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HUMAN CLONING AND STEM-CELL RESEARCH — SCIENCE'S "SLIPPERY SLOPE" [PART I]

Bert Thompson, Ph.D. and Brad Harrub, Ph.D.

[EDITOR'S NOTE: Two of the most hotly debated and currently controversial topics—in the fields of science, religion, ethics, and politics—are human cloning and stem-cell research. When the editors of *Time* screamed on the cover of their February 19, 2001 issue, "Human Cloning is Closer than You Think!," they probably had no idea how prescient they were. The very day we were to send this issue of *Reason & Revelation* to the printer (August 7), two scientists, Dr. Panos Zavos of Kentucky and Dr. Severino Antinori of Italy, announced to the National Academy of Sciences Conference on Cloning in Washington, D.C. that they plan to impregnate as many as 200 women volunteers with cloned embryos—**by November of this year!** Our regular subscribers know that it is our standing policy to publish the latest, most up-to-date information on such topics. For example, in May and June 1997, I authored a series on "Cloning—Scientific and Biblical Ramifications." In the August and September 2000 issues, I penned two articles on "Cracking the Code—The Human Genome Project in Perspective." Now, with reports arriving almost daily about proposals to clone humans, and with similar reports surfacing with disturbing frequency about scientists' planned use of human-derived stem cells, I believe that an in-depth analysis of these two subjects is both timely and warranted. Dr. Brad Harrub (our Director of Scientific Information) and I invite your attention to these matters. Human lives, souls, and dignity are at stake!]

The news landed like a bombshell. It was completely unexpected. Hardly anyone thought it could be accomplished. Nobel laureates had suggested that it was extremely unlikely. One specialist in the field even had gone so far as to boast that it "was impossible," while another denied that it could "ever occur." Then, suddenly, without warning, it happened.

The February 27, 1997 issue of *Nature* reported it in a mundanely titled article, "Viable Offspring Derived from Fetal and Adult Mammalian Cells." **An adult mammal had been cloned!** "Dolly," as the sheep came to be known, was introduced to a world awash with incredulity. Scottish embryologist Ian Wilmut and his colleagues had taken a mammary gland cell from a six-year-old Scottish Finn Dorset ewe and, via a process known as "nuclear transfer," succeeded in placing the genetic material from that cell into a hollowed-out egg cell from a Scottish Blackface sheep. That zygote—which then contained the full complement of 54 chromosomes (as if it had been fertilized by a sperm cell)—was placed into the uterus of a second Scottish Blackface sheep that served as a surrogate mother. A few months later, Dolly was born.

Scientists around the world gasped—first in complete disbelief, and then in "udder" awe. The "news" part of the story was not merely that a mammal had been cloned; that had been accomplished in the past. The news was that a mammal had been cloned from an **adult** cell—something that even scientists like James Watson and Francis Crick (who were awarded the 1962 Nobel Prize in Physiology or Medicine for their elucidation of the molecular structure of DNA) had gone on record as stating was very likely impossible. Dr. Wilmut and his team at the Roslin Institute outside of Edinburgh, Scotland, had shown that it **was** possible. But, as the old adage suggests, "that was then; this is now." It turns out that the successful cloning of Dolly was only the tip of the proverbial iceberg.

Shortly after the details of the procedure used to produce Dolly were published, scientists began to report one success story after another using the same procedure (or ones similar to it) to clone additional mammals from adult cells, including mice (Wakayama, et al., 1998), cattle (Kato, et al., 1998), goats (Baguisi, et al., 1999), rhesus monkeys (Chan, et al., 2000), and pigs (Onishi, et al., 2000; Polejaeva, et al., 2000).

Sheep, mice, cattle, goats, monkeys, and pigs are all mammals. Remember the definition of a mammal from your high school biology textbook? Mammals are animals that:

Roslin Institute

Dolly (cloned from a mammary gland cell of a Finn Dorset ewe) and her Scottish Blackface surrogate mother

CONTENTS

ARTICLES

DEPARTMENTS

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Editor:
Bert Thompson, Ph.D.*
(*Microbiology, Texas A&M University)

Associate Editor
Brad Harrub, Ph.D.*
(*Neurobiology, University of Tennessee)

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Mailing Address:
Apologetics Press, Inc.
230 Landmark Drive
Montgomery, AL 36117-2752

General inquiries, changes of address, or international callers:
Phone: (334) 272-8558
Fax: (334) 270-2002

Orders:
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(a) are warm-blooded; (b) have an insulating body covering of hair (or fur, wool, etc.); (c) suckle their young; and (c) possess a four-chambered heart (see Hine, 1999, pp. 193-194). From a biological classification viewpoint, is a human a mammal? Yes. Then surely the next question becomes obvious: If scientists have successfully cloned sheep, mice, cattle, goats, monkeys, and pigs (all of which are mammals), can they then clone humans—who likewise are mammals? And more important, if they **can**, **will** they?

