the originating nucleus, rather than like their surrogate mothers or the egg donors. Genetic tests prove beyond doubt that Dolly is indeed a clone of an adult. It is most likely that she was derived from a fully differentiated mammary cell, although it is impossible to be certain because the culture also contained some less differentiated cells found in small numbers in the mammary gland. Other laboratories have since used an essentially similar technique to create healthy clones of cattle and mice from cultured cells, including ones from nonpregnant animals.

Although cloning by nuclear transfer is repeatable, it has limitations. Some cloned cattle and sheep are unusually large, but this effect has also been seen when embryos are simply cultured before gestation. Perhaps more important, nuclear transfer is not yet efficient. John B. Gurdon, now at the University of Cambridge, found in nuclear-transfer experiments with frogs almost 30 years ago that the number of embryos surviving to become tadpoles was smaller when donor cells were taken from animals at a more advanced developmental stage. Our first results with mammals showed a similar pattern. All the cloning studies described so far show a consistent pattern of deaths during embryonic and fetal development, with laboratories reporting only 1 to 2 percent of embryos surviving to become live offspring. Sadly, even some clones that survive through birth die shortly afterward.

Clones with a Difference

The cause of these losses remains unknown, but it may reflect the complexity of the genetic reprogramming needed if a healthy offspring is to be born. If even one gene inappropriately expresses or fails to express a crucial protein at a sensitive point, the result might be fatal. Yet reprogramming might involve regulating thousands of genes in a process that could involve some randomness. Technical improvements, such as the use of different donor cells, might reduce the toll.

The ability to produce offspring from cultured cells opens up relatively easy ways to make genetically modified, or transgenic, animals. Such animals are important for research and can produce medically valuable human proteins.

The standard technique for making transgenic animals is painfully slow and inefficient. It entails microinjecting a genetic construct--a DNA sequence incorporating a desired gene--into a large number of fertilized eggs. A few of them take up the introduced DNA so that the resulting offspring express it. These animals are then bred to pass on the construct [see "Transgenic Livestock as Drug Factories," by William H. Velander, Henryk Lubon and William N. Drohan; *Scientific American*, January 1997].

In contrast, a simple chemical treatment can persuade cultured cells to take up a DNA construct. If these cells are then used as donors for nuclear transfer, the resulting cloned offspring will all carry the construct. The Roslin Institute and PPL Therapeutics have already used this approach to produce transgenic animals more efficiently than is possible with microinjection [see [illustration](#)].

We have incorporated into sheep the gene for human factor IX, a blood-clotting protein used to treat hemophilia B. In [this experiment](#) we transferred an antibiotic-resistance gene to the donor cells along with the factor IX gene, so that by adding a toxic dose of the antibiotic neomycin to the culture, we could kill cells that had failed to take up the added DNA. Yet despite this genetic disruption, the proportion of embryos that developed to term after nuclear transfer was in line with our previous results.

The first transgenic sheep produced this way, Polly, was born in the summer of 1997. Polly and other transgenic clones secrete the human protein in their milk. These observations suggest that once techniques for the retrieval of egg cells in different species have been perfected, cloning will make it possible to introduce precise genetic changes into any mammal and to create multiple individuals bearing the alteration.

Cultures of mammary gland cells might have a particular advantage as donor material. Until recently, the only practical way to assess whether a DNA construct would cause a protein to be secreted in milk was to transfer it into female mice, then test their milk. It should be possible, however, to test mammary cells in culture directly. That will speed up the process of finding good constructs and cells that have incorporated them so as to give efficient secretion of the protein.

Cloning offers many other possibilities. One is the generation of genetically modified animal organs that are suitable for transplantation into humans. At present, thousands of patients die every year before a replacement heart, liver or kidney becomes

available. A normal pig organ would be rapidly destroyed by a "hyperacute" immune reaction if transplanted into a human. This reaction is triggered by proteins on the pig cells that have been modified by an enzyme called alpha-galactosyl transferase. It stands to reason, then, that an organ from a pig that has been genetically altered so that it lacks this enzyme might be well tolerated if doctors gave the recipient drugs to suppress other, less extreme immune reactions.

Another promising area is the rapid production of large animals carrying genetic defects that mimic human illnesses, such as cystic fibrosis. Although mice have provided some information, mice and humans have very different genes for cystic fibrosis. Sheep are expected to be more valuable for research into this condition, because their lungs resemble those of humans. Moreover, because sheep live for years, scientists can evaluate their long-term responses to treatments.

Creating animals with genetic defects raises challenging ethical questions. But it seems clear that society does in the main support research on animals, provided that the illnesses being studied are serious ones and that efforts are made to avoid unnecessary suffering.

