Cloning:
Where We Have Been and Where We Will Go from Here

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In *The Devil's Dictionary,* American author and satirist Ambrose Bierce defines admiration as "our polite recognition of another's resemblance to ourselves." Indeed, we all love ourselves. There are a few others whom we can love to the same extent: our parents, our significant others, and our children. But can we also love our clones, exact genetic replicas of ourselves? That is, if we were ever to have clones. This seems like a very distant possibility. However, we may not be too far away from a world where we coexist with our clones.

At the dawn of 2003, Brigitte Boisselier, a French chemist, claimed the birth of the first human clone nickednamed Baby Eve. Boisselier was also busy running the first human cloning company, Clonaid, and serving as the bishop of the Raelian religion, a new religious sect that believes aliens created life on earth, that sexual freedom is important, and that life can be eternalized through cloning technologies.[1] She managed to shake the scientific community, add fuel to the already burning cloning debate in the U.S., and stir a bigger wave of controversy among religious groups with her evidence-deficient claim before the festive New Year.

Scientific technology has advanced rapidly over the past six years since the birth of Dolly, the first cloned mammal, in 1996. The question used to be: "Is it possible to clone?" The question today is: "To clone or not to clone?" In just a few years, an array of different animals has been cloned as the technology has continuously improved. We can now look back at what we have accomplished and ask ourselves, "Where we will go from here?"

Although not an easy thing to do, cloning has proved to be contagious. Now there are hundreds of cloned animals, including sheep, goats, mice, pigs, cows, cats, and, most recently, rabbits.

The Journey So Far

Dolly: The Cloned Sheep

The hype about cloning began with the birth of Dolly, the first cloned mammal born on July 5, 1996, at the Roslin Institute in Edinburgh, Scotland.[2] The project was headed by Dr. Ian

Wilmut and his team of embryologists. Their success not only opened a new frontier in biological possibilities but also initiated the first wave of debate on the ethics of cloning.

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Dolly was cloned from an udder cell of a 6-year-old Finn Dorset ewe.[3] Out of 250 attempts and twenty-nine cloned embryos created by the team, only Dolly developed successfully, a first sign indicating that cloning is not an easy business.[4] Nevertheless, Dolly was able to mate normally and give birth to healthy lambs, proving that clones are reproductively capable. A clone's life, however, is not easy. Besides being under constant attention, Dolly developed arthritis, obesity, and lung complications that rendered her a rather uncomfortable life. As a result, Dolly was euthanized in mid-February this year at the age of 6, about half of an average sheep's life expectancy.[3]

Before a postmortem autopsy is performed, it is hard to tell if Dolly's declined health was a result of her being a clone. After all, Dolly was not an ordinary sheep. As a celebrity animal, she spent most of her time indoors; a factor that scientists now suspect might have contributed to her lung failure. Her other health-related disorders such as arthritis and obesity have also been considered side effects of her constantly begging for treats and standing on her hind legs.[5]

Some researchers, however, have found some scientific evidence suggesting that her arthritis and her lung problem, a common lung disease seen in indoor elder sheep, were due to her being a clone.[5] A study conducted when Dolly was 3 revealed that Dolly was in fact older than thought. At the tips of the chromosomes there is a region called the telomeres, which usually becomes shorter as cells continue to divide and develop. Scientists found Dolly's telomeres much shorter than other sheep of her age. Although only 3 years old when the test was conducted, her telomeres were similar to those in a 6-year-old sheep, an indication that Dolly could have had a shorter life expectancy.[6] The decision to put her to death this past February because of her failing health might have validated this omen.

Cloned Mice

Almost two years after Dolly's birth, scientists in the laboratory of Ryuzo Yanagimachi at the University of Hawaii successfully created cloned mice. Even more astounding is the fact that the cloned mice were produced using a different technique than that which produced Dolly, indicating that more than one way exists to clone animals. A drawback to the technique is that it requires types of cells found only in female bodies. As a result, the technique only works on females. Like Dolly, the first cloned mouse that successfully reached adulthood was also given a name, Cumulina. Born on October 3, 1998, it was among more than fifty cloned mice produced after hundreds of attempts. Similar to Wilmut's experiment, the success rate for cloning was much lower than one might have expected; only about 1 to 2 percent of the clones were born. However, the team was also able to produce second-generation cloned mice, clones of clones.[7]

A more important aspect of the team's experiment is that the animal cloned was a mouse. Experts previously thought that Dolly was a success because she was a sheep. Many farm animals have cellular DNA intervention fairly late in embryonic development. The delay buys time for the implanted genetic material "to be reprogrammed by the egg."[7] However, DNA starts doing its work very early in mice and human embryonic development. The early intervention would require functional DNA that has already been "properly programmed."[7] The fact that cloned mice are attainable indicates that DNA can be reprogrammed in a short amount of time, which suggests that a cloned human can be created.