As frightening as the thought may be to many within the general populace, the simple fact is that scientists worldwide already are working on producing human clones—a fact that hardly should be surprising. Imagine the fame and fortune that await the first scientist who can announce to the world, "**I** cloned the first **human**!"

SCIENCE RUN AMOK

And so, the race is on. Shortly after Dolly was cloned, Richard Seed (who is not even a life scientist, but instead holds a Ph.D. in physics) proclaimed publicly that he was going to establish a laboratory in Chicago, Illinois, whose sole purpose was to clone humans. [Federal regulations enacted shortly after Dolly's cloning specifically prohibit the cloning of humans in America in laboratories receiving government funds. Dr. Seed has repeatedly stated that he neither will seek nor accept any such funding; therefore, in his view, the law's prohibitions would not apply to his efforts. However, on March 27, 2001, the United States Food and Drug Administration (FDA) mailed Dr. Seed a letter, warning him that any attempt to clone a human might place him in violation of federal regulations governing experimental medical procedures. In the July 9/16, 2001 special double issue of *U.S. News and World Report*, Dr. Seed offered a response to the letter when he said: "I think their purpose was to frighten me, and they did!" (as quoted in Boyce and Kaplan, 2001, 131[2]:21).]

To complicate matters, reports are beginning to surface almost daily about other scientific groups that either are attempting to take cloning one step farther or that already have done so—with varying degrees of success. Consider, for example, Clonaid, a Bahamas-based company that was established in 1997 by Claude Vorilhon, a colorful French race-car driver and former journalist (now known as "Rael the prophet," head of a sect known as "the Raelians"). Under the direction of French scientist Brigitte Boisselier, Ph.D., Clonaid announced early in 2001 that it was moving forward with plans to clone the very first human before the end of the year. On March 25, 2001, Dr. Boisselier testified under oath before the Subcommittee of Oversights and Investigations of the United States Congress about the company's intention to clone a human (specifically, a 10-month-old baby boy that had died as the result of a tragic mishap at a hospital). She also discussed the progress that Clonaid was making, and its formal response to critics of human cloning (Boisselier, 2001a). On Clonaid's official Web site, Dr. Boisselier is quoted as saying: "Our first goal at Clonaid is to develop a safe and reliable way of cloning a human being. Who, today, would be scandalized by the idea of bringing back to life a 10-month-old child who died accidentally? The technology allows it, the parents desire it, and I don't see any ethical problems with it" (2001b). According to published reports, more than 50 prospective surrogate mothers already have been chosen to carry cloned fetuses, including Dr. Boisellier's 22-year-old daughter, Marina Cocolios. And, Clonaid admits to having established a secret laboratory in the U.S. for the purpose of cloning humans (see Dixon, 2001). Cost, according to Clonaid's Web site, is $200,000.

A mere two days after her testimony before Congress, Dr. Boisselier received a letter from the FDA, informing her that Clonaid could be in violation of federal regulations by attempting to clone a human. Just as this issue of *Reason & Revelation* was about to go to press, we received news that on May 29, U.S. Representative James Greenwood (D-PA), wrote the FDA to ask the agency to examine more closely Clonaid's intentions. In the special double issue of *U.S. News and World Report* mentioned above, staff writers Nell Boyce and David Kaplan exposed the heretofore private details surrounding the FDA's investigation of Clonaid:

> ...[I]n what appears to be an unprecedented probe into the sect's activities, ...Food & Drug Administration agents visited the lab recently and ordered any human cloning experiments to cease. Says one official: "There's a timeout in force...." The crackdown marks the first time that investigators have uncovered a secret lab tied to human cloning in the United States, government sources say. Among areas under investigation are possible violations of FDA regulations that govern experimental medical procedures.... (2001, 131[2]:21-22).