The power to make animals with a precisely engineered genetic constitution could also be employed more directly in cell-based therapies for important illnesses, including Parkinson's disease, diabetes and muscular dystrophy. None of these conditions currently has any fully effective treatment. In each, some pathological process damages specific cell populations, which are unable to repair or replace themselves. Several novel approaches are now being explored that would provide new cells--ones taken from the patient and cultured, donated by other humans or taken from animals.

To be useful, transferred cells must be incapable of transmitting new disease and must match the patient's physiological need closely. Any immune response they produce must be manageable. Cloned animals with precise genetic modifications that minimize the human immune response might constitute a plentiful supply of suitable cells. Animals might even produce cells with special properties, although any modifications would risk a stronger immune reaction.

Cloning could also be a way to produce herds of cattle that lack the prion protein gene. This gene makes cattle susceptible to infection with prions, agents that cause bovine spongiform encephalitis (BSE), or mad cow disease. Because many medicines contain gelatin or other products derived from cattle, health officials are concerned that prions from infected animals could infect patients. Cloning could create herds that, lacking the prion protein gene, would be a source of ingredients for certifiable prion-free medicines.

The technique might in addition curtail the transmission of genetic disease. Many scientists are now working on therapies that would supplement or replace defective genes in cells, but even successfully treated patients will still pass on defective genes to their offspring. If a couple was willing to produce an embryo that could be treated by advanced forms of gene therapy, nuclei from modified embryonic cells could be transferred to eggs to create children who would be entirely free of a given disease.

Some of the most ambitious medical projects now being considered envision the production of universal human donor cells. Scientists know how to isolate from very early mouse embryos undifferentiated stem cells, which can contribute to all the different tissues of the adult. Equivalent cells can be obtained for some other species, and humans are probably no exception. Scientists are learning how to differentiate stem cells in culture, so it may be possible to manufacture cells to repair or replace tissue damaged by illness.

Making Human Stem Cells

Stem cells matched to an individual patient could be made by creating an embryo by nuclear transfer just for that purpose, using one of the patient's cells as the donor and a human egg as the recipient. The embryo would be allowed to develop only to the stage needed to separate and culture stem cells from it. At that point, an embryo has only a few hundred cells, and they have not started to differentiate. In particular, the nervous system has not begun to develop, so the embryo has no means of feeling pain or sensing the environment. Embryo-derived cells might be used to treat a variety of serious diseases caused by damage to cells, perhaps including AIDS as well as Parkinson's, muscular dystrophy and diabetes.

Scenarios that involve growing human embryos for their cells are deeply disturbing to some people, because embryos have the potential to become people. The views of those who consider life sacred from conception should be respected, but I suggest a contrasting view. The embryo is a cluster of cells that does not become a sentient being until much later in development, so it is not yet a person. In the U.K., the Human Genetics Advisory Commission has initiated a major public consultation to assess attitudes toward this use of cloning.

Creating an embryo to treat a specific patient is likely to be an expensive proposition, so it might be more practical to establish permanent, stable human embryonic stem-cell lines from cloned embryos. Cells could then be differentiated as needed. Implanted cells derived this way would not be genetically perfect matches, but the immune reaction would probably be controllable. In the longer term, scientists might be able to develop methods for manufacturing genetically matched stem cells for a patient by "dedifferentiating" them directly, without having to utilize an embryo to do it.

No to Cloned People

Several commentators and scientists have suggested that it might in some cases be ethically acceptable to clone existing people. One scenario envisages generating a replacement for a dying relative. All such possibilities, however, raise the concern that the clone would be treated as less than a complete individual, because he or she would likely be subjected to limitations and expectations based on the family's knowledge of the genetic "twin." Those expectations might be false, because human personality is only partly determined by genes. The clone of an extrovert could have a quite different demeanor. Clones of athletes, movie stars, entrepreneurs or scientists might well choose different careers because of chance events in early life.

Some pontificators have also put forward the notion that couples in which one member is infertile might choose to make a copy of one or the other partner. But society ought to be concerned that a couple might not treat naturally a child who is a copy of just one of them. Because other methods are available for the treatment of all known types of infertility, conventional therapeutic avenues

seem more appropriate. None of the suggested uses of cloning for making copies of existing people is ethically acceptable to my way of thinking, because they are not in the interests of the resulting child. It should go without saying that I strongly oppose allowing cloned human embryos to develop so that they can be tissue donors.

It nonetheless seems clear that cloning from cultured cells will offer important medical opportunities. Predictions about new technologies are often wrong: societal attitudes change; unexpected developments occur. Time will tell. But biomedical researchers probing the potential of cloning now have a full agenda.