Cloned Human Embryo

A Worcester, Mass.–based company, Advanced Cell Technology (ACT), announced in late November 2001 that it had successfully cloned human embryos. By using the

standard cloning technique (as explained in the next section), the company was able to create a six-cell human embryo.[8] The news invited excitement, outrage, and skepticism. Many scientists thought the announcement was rather hasty and premature, because a mere six-cell embryo is a far cry from a clone. According to experts, an ovum is capable of developing through the eight-cell stage "without any signals from the DNA in the nucleus."[9] Therefore, it is possible that what ACT observed is not the genuine success of cloned embryos.

ACT is not new to the cloning business. The company was known to have created an embryo by inserting human DNA into a cow's ovum. The high degree of reaction to such a quasi-minotaur creation is to be expected. But the company only allowed the embryo to grow through five cell divisions, as the researchers' goal was not to create an actual human clone but to experiment with possibilities in stem cell research.[10]

The company also experimented with parthenogenesis, a process in which a human ovum is allowed to "divide into early embryos without being fertilized by a sperm or being enucleated and injected with a donor cell." The goal of this was to obtain stem cells to grow transplantable organs that are less likely to be rejected by patients. Although previous experiments done by other experts with eggs from other animals have proven successful, ACT was not able to produce successful embryos that contain stem cells.[11]

Cloned Pet

Although not an easy thing to do, cloning has proved to be contagious. Now there are hundreds of cloned animals, including sheep, goats, mice, pigs, cows, cats, and, most recently, rabbits.[5] The famous first cloned pet, a cat named Cc, was born at the end of 2001 in a laboratory in Texas. Cc was the only one to survive out of eighty-seven cloned embryos. Not unlike other cloning success stories, Cc's birth also generated immense excitement and controversy. Experts are now looking into cloning technology to save endangered species; a type of endangered wild cattle has already been cloned successfully. Businessmen are also hoping that one day cloning technology can be used commercially to allow pet owners to re-create their deceased beloved companions.[12] Although many types of animals have already been cloned so, animals such as dogs, certain monkeys, and human beings have yet to be replicated.[5]

Cloned Human?

Baby Eve is allegedly a clone of her 31-year-old American mother made from her skin cell and an ovum. She was the first of the five cloned babies claimed by Clonaid to be born.[1] All babies were due to be born by early February 2003, including the baby of a Dutch lesbian couple. Although Boisselier maintains that the birth of the cloned babies is a new scientific breakthrough, most experts are highly skeptical of her claim. Not only does Boisselier have no evidence to prove the baby's existence or the fact that she's a clone, but she has also backed off from having the baby tested for authenticity because of her concerns for the safety of the baby. The fact that Clonaid has not cloned anything before and that their success rate of the claimed human clone—five in ten—gave the public legitimate reason to doubt. But as what Robert P. Lanza, a cloning expert with ACT, points out, "It may be rather easier than any of us thought to clone a human."[13] Maybe, just maybe, we are all looking in the wrong direction.

With the low success rate of producing a viable cloned embryo, it is legitimate to question how we will be able to obtain hundreds of eggs just to produce one or two cloned embryos.

The Process

Cloning, another term for making an exact genetic replica, is not unnatural in the biological field. Many organisms rely on cloning to continue their existence. Cloning, however, is an artificial novelty in animals, especially mammals. Decades ago, it was fictional or even fanatical to talk about cloning, making a genetic copy of an animal, let alone a human. Are we magicians, are we miracle workers, or are we Dr.

Frankenstein reborn? How does cloning really work?

A generic cloning technology, somatic-cell nuclear transfer, provides the basic framework for other different cloning techniques. Somatic cells are the so-called body cells. In the process of somatic-cell transfer, a somatic cell's nucleus, the part of a cell that contains the DNA, is extracted and inserted into an enucleated ovum. The combined entity will develop into an embryo that will then carry the DNA of the somatic cell and therefore the same gene as the donor of the somatic cell in every one of the new embryo's cells.[6] The exact process, of course, is not so simple. The ovum, or egg as it is commonly known, first needs to be placed in a culture dish until it matures, while being soaked in a chemical bath, and then its genetic material is removed. Everything is also done on a microscopic level, which makes the process extremely painstaking. In order to enucleate the ovum, the researchers have to first remove a small portion of a protective layer, called the "zona pellucida," on the outside of the ovum. To do this, a microscopic needle is used to "drill" out the small piece of the layer, called a plug, while a pipette is holding onto the ovum. After the plug is removed, the polar body and the genetic material in the ovum are sucked out with a needle. The nucleus or sometimes the entire somatic cell is then inserted into the ovum through the "hole" created. The resulting entity is then placed in a chemical bath that will stimulate it to divide and develop.[14]