But things have gotten even spookier since the technology that made Dolly possible arrived on the scene. In the May 22, 1998 issue of *Science*, scientists at a Worcester, Massachusetts, company, Advanced Cell Technology, reported that they had created a "transgenic" (across species lines) **bovine-human hybrid** embryo that consisted of a **human** somatic cell's nucleus inside a **cow's** egg. The researchers actually took a cell from Dr. Jose Cibelli, the lead scientist in the study, removed its nuclear-based genetic material, and placed it into a cow's egg from which the nucleus had been removed. Once inside the bovine egg, the contents of the human cell activated and the egg began to divide normally until it had reached the 32-cell stage, at which time it was destroyed (Cibelli, et al., 1998, 280:1256-1258). One year later, *New Scientist* published a report about a Japanese researcher from Tokyo University of Agriculture and Technology, Setsuo Iwasaki, who removed the chromosomes from 27 cows' eggs and implanted the eggs with nuclei from human somatic cells. His stated goal was to isolate embryonic stem cells, which would have meant culturing the hybrid embryos for a minimum of five days until they formed a hollow ball known as a blastocyst. But, Iwasaki reported, most of the embryos did not develop, and none went through more than three cycles of division (see Hadfield, 1999).

But the news does not stop at human/cow hybrids. According to the March 13, 2001 issue of the *New Zealand Herald*, Australian scientists at a Melbourne company, Stem Cell Sciences, reportedly produced a cloned human embryo in 1999 by combining an empty **pig** egg with a **human** somatic cell (see "Human-Pig Embryo Accusation Provokes Debate," 2000). [Similar experiments were carried out by an American company, BioTransplant. In both cases, the resulting human cloned embryo was allowed to divide to a 32-cell stage before being destroyed.] Apparently, Australia has been home to somewhat secretive human cloning experiments for several years. Based on the fact that approximately 1% of the DNA in the human/pig hybrid would have been donated by the pig cells' mitochondria (the "energy factories" of the cell, which contain their own extranuclear DNA), the Australian government has vehemently rejected the idea that such a hybrid could be referred to legitimately as a "human" clone, and therefore has denied most emphatically that **human** cloning has taken place in "the land down under" (a matter of semantics, to be sure). And so, laboratories around the world have come to realize that an organism containing 99% human genes and 1% animal genes allows them to claim, "technically," that they are not cloning humans. This technicality, then, allows their research to continue, even though many countries worldwide (including 29 in Europe alone—see Willing, 2001) have adopted a ban on non-therapeutic human cloning. In an editorial in the July 19, 2001 issue of *Nature* titled "The Meaning of Life," the editor commented on this "technicality" concerning embryonic stem [ES] cells when he wrote:

> Advanced Cell Technology (ACT) of Worcester, Massachusetts says it is trying to generate human embryos by cloning, and then harvest ES cells from them. The company hopes to sidestep moral objections, as fertilization is not involved. Indeed, the chair of ACT's ethical advisory board argues that an embryo created in this way is not a bona fide embryo, and suggests the term "ovumsum." The procedure that ACT is experimenting with, known as therapeutic cloning, might one day prove useful in generating ES cells that are genetically matched to patients requiring tissue grafts. **But to suggest that it does not involve the creation of embryos is misleading** (see "The Meaning of Life," 2001, 412:255, emp. added).

Misleading indeed! When even the editors of major science journals recognize that some of this research is "misleading" (read that as "morally objectionable"), surely it is time to reassess the slippery slope on which science finds itself. If it becomes possible to create a hybrid "cross" between a human and an animal, then such technology could be used to grow "things" that possess human characteristics, yet that are not considered "fully human." These "almost-but-not-quite-human" creatures then could be employed as "workhorses" to carry out tasks that humans no longer wish to perform—like picking cotton, working in harsh factory conditions, doing dull, repetitive jobs, etc. With current patenting laws allowing scientists exclusive rights to newly created life forms, researchers, backed by any number of deep-pocketed financiers, could be well on their way not just to fame, but to fortune as well.

CLONING—1901 TO 2001

What's going on here? How did all of this get started? And where is it likely to lead? A brief examination of the history of cloning is appropriate, after which, we will examine current stem-cell research and the implications of both of these technologies for society today.

