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House Health and Government Operations Committee
and
House Appropriations Committee
Maryland Legislature
AGAINST House Bill 1183; "Maryland Stem Cell Research Act of 2005"
March 2, 2005

Thank you for the opportunity to provide testimony on this important subject.

I am a cell biologist, currently working for a think tank in Washington, D.C. For the last 20 years I was Professor of Life Sciences at Indiana State University and Adjunct Professor of Medical & Molecular Genetics at Indiana University School of Medicine, and I have done federally-funded laboratory research, lectured, and advised on these subjects extensively, in the U.S. and internationally. I have very recently become a Maryland resident (Upper Marlboro).

Mark Twain noted that "There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact." This is certainly true regarding the hype and emotion surrounding the issue of cloning.

The Bill under consideration purports to promote "stem cell research", including the use of stem cells produced by "somatic cell nuclear transfer". Looking at the facts of the Bill and the real science behind the term, what it actually promotes is the use of cloning technology to create human embryos for experiments.

We should start with some biological definitions, to provide a common scientific frame of reference.

> "Almost all higher animals start their lives from a single cell, the fertilized ovum (zygote)... The time of fertilization represents the starting point in the life history, or ontogeny, of the individual."[1]

This is true whether within the body or in the laboratory via In vitro fertilization or other assisted reproductive techniques, the first stage of development of a new individual begins with the one-cell embryo, or zygote.

As far as the definition of embryo, the National Academy of Sciences gives the following:

> "**Embryo** - A group of cells arising from the egg that has the potential to develop into a complete organism. In medical terms, embryo usually refers to the developing human from fertilization (the zygote stage) until the end of the eighth week of gestation when the beginnings of the major organ systems have been established."[2]

Virtually the same definition is given in other reports by the National Academy of Sciences, as well as by the National Institutes of Health and other recognized scientific authorities.

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[1] Carlson, Bruce M.; Patten's Foundations of Embryology, 6th edition. New York: McGraw-Hill, 1996, p. 3

[2] Scientific and Medical Aspects of Human Reproductive Cloning, Report of the National Academy of Sciences and the Institute of Medicine, National Academy Press, Washington, DC, Jan 2002; Glossary.

Regarding **human cloning**, it is **human asexual reproduction**, termed "asexual" because it does not involve the combining of egg and sperm to form an embryo. The focal technique to accomplish this is the technique of **somatic cell nuclear transfer (SCNT)**—introducing the nuclear genetic material from one or more human somatic (body) cells into a fertilized or unfertilized egg cell whose nuclear genetic material has been removed or inactivated, producing a human embryo who is virtually genetically identical to an existing or previously existing human being.

Proponents of human cloning hold out two hopes for its use: (1) creating live born children for infertile couples or those grieving over the loss of a loved one, so-called "reproductive cloning" (live birth cloning), and (2) promises of medical miracles to cure diseases by harvesting embryonic stem cells from cloned embryos created from patients, euphemistically termed "therapeutic cloning" (more properly termed research cloning.)

Biologically the process of cloning (somatic cell nuclear transfer; SCNT) also produces a zygote as the starting point for development. As the President's Council on Bioethics has noted, "The first product of SCNT