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Dolly was produced using the somatic cell from a ewe. The specific technique used by Wilmut's team was the fusion of the entire udder cell and the enucleated ovum by electrical jolt. The cloned mice, on the other hand, were produced using cumulus cells, which nourish and cling to the ova on the outside. In addition, a cumulus cell was inserted into the ovum by injection rather than electrical fusion. Replacing just any somatic cell with a cumulus cell is also significant in that cumulus cells are found on human ova as well.[7]

From the findings of cloned mice, ACT was able to use two techniques to make the human cloned embryos. The company injected nuclei of skin cells into some ova and cumulus cells into others. Like other cloning experiments, it took many attempts before they were able to produce a successful cloned embryo from the ovum that was injected with cumulus cells.[11]

The Moral Dilemma

We have longed to do it, and now we have done it. But what remains is the moral question of the line between therapeutic cloning and reproductive cloning. Therapeutic cloning explains why we wanted to clone in the first place.

The original goal of Dr. Wilmut and his team of scientists was purely therapeutic. They made Dolly in the hope that the experiment would lead to the mass production of genetically engineered farm animals whose organs could be used for transplantation or whose milk would have medicinal purposes for sick patients.[2] Yanagimachi's team and ACT's researchers have also had similar goals in mind when they conducted their studies.

Therapeutic Cloning

"Therapeutic cloning" is a term coined to describe the process of harvesting stem cells from a cloned embryo, which "is made using the DNA of a patient who could benefit from a stem cell transplant."[15] The harvested stem cells can then be developed into the specific tissue, organs, or even nerves that the patient needs. A wide range of disorders can be cured with the compatible body parts grown from stem cells, including diabetes, Parkinson's disease, Alzheimer's disease, stroke, and epilepsy. It is even possible to create blood cells and bone marrow from stem cells with proper cell differentiation.[11]

The ultimate goal is laudable, but it is the process of harvesting the stem cells that has

generated an immense wave of controversy—a hot topic excessively discussed in the abortion issue, namely the debate of whether an embryo is a human being or just a bunch of cells.

Dr. Jeffrey Kahn, the director of the Center for Bioethics at the University of Minnesota, points out that the majority of indignation against therapeutic cloning is because most people think "it is unethical to create human life that will be destroyed."[16] Indeed, the people who are enraged by such scientific attempts range from religious to political leaders. When ACT first announced its human embryo in 2001, President Bush had already expressed his strong disapproval. He maintained that "we should not as a society grow life to destroy it."[17] Although Archbishop Tarcisio Bertone praised the therapeutic aims of cloning, he insisted that "if the process involves production and destruction of human beings to treat other human beings, then the end doesn't justify the means."[8]

Other scientists and religious leaders, such as Cynthia Cohen, a researcher at the Kennedy Institute of Ethics at Georgetown University, have come to the conclusion that any embryo "younger than 14 days cannot be considered human because cells have not formed a single individualized entity."[18] For some, then, research dealing with cloned embryos no older than 14 days old is therefore acceptable and ethical.

As it turns out, some scientists also hold a very skeptical view on how much embryonic cloning will modernize stem cell therapy. There are millions of people suffering from diseases that require various transplantations, but as Harry Griffin, assistant director at the Roslin Institute, points out, "There are simply not enough human eggs available" to produce cloned embryos from which to harvest stem cells.[9] With the low success rate of producing a viable cloned embryo, it is legitimate to question how we will be able to obtain hundreds of eggs just to produce one or two cloned embryos.[6]

Reproductive Cloning

Another aspect of cloning research that is belittled by politicians and scientists alike is reproductive cloning. The process is essentially the same as that of therapeutic cloning in terms of creating the embryo. In reproductive cloning, however, the embryo is planted into a woman's womb and developed into a fetus. But with in vitro fertilization and other infertility treatment readily available, why would one turn to cloning for babies? It turns out that people who don't have ova, sperm, or either can use cloning to produce a child that is genetically related (more accurately, identical) to them by taking one parent's somatic cell nucleus and inserting it into a donor egg that does not contribute to the genetic make-up of the embryo.[6]

Although these applications of cloning make the technology seem like a panacea to infertility and genetic disease-related problems, from a bioethical point of view, reproductive cloning is really the fountainhead of all moral predicaments.

Other candidates who might benefit from reproductive cloning are lesbian couples who don't want their children to carry the genes of unrelated sperm donors. Couples who are genetic disease carriers might also want to use cloning to prevent having children with a full-blown version of their diseases that might result from the genetic mixing during sexual reproduction. Furthermore, these parents can have gene therapy applied to their diseased somatic cell before its nucleus is inserted into the egg to form an embryo, thereby forever obliterating the diseased gene from the family tree.[6]

Although these applications of cloning make the technology seem like a panacea to infertility and genetic disease-related problems, from a bioethical point of view, reproductive cloning is really the fountainhead of all moral predicaments.