In biology, the **noun** "clone" refers to a cell or an organism that is genetically identical to another cell or organism from which it was derived. For example, some organisms (like bacteria) reproduce themselves by copying their DNA and then splitting in half. The two resulting bacteria are thus clones. The **verb** "clone" refers to the process of creating cloned cells or organisms. The beginnings of what we today refer to as cloning actually go back to the early part of the twentieth century—1901 to be exact. Hans Spemann (1869-1941) was a German embryologist who was a professor of zoology (1919-1935) at the University of Freiburg. In 1901, he split a 2-cell newt embryo into two distinct parts, successfully producing two different larvae. In 1914, he conducted the earliest known experiments on nuclear transfer. By using a tiny strand of baby hair, Spemann partially constricted a newly fertilized egg (zygote), thereby forcing the nucleus to one side of the cell and the cytoplasm to the other side. As the nucleus side of the cell began to divide into a 16-cell stage, the nucleus slipped over to the cytoplasm on the other side. Cell division began on this side too, and the hair knot was tightened to prevent any additional nuclear transfer. Twin larvae developed, with one side (the side with the initial nucleus) being slightly older than the other (the side with the initial cytoplasm). This proved that the nucleus from a 16-cell stage could direct the growth of another larva. From his observations, Dr. Spemann proposed removing the nucleus from an unfertilized egg and replacing it with the nucleus from a fertilized cell. In fact, he did just that, and used the nucleus from a 16-cell salamander embryo to create an identical twin. By transplanting embryonic tissue to a new location within the embryo (or to another embryo entirely), he was able to identify the agency that governs the growth and differentiation of cells. He received the 1935 Nobel Prize in Physiology or Medicine, and three years later described his award-winning research in his classic text, *Embryonic Development and Induction* (1938).

During the early 1950s, F.C. Steward of Cornell University demonstrated how to clone plants, and produced carrots by the thousands via his procedure (see Steward, 1970). In 1952, Robert Briggs and Thomas King of the Institute for Cancer Research in Philadelphia cloned a leopard frog using body cells from frog embryos, but allowed the organisms to live only to a tadpole stage (Briggs and King, 1952). Since then, carrots, tomatoes, fruit flies, and numerous other plants and animals have been cloned.

Then, on April 25, 1953, James Watson and Francis Crick published their scientific paper describing for the first time the intricacies of the double-helical structure of the DNA molecule (Watson and Crick, 1953). For this attainment, they were awarded the 1962 Nobel Prize in Physiology or Medicine—and initiated a biological revolution. The elucidation of the molecular structure of the gene clearly ranks among the grandest scientific achievements of all time. As a result of their discovery, a new age has dawned—the Genetic Age. Prior to this discovery, many scientists viewed the Nuclear Age as the last great revolution in science. Nuclear technology tends to be viewed as either the most powerful industry for human benefit, or the most dangerous tool for human destruction ever available for mankind's use. With the development of genetic engineering, the potential for controversy is even greater because in their experiments, researchers no longer are dealing with merely inanimate nature, but with **human** subjects, and the consequences are far-reaching indeed.

The same year that Watson and Crick were awarded the Nobel Prize, John Gurdon of Oxford University cloned sexually mature frogs from the intestinal cells of adult frogs (1964, 4:1-43). A year later, in 1963, British scientist J.B.S. Haldane first employed the word "clone" (Greek for "twig") to describe Gurdon's frog experiments in his chapter, "Biological Possibilities for the Human Species of the Next Ten-Thousand Years," in the book, *Man and His Future* (Haldane, 1963). Three years later, Gurdon and Uehlinger succeeded in growing an adult clawed frog from an injection of a tadpole intestinal cell nucleus into an enucleated oocyte (which, unlike Briggs' tadpoles, was allowed to grow into an adult), thus representing the first cloning procedure that resulted in an adult vertebrate (see Gurdon and Uehlinger, 1966; Gurdon and Laskey, 1970a, 1970b).

In 1970, Paul Berg and Stanley Cohen of the United States achieved a monumental breakthrough in genetic engineering with the first successful gene splicing (see Cohen, et al., 1973). [Splicing occurs when pieces of genetic material, such as DNA or RNA, are cut and removed and the remaining pieces are rejoined.] Together, they created the first recombinant DNA organism using techniques pioneered a year earlier by Paul Berg (who received the 1980 Nobel Prize in Physiology or Medicine in recognition of his new gene-splicing technology).

On January 22, 1973, the nine justices that comprised the United States Supreme Court issued their infamous Roe vs. Wade (7-2) decision legalizing abortion, which resulted in a moratorium on government financing for embryo research. The 1974 National Research Act, which addressed this issue (among others), contained among its provisions a temporary moratorium on federally funded fetal research either "before or after abortion." That moratorium remained in effect until 1975, at which time the Department of Health, Education, and Welfare (now known as the Department of Health and Human Services) issued extensive regulations governing federally funded fetal research.