Related Links

["Cloning Hits the Big Time"](#) by Tim Beardsley; Scientific American Exploration, February 9, 1997

["A Clone in Sheep's Clothing"](#) by Tim Beardsley; Scientific American Exploration, March 3, 1997

["Send in the Clones"](#) by Kristin Leutwyler; Scientific American Explorations, July 27, 1998

[Information on Cloning and Nuclear transfer](#): Roslin Institute Online

[Cloning--A special report](#): The *New Scientist*

[The Ethics of Human Cloning](#) from the Institute for Philosophy & Public Policy at the University of Maryland

Further Reading

CELL CYCLE CO-ORDINATION IN EMBRYO CLONING BY NUCLEAR TRANSFER. K.H.S. Campbell, P. Loi, P. J. Otaegui and I. Wilmut in *Reviews of Reproduction*, Vol. 1, No. 1, pages 40--46; January 1996.

GENOMIC POTENTIAL OF DIFFERENTIATED CELLS. Marie A. Di Berardino. Columbia University Press, 1997.

SHEEP CLONED BY NUCLEAR TRANSFER FROM A CULTURED CELL LINE. K.H.S. Campbell, J. McWhir, W. A. Ritchie and I. Wilmut in *Nature*, Vol. 385, pages 810--813; February 27, 1997.

HUMAN FACTOR IX TRANSGENIC SHEEP PRODUCED BY TRANSFER OF NUCLEI FROM TRANSFECTED FETAL FIBROBLASTS. E. Schnieke et al. in *Science*, Vol. 278, pages 2130--2133; December 19, 1997.

The Author

[IAN WILMUT](#) pursues research on the genetic engineering of livestock at the [Roslin Institute](#) near Edinburgh in Midlothian, Scotland. After obtaining a Ph.D. from the [University of Cambridge](#) for research on methods of freezing boar semen, he did postdoctoral work at Cambridge on techniques for freezing animal embryos. Later Wilmut identified developmental and physiological causes of prenatal death in sheep and pigs, before turning to studies of ways to improve economically important animals.

Friday, 4 May, 2001, 14:55 GMT 15:55 UK

The human gene harvest



Tobacco plants containing human genes have been grown in the US

By BBC News Online's Helen Briggs

Rows of tobacco plants grow in a remote field in Virginia, United States.

Although they look like any other crop, these plants, which contain a human gene, represent the future hopes of the biotech industry.

“
We had human serum albumin and another human protein growing in seven different sites in the state of Virginia in the field last summer

Carole Kramer, Chief Scientific Officer, CropTech

CropTech Corporation, a company trying to turn plants into medicine factories, believes that tobacco plants like these, tested in field trials last summer, will one day be able to manufacture human proteins capable of treating a host of diseases.

But the research has triggered debate among those opposed to the transplant of human genes into plants, including the Catholic Church.

GM first

Tobacco was the first plant ever to be genetically modified, back in the 1980s. The easiest plant to genetically engineer, it is a rapid and efficient biomass producer.

"Tobacco has a great reproductive rate and so a single plant will produce up to a million seeds," says Professor Carole Cramer, Chief Scientific Officer at CropTech and a professor at Virginia Tech. "If you compare that say with corn - a single corn plant will produce maybe 300 seeds.



Infants with rare genetic diseases could one day be treated with medicines made by plants

She says that, in many cases, plants will be able to make drugs that no other system can make.

"In a situation where medical costs are escalating at such a rate if we can actually come up with technologies that bring the forefront of science, the new medicines that are available, to people in a cost-effective way, that is significant."

CropTech, based in Blacksburg, Virginia, has already inserted nine different human genes into tobacco. It is also testing proteins from a number of other biotech and pharmaceutical companies to see whether plants can be persuaded to synthesise these potential drugs.

Enzyme factory

One example of a human protein that has been successfully expressed in tobacco plants, albeit in small quantities, is the human enzyme glucocerebrosidase, which processes an essential fatty substance in the body.

If the enzyme is absent, because of a genetic mutation, the fat builds up in the organs and sometimes brains of newborn babies.

The result is a rare genetic disorder known as Gaucher's disease, which, in the most severe cases, is fatal by the age of six months.



Plants may be able to produce blood products

Gaucher's disease can be treated - by replacing the missing enzyme - but the treatment is very expensive and must be taken for life. Until recently, the enzyme replacement therapy used to treat Gaucher's disease, with an average price per patient of more than \$150,000 (£104,000) a year, was known as the "most expensive drug in the world".

The drug had to be laboriously extracted from human placenta, a single dose requiring 400-2,000 of them.

Last year, a new drug, manufactured in a mammalian cell culture system, came on to the market. Although the drug is regarded as safer, it is no cheaper, which is why CropTech is trying to produce the drug in tobacco.