One potential problem has to do with the clone's identity. Because the clone has the same DNA as its somatic cell nucleus donor, the two are essentially identical twins. As a result, one "could give birth to [one's] own twin, or the twin of [one's] mother or

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Because the clone has the same DNA as its somatic cell nucleus donor, the two are essentially identical twins. As a result, one "could give birth to [one's] own twin, or the twin of [one's] mother or father."

father."[16] Although people are made up of more than genes and environmental factors play a significant role in their personality and appearance, it is expected that clones, however different they might be from their adult "originals," would encounter difficulties in psychological development. The cloned child might be expected to live a life similar to the "original" and might be looked down on if he or she fails to do so. The cloned children might also have low self-esteem because they are copies of someone else. They might lack motivation to control their own life because they already know certain traits from their adult "originals" that they are destined to bear, such as shortness or baldness.

Furthermore, will we move from reproductive cloning to selective cloning? Will we choose to clone only the beautiful, the healthy, the strong, and the smart adults among us? As Robert Wachbroit points out in "Genetic Encores: The Ethics of Human Cloning," we know some newborns will lead difficult lives such as the children who are born into poverty, "but we don't thereby conclude that such children shouldn't be born."[19] These children might not have material luxury, but they can still enjoy loving families. How do we decide who should be cloned? And by performing artificial selection, are we meddling with Mother Nature? What would become of human evolution?[19]

These questions may appear far-fetched and even unrealistic right now, but they are legitimate concerns once we start cloning humans as frequently as we use in vitro fertilization today.

But before we worry ourselves sick with these ethical questions, we should ask if human cloning is safe. As it turns out, human cloning might be a dream too good to be true. Professor Rudolf Jaenisch at the Whitehead Institute for Biomedical Research at MIT and his team reported in last September's issue of *Proceedings of the National Academy of Sciences* that "the cloning process jeopardizes the integrity of an animal's entire genetic make-up."[20] Having studied around 10,000 genes, researchers found that in cloned mice's placentas as much as 4 percent of the genes is abnormal.[20] Two other studies also showed that the path to human cloning might not be as bright as we thought. Researchers from the University of Connecticut in Storrs have been studying the X chromosomes in unsuccessfully cloned cows and found that some genes on the chromosomes are not expressed. Researchers at the University of Pennsylvania have also discovered that a fate-determining gene called Oct4 goes awry in more than 90 percent of the cloned mouse embryos.[21]

These findings not only put a stop sign in the middle of the human cloning rush but also raise doubts about the safety of stem cells harvested from cloned embryos. Researchers like Jaenish, however, have confidence in the safety of therapeutic cloning because tissues or organs grown from such stem cells "would not contribute to the development of [the] whole organism."[21]

What Do the Politicians Say?

They say "no" to cloning, period. Reproductive cloning has never received much support, but people have also been looking askance at therapeutic cloning, trying to nudge it out of the picture inch by inch.

Long before Dolly was born, the talk of human cloning had already begun in the scientific community. By the end of 1994, the National Institutes of Health (NIH) decided to prohibit human cloning research but expressed desire to permit federal funding for some human embryo research that might lead to the discovery of treatments for terminal diseases. President Clinton, however, thought otherwise and prohibited NIH to fund human embryo research.[2] When Dolly's birth was announced, President Clinton took it one step further and established a moratorium on all human cloning experiments with federal funds. At the same time, the National Bioethics Advisory Commission wanted a ban on private research as well.[6] When President Bush asked Congress to ban cloning in 2002, the House of Representatives agreed with him and introduced the bill again as soon as Boisselier announced Baby Eve's birth. As of mid-February, the cloning ban has been endorsed by the House Judiciary Committee, pending floor debate and vote.[22]

While lawmakers unanimously agree to place restrictions on cloning research, the Republicans seem to be more uncompromising than their Democrat colleagues. They are seeking to pass a bill in the Senate that not only puts a stop to cloning attempts but also to the creation of embryos for any purpose. Democrats, on the other hand, hope to exempt therapeutic cloning research in their own bill.[18]

Cloning is such a familiar yet strange word. We have come a long way, yet there is still so much unknown. Surely scientists will one day figure it all out. The question is: How will we deal with the moral issues of the findings? And in the meantime, will legal issues stand in the way? As Dr. Kahn points out, "It is not cloning techniques that are unethical, but some of their potential applications."[15] Ultimately, what the future of cloning will be is a question that only time can answer.

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