On July 25, 1978, Louise Brown, the first baby resulting from *in vitro* fertilization techniques, was born in Great Britain to her 30-year-old mother, Leslie, an Englishwoman who, during her nine-year marriage to her husband John, had been unable to conceive. Louise was the result of the combined efforts of Patrick Steptoe, a gynecologist in Oldham, Lancashire in Great Britain, and Robert Edwards, a physiologist from Cambridge University (see Gwynne, 1978; Napgal, 1978; and "The First Test-Tube Baby," 1978). That same year, U.S. freelance writer David Rorvik authored, and the J.B. Lippincott Company of Philadelphia published, *In His Image: The Cloning of a Man*, the purported story of an eccentric 67-year-old millionaire who had himself secretly cloned (Rorvik, 1978). The book caused such a furor that the United States Congress held hearings on the veracity of the account as reported by Rorvik. In 1981, after reviewing the evidence, U.S. District Court judge John Fullam ruled the book to be fiction (Fullam, 1981, p. 2-F) and, in 1982, Lippincott was forced to acknowledge publicly that the book was a hoax (but only after making some $730,000 in sales!).

Then, in 1980, the U.S. Supreme Court ruled that a new, genetically altered bacterium (i.e., a non-natural microorganism) could be patented (see Supreme Court of the United States, 1980). This widely publicized case demonstrated to scientists the profitability of genetic research; living things genetically altered by man now could be patented. In 1981, Curt Civin, director of pediatric oncology at Johns Hopkins University School of Medicine, discovered how to isolate and purify human stem cells. That same year, Dr. Civin discovered the first stem cell antibody, winning a patent to the entire class of cell hunters. In 1984, after extensive experiments with mice, Davor Solter of the Wistar Institute of Philadelphia claimed that the cloning of mammals was biologically impossible. The last phrase of the last line of Solter's paper (published in *Science*) has reverberated through the halls of academia ever since. He wrote: "The cloning of mammals by simple nuclear transfer is biologically impossible" (McGrath and Solter, 1984, 226: 1317-1319). Solter's conclusion was accepted as "fact," and for years to follow, funding for research on cloning was marginalized and almost impossible to obtain. [Just five years earlier, in 1979, R. McKinnelly, a professor of genetics and cell biology at the University of Minnesota who specializes in frog cloning, wrote in his book *Cloning*: "I never expect to witness the construction of carbon copy humans. I do not believe that nuclear transplantation for the purpose of producing human beings will ever routinely occur" (1979, p. 102).]

On the other side of the globe, in 1984, Steen Willadsen of Denmark cloned a lamb by transferring a single cell from an 8-cell sheep embryo to an unfertilized egg whose nucleus had been destroyed. Three of the four reconstituted embryos transferred to ewes' oviducts developed into genetically identical lambs. He also mixed embryonic cells of different species to create sheep-goats and sheep-cows. Other scientists followed his example and cloned a variety of animals. His work was the first verified cloning of a mammal using the method of nuclear transfer. A year later, Willadsen joined Grenada Genetics, a bioengineering company, and was the first to clone a farm animal using the nuclear transfer method (when he used his cloning technique to duplicate the embryos of prize cattle). Willadsen's work, however, still involved embryonic cells, not adult cells.

In 1986, while working at Grenada Genetics, Willadsen cloned a cow using differentiated, one-week-old embryo cells. His efforts proved that the genetic information of a cell did not diminish as the cell specialized, and that DNA could be returned to its original state. Willadsen's work (1986) was an extremely strong influence on Ian Wilmut's decision to attempt to clone sheep from adult cells, which he ultimately accomplished with the famous 1996 birth of Dolly.

In October 1990, the National Institutes of Health officially announced the beginning of the Human Genome Project, a massive, international collaborative effort to locate the estimated 50,000 to 100,000 genes within the human genome, and the sequencing of the estimated 3 billion nucleotides that compose that genome (see Thompson, 2000a; 2000b). In October 1993, at a meeting of the American Fertility Society in Montreal, Canada, two American scientists, Jerry Hall and Robert Stillman, touched off an unexpected controversy when they presented a paper on facets of their research in the area of *in vitro* fertilization techniques. At the time, Dr. Hall was the director of the *in vitro* laboratory at George Washington University; Dr. Stillman headed the university's entire *in vitro* fertilization program. Beginning with 17 microscopic human embryos ranging from the 2-cell to the 8-cell stage, Hall and Stillman used new technology to multiply the total number of embryos from 17 to 48. Major newspapers and magazines announced the landmark event with feature articles. The *New York Times* ran a front-page article under the headline "Scientist Clones Human Embryos, and Creates an Ethical Challenge." Both *Newsweek* and *Time* prepared cover stories on the Hall/Stillman experiments (see Adler, 1993; Elmer-Dewitt, 1993).

Hall and Stillman wanted to increase the success rate of *in vitro* fertilization by finding a way to clone a single embryo into three or four embryos, which would increase dramatically the chances of a successful pregnancy. They were not attempting to produce cloned embryos to implant in a potential mother. Rather, they were examining embryos that resulted from fertilization of an egg by multiple sperm cells, and that therefore would not live more than a few days at best. Criticism, however, was quick to arrive (see Fackelmann, 1994b). Sadly, headlines in major newspapers and magazines were not always representative of the actual facts. Humans had not been cloned. An in-depth description of the process used in the Hall/Stillman experiment was published in *Science News* (see Fackelmann, 1994a).

In 1994, the Human Embryo Research Panel, a body convened by the National Institutes of Health, concluded that embryonic stem-cell research should be publicly funded, as long as the embryos were not created originally for research purposes. That same year, the U.S. Government published guidelines for research on transplantation of fetal tissue. Also in 1994, United States scientists M. Sims and N.L. First cloned calves from cells of early embryos (1994).

In 1995, Ian Wilmut and Keith Campbell of Great Britain produced the world's first cloned sheep, Megan and Morag, from 9-day-old embryos (Campbell, et al., 1996). In 1996, Ian Wilmut and his team of Scottish scientists took their experiments one step farther and cloned the world's first mammal from **adult** cells—Dolly the sheep, which was created using udder cells from a six-year-old ewe (Wilmut, et al., 1997). Somewhat ironically, in 1996 federal money was banned for stem-cell research involving embryos. In 1997, the Oregon Regional Primate Research Center cloned two rhesus macaques, Neti and Ditto, that were created from the DNA of developing monkey embryos (Meng, et al., 1997). Also in 1997, the first human embryonic stem cells were isolated (Thomson, 1998; Gearhart, 1998), and Ian Wilmut and his colleagues created Polly, the first sheep with a human gene in every cell of its body (Schnieke, et al., 1997). Plus, University of Massachusetts researchers reported the successful cloning of cattle using fetal cells (Kato, et al., 1998). Following the announcement of Dolly's arrival, announcements of the success of additional similar procedures began to occur at almost lightning speed.

In 1998, Teruhiko Wakayama and his colleagues reported that they had successfully cloned a mouse named Cumulina (1998). To date, approximately 50 more mice have been cloned, some through three generations. Two other momentous events occurred in 1998. The first was reported in the April 25 issue of *Science News*. Dolly had been bred to David, a Welsh Mountain ram, and was pregnant (see Travis, 1998, 153:263). [Actually, by the time the story got to press, Dolly already had given birth. On April 13, 1998 she produced a 6.7-pound baby ewe by the name of Bonnie. Almost a year later, on March 24, 1999, Dolly gave birth to three healthy lambs—two males and one female.] This news dispelled the idea that as a clone she might be sterile, and paved the way for future successes in the breeding of clones.

The second significant event was reported in the November 6, 1998 issue of *Science*, which discussed the creation of an immortal line of embryonic stem cells taken from discarded embryos donated by IVF clinics (Thomson, 1998). Shortly thereafter, scientists from Johns Hopkins announced a method of obtaining similar cells from the primordial tis-

Dr. Bert Thompson

September 14-16	Limon, CO	(719) 775-2772
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Dr. Brad Harrub

August 29	Dothan, AL	(334) 793-1500

Kyle Butt

September 16	Talladega, AL	(256) 761-1045

Eric Lyons

September 15	Adamsville, AL	(205) 674-5659

sue of aborted fetuses (Gearhart, 1998). In 1999, A. Baguisi and coworkers reported their successful attempts to clone goats (Baguisi, et al., 1999). Then, the April 2, 1999 issue of *Science* reported on the development of a line of adult human mesenchymal stem cells (Pittenger, et al., 1999).

One of the most important milestones in the cloning controversy was reported in the May 27, 1999 issue of *Nature*, which discussed Dr. Wilmut's examination of Dolly's chromosomes. Wilmut and his coworkers studied the length of the chromosome ends (telomeres) from Dolly and two other sheep produced by the same process used to clone her. It generally has been accepted scientifically that telomere deterioration is a reliable indication of a reduction in life span; the more rapid and serious the telomere deterioration, the shorter the expected life span. Wilmut and his team reported a marked deterioration in Dolly's telomeres compared to those from non-cloned animals, and even suggested that "the most likely explanation" for the deterioration observed in these animals "reflects that of the transferred nucleus. Full restoration of telomere length did not occur because **these animals were produced without germline involvement**" (Shiels, et al., 1999, 399:317, emp. added).

In other words, since Dolly was cloned from the mammary gland cell of a six-year-old sheep, in essence her telomeres already were six years old and therefore deteriorated more rapidly than those of non-cloned animals. The scientists involved in this research stressed that "it remains to be seen whether a critical length will be reached during the animal's lifetime." That is to say, at present it is impossible to state with certainty whether the telomere deterioration will cause Dolly to die prematurely. However, these same scientists admitted that "[t]elomere-based models...predict that the nuclear-transfer-derived animal 6LL3 [Dolly's numerical designation in the scientists' study—BT/BH] might well reach a critical telomere length sooner than age-matched controls" (Shiels, et al., 399: 317). Thus, cloned creatures may have markedly reduced life spans compared to those produced via normal, sexual reproduction. If these data are confirmed, they will have serious implications for human cloning. [In the April 28, 2000 issue of *Science*, a report was published which suggested that cloned calves actually had **longer** telomeres than normal, and thus might not be prone to an early death. Yet, the author admitted:

> Why these findings are so dramatically different from those on Dolly is not yet clear.... Other scientists are more cautious, noting that aging is extremely complex and is controlled by more than just telomere length.... No one is yet able to explain the difference between Dolly and the cloned calves. It might be due to random variation, species differences, a difference in the cell type, or different methods of nuclear transfer (Vogel, 2000, 288:586-587).

The jury still is out on the early demise of cloned organisms, but results at this point do not look promising in certain species (see, for example, Humphreys, 2001).]

On August 23, 2000, the National Institutes of Health (NIH) "opened the floodgates" by publishing guidelines for the public funding of embryo stem-cell research in the United States, an about-face of its earlier position. Previously, embryo stem-cell research was funded exclusively from private sources. The NIH announcement lifted a ban that had been in place on such research since 1996. Later that year, scientists reported that they had been successful in attempts to clone pigs (Onishi, et al., 2000; Polejaeva, et al., 2000). Also in 2000, scientists performed transgenic cloning experiments, combining pig oocytes and human somatic cells (see "Human-Pig Embryo Accusation Provokes Debate," 2000).

On January 22, 2001, Britain's House of Lords became the first government to effectively legitimize cloning of human embryos for stem-cell research (with the stipulation that the cloned embryos be destroyed no later than 14 days after having been created). Also in 2001, two separate animal cloning studies showed that insulin-producing cells could be produced from a cloned animal embryo. In work led by Teruhiko Wakayama of New York's Rockefeller University, in association with the Sloan-Kettering Institute, scientists created a cloned embryo from a mouse tail cell combined with a mouse egg. This fueled the debate over human cloning experiments where the aim is to produce an embryo for medical research, rather than for implantation. Similar cloning experiments were conducted by the National Institutes of Health (see Wakayama, et al., 2001).

On March 9, 2001, three cattle (Martie, Natalie, and Emily) cloned by scientists at California State University at Chico appeared to have been born healthy, but on day 12 Natalie died, and on day 15 Emily succumbed as well—both from abrupt immune system failure. Martie was reported to be failing rapidly. Project director Cindy Daley said that things "looked normal" until that Wednesday evening when she went to check on, and feed, the animals (see Cooper, 2001). While not widely reported in the news media, such events are becoming quite common in regard to cloned animals, and serve to demonstrate the potential dangers of human cloning. Many cloned animals have experienced obvious mutations, while others have died shortly after birth, even though outwardly they appeared to be quite normal (see, for example, Humphreys, 2001). As one scientist, Rebecca Krisher, assistant professor of animal reproduction at Purdue University, put it: "Almost all of these animals, if born on a farm without a vet hospital, probably would not survive" (as quoted in Cooper, 2001). In studies performed on cloned cattle by Cyagra, a Kansas company that studies commercial aspects of cloning livestock, "the company has about a 6 percent birth rate; of those calves, about half die soon after they are born" (as quoted in Cooper, 2001).

