Background on Cloning

If Bill Gates wanted to clone himself – creating Bill Gates 5.0, 5.1, 6.0 and, after throwing in a little genetic enhancement to make him run faster, Gates XP Pro – would any existing law stop him? What if Gates decided not to clone himself entirely, but wanted to instead create a cloned heart, "just in case." Could he?

"Clone" and "cloning" are actually imprecise terms. While scientists use clone as a noun that refers to genetically identical molecules, cells, or organisms descended from a common ancestor, the public uses "cloning" in a more fantastic way. To us, cloning refers to Frankensteinian asexual replication of a human or animal, creating identical twins born years apart or spare organs.

All cloning is experimental, but different types of cloning have different goals. Bill Gates' identical twin would be the result of cloning that intends to bring about the birth of a child that is a replicate of an existing, or previously existing, human or animal, which is sometimes called "reproductive" cloning. Through somatic cell nuclear transfer ("SCNT"), the nucleus of a somatic cell[1] is fused with or injected into an unfertilized "enucleated" egg. An "enucleated" egg is one that has had its nucleus, and DNA, removed. The result is a fertilized egg, or embryo, which is implanted into a surrogate with the intent that the surrogate will gestate, and give birth to, a nearly genetically-identical replicate of the somatic cell donor is born. The cloned embryo is *nearly* identical because enucleating the egg will likely not strip all of the egg's mitochondrial DNA, so the cloned embryo will have a slightly different genetic makeup from the somatic and egg cell donors.

Creating an organ for Gates is an example of research cloning, where the goal is to create clonal fertilized eggs, but not for implantation and gestation. Rather, the fertilized egg would be allowed to divide until it reaches the blastocyst stage, at which time stem cells would be removed and cultured from the blastocyst's inner cell mass, resulting in the destruction of the fertilized egg. It is believed that embryonic stem cells are capable of being turned into almost any type of cell in the body, although the therapeutic or other value of embryonic stem cells for humans has not yet been established. Scientists speculate that embryonic stem cells may be used to create tissues or organs for transplantation.

What is the most recent scientific research?

If we cloned your favorite cat (or mouse, pig, rabbit, sheep, goat, deer), there is a one to three percent chance the cloned embryo would survive gestation to birth.[2] The low success, or "efficiency," rate is mainly due to improper reprogramming (or reactivation) of the genes in the donor's cell.[3]

The team that created Dolly the sheep used a mammary cell to create 277 cloned embryos. About ten percent of the cloned embryos (29) developed enough to be implanted into a surrogate mother for gestation. Only Dolly was born.[4] In published

experiments involving cloned mice, it took 613 cloned embryos in one study to yield five born mice, and another required almost 1,000 cloned embryos to yield only two live births. 1,852 cloned rabbit embryos resulted in six born rabbits; 72 cloned embryos resulted in five born pigs; 85 cloned goat embryos resulted in three born goats; and 188 cloned cat embryos resulted in just one born kitten named "CC," for carbon copy.

Cells from one Brahman bull, named Chance, were fused into 189 eggs, but only 105 survived the infusion.[5] Of the 105 fertilized embryos, only 38 were viable after one week, and just 26 were implanted. But only one clone – "Second Chance" – was born. In another experiment, 496 cloned embryos resulted in 24 born cattle. And, unlike other animal species, cows have a better cloning track-record (there is up to ten percent chance of a cloned cow embryo surviving to birth).[6]

Many of these clones grew unusually large in the womb, resulting in "large offspring syndrome."[7] Cloned cattle weigh up to more than twice the normal birth weight, causing risks to the gestating mother.[8] Large offspring syndrome poses a risk to the cloned animal and its surrogate mother. Cloned calves have also been born with diabetes, enlarged hearts, and other diseases, and eighteen to thirty percent that beat the odds and survived to birth died shortly thereafter, as did some of the surrogate mothers.[9]

Aging cloned mice have become obese, had tumors, and died prematurely.[10] Indeed, the source of the somatic cell used to create the clone may predict the kind of abnormality a clone may exhibit later in life; it appears that clones from cumulus cells become obese and those from Sertoli cells die prematurely.[11] CC, the cloned kitten, has not exhibited a disease, but a striking difference from her somatic cell donor. CC only has two colors, but her "identical" cell donor was a tricolor calico cat.[12]

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[1] "A somatic cell is any cell of a multicellular organism that does not participate in the production of reproductive or germ line cells. Somatic cells differentiate to specialized cells with a limited potential to divide." *Available at* http://www.telogene.com/glossary.shtml (last visited March 29, 2004).

[2] The 1-3% figure is higher in cattle, where up to 10% of cloned cow embryos survive to birth. *See*, Konrad Hochedlinger and Rudolf Jaenisch, "Nuclear Transplantation, Embryonic Stem Cells, and the Potential for Cell Therapy," 349 N. Engl. J. Med 275-286, 278 (2003).

[3] *See* Konrad Hochedlinger and Rudolf Jaenisch, "Nuclear Transplantation, Embryonic Stem Cells, and the Potential for Cell Therapy," 349 N. Engl. J. Med 275-286, 275 (2003).

[4] *See* I. Wilmut, A.E. Schnieke, J. McWhir., A.J. Kind, & K.H.S. Campbell, "Viable Offspring Derived From Fetal and Adult Mammalian Cells" (Letter to magazine),385 Nature 810-813 (1997).

[5] *See* Karen Brooks, "Cloning Becomes Norm at Texas A&M," Los Angeles Daily News, March 27, 2004.

[6] The 1-3% figure is higher in cattle, where up to 10% of cloned cow embryos survive to birth. *See*, Konrad Hochedlinger and Rudolf Jaenisch, "Nuclear Transplantation, Embryonic Stem Cells, and the Potential for Cell Therapy," 349 N. Engl. J. Med 275-286, 278 (2003).

[7] *See* David A. Prentice, Stem Cells and Cloning, 24 (Benjamin Cummings 2003); *see also* Konrad Hochedlinger and Rudolf Jaenisch, "Nuclear Transplantation, Embryonic Stem Cells, and the Potential for Cell Therapy," 349 N. Engl. J. Med 275-286, 275 (2003).

[8] *See* "Horizon: Dawn of the Clone Age" (BBC television broadcast, Sept. 10, 1997), *transcript available at* http://www.bbc.co.uk/horizon/cloneagetrans.shtml.

[9] Rick Weiss, "Dolly, A 'Sheep in Lamb's Clothing,'" The Washington Post, May 27, 1999, at A1.

[10] Konrad Hochedlinger and Rudolf Jaenisch, "Nuclear Transplantation, Embryonic Stem Cells, and the Potential for Cell Therapy," 349 N. Engl. J. Med 275-286, 276 (2003).

[11] Konrad Hochedlinger and Rudolf Jaenisch, "Nuclear Transplantation, Embryonic Stem Cells, and the Potential for Cell Therapy," 349 N. Engl. J. Med 275-286, 276 (2003) (reporting that "clones derived from cumulus cells (somatic cells that surround the egg) become obese, whereas clones derived from Sertoli cells (somatic cells that nourish the egg) die prematurely").

[12] *See* Karen Brooks, "Cloning Becomes Norm at Texas A&M," Los Angeles Daily News, March 27, 2004.