Clinical trials

Professor Cramer says the best tobacco plants are able to synthesise a single dose of active enzyme - but not in the exact form needed for human metabolism.

"This has not moved into human clinical trials because for this particular enzyme the exact shape of the sugars on the outside are critical for it to function appropriately in the human body and tobacco doesn't do that quite right," she says.

CropTech is also working on producing blood clotting replacement products such as human serum albumin in bioengineered plants. The first generation of tobacco plants made human serum albumin but not in commercially useful quantities.

"We had human serum albumin and another human protein [a clot bluster, a blood protein] growing in seven different sites in the state of Virginia in the field last summer," says Professor Cramer.

"We are hopeful that there will be a commercial launch between 2003 and 2005 of RoundUp Ready spring wheat in North America only," says Monsanto's Mark Buckingham.



The GM loaf is on the way

As a staple part of the diet of millions of people around the world, the advent of the GM loaf is likely to be a particularly sensitive issue for consumers. And there are signs that the US wheat industry is being very cautious about deciding whether or not to go forward with the technology.

However, biotech enthusiasts argue that a new wave of products - the first GM foods with enhanced nutritional qualities - will be more palatable to consumers.

The first such foods are likely to appear on the supermarket shelves in the next few years.

Golden rice

One of the first examples is being kept under lock and key in a grenade-proof greenhouse on the outskirts of Zurich, Switzerland.

Unlike any other rice, this genetically modified variety contains a gene from a daffodil that enables it to produce beta-carotene in seeds. Beta-carotene, which is converted into vitamin A in the body, is crucial for healthy vision. The World Health Organisation estimates that 124 million children in developing countries do not get enough vitamin A.



Professor Ingo Potrykus handles stalks of GM rice

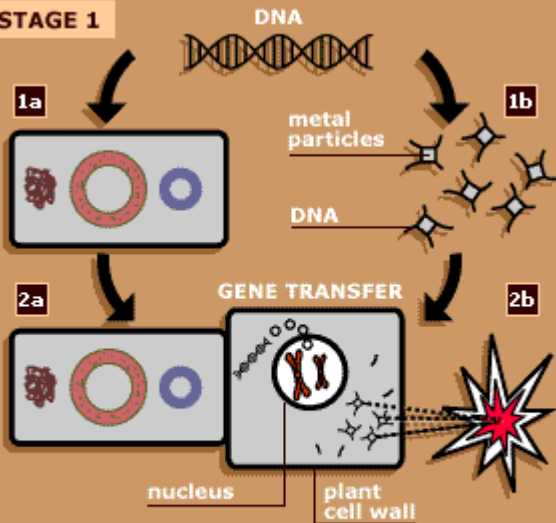
The scientists who invented Vitamin A rice, Ingo Potrykus and Peter Beyer, have promised to make their share of the golden rice intellectual property available to poor farmers for free. But the rice is still subject to about 70 other patents and legal agreements.

Advocates believe that vitamin A producing plants, such as golden rice and a new bright orange vitamin A sweet potato, could alleviate suffering.

But environmentalists challenge such claims, accusing the biotech industry of cynically promoting the benefits of such crops to thrust GMOs on the developed world.

Methods for genetically engineering a plant

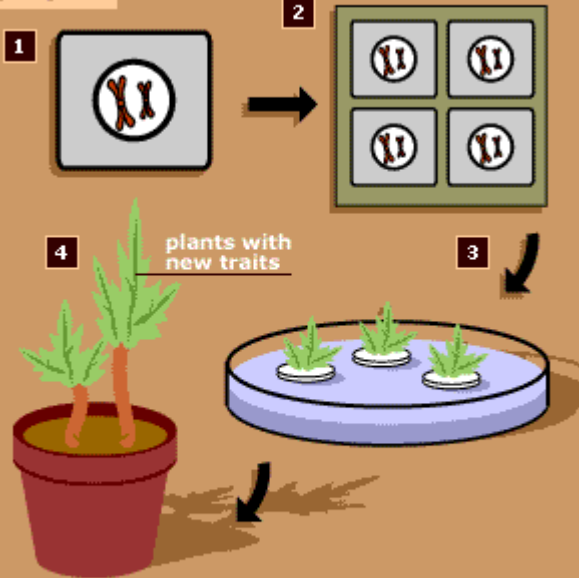
STAGE 1



- 1a Introduce DNA into agrobacterium
- 1b DNA coating of microscopic metal particles
- 2a Bacterial transfer of DNA
- 2b Accelerate particles into plant cells

Methods for genetically engineering a plant

STAGE 2



- 1 DNA insertion
- 2 Cell division
- 3 Cells regenerate into plantlets
- 4 Transfer to soil

Links :

[Yahoo Search Reults for Cloning](#)