The foundation upon which cloning had perched began crumbling with the publication of an unsettling report that appeared in the July 6, 2001 issue of *Science*. The article documented the fact that while cloned animals may **appear** to be normal, and may even **behave** in a somewhat normal fashion, the truth is that sometimes these animals are far from normal. The report went on to announce that scientists have uncovered the first evidence that "normal-looking" clones can harbor serious genetic abnormalities, which would explain why many animals live only a few days after their birth. For scientists interested in pursuing cloning as an alternate method of reproduction, the news from researchers at the Whitehead Institute for Biomedical Research and the University of Hawaii represents a veritable bomb detonated on their very doorsteps. The first statement in a paper titled "Epigenetic Instability in ES Cells and Cloned Mice" by David Humphreys and colleagues reads as follows: **"Cloning by nuclear transfer is an inefficient process in which most clones die before birth and survivors often display growth abnormalities"** (p. 95, emp. added). This is not exactly the image of cloning that federally funded researchers wanted the public at large to see.

[to be continued]

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NOTE FROM THE EDITOR

DISCOVERY MAGAZINE FOR CHILDREN ON THE WORLD WIDE WEB

In my "Note from the Editor" in the August 2000 issue of *Reason & Revelation*, I announced the implementation of our new **DiscoveryMagazine.com** Web site. It is now with a great deal of pleasure that I announce sweeping changes and significant additions to that Web site.

Discovery is an attractive, eight-page, full-color monthly magazine on Scripture and science for children. Currently, we are mailing approximately 8,000 copies per month. Each issue contains intriguing, faith-building articles—written by dedicated Christians—about God's Word and God's world. *Discovery* has been, and continues to be, a huge success story.

At its "grand opening" exactly one year ago this month, the **DiscoveryMagazine.com** Web site contained: (1) answers to questions (over 100 of them—and more have been added since!) sent in by kids to our mole-sleuth, "Digger Doug"; (2) printable artwork for use by either children or teachers; (3) frequently asked questions about *Discovery*; (4) a sample issue of the magazine [in a full-color, PDF format]; (5) a form for use in requesting a free sample of *Discovery* by mail; and (6) a subscription form.

In my August 2000 editor's note, I also mentioned that we were planning to add more materials to the Web site, including interactive instructional programs. True to our word, we have done exactly that—which is what I would like to discuss with you at length in my "Note from the Editor" this month.

Even before we began construction of the Web site in late 2000, we realized, for several reasons, that it simply would not be practical to try to include entire issues of *Discovery* on the site. First, because *Discovery* is such a graphics-intensive publication, it would take far too long for most people to load into their browsers. Second, some of the artwork in *Discovery* is material that we have purchased for a "one-time-only" use, and we therefore cannot use it elsewhere (even on our Web site). Third, since *Discovery* contains so many graphics-related items, it would consume huge amounts of hard-drive space on a computer server (space for which we are required to pay a fee). And so on. Thus, all things considered, we decided not to publish each month's issue of *Discovery* on the Web (as we do *Reason & Revelation*—in both PDF and html formats).

But as of August 1, 2001, we **have** placed on the site literally hundreds of articles from past issues of *Discovery*. These articles have been carefully selected from each year, beginning with 1990 and continuing up to 2001. Now, children can have access to many of the articles that kids over the past decade have enjoyed so much. In addition, we have carefully selected appropriate artwork to go with some of the articles (specifically, images that do not have lengthy loading times). Many of those are printable for use in Bible school classes, home schooling situations, etc. And that's not all. We also have been preparing interactive programs for the Web site, the first of which has "Private Eye Digger Doug" working for a client to try to find the long-lost "evolutionary missing link" (a task, as you might surmise, that is doomed to failure). By the time you read this, the new program should appear on the Web site. A second interactive experience for kids is in the works, and should be on the site by late fall 2001.

Please encourage children to visit the newly revamped Web site soon, won't you? They'll be glad they did—and so will you! Plus, watch for more exciting **DiscoveryMagazine.com** news in the not-too-distant future. We're just getting started! [Subscribe to the printed version of *Discovery* for only $12/year.]

Bert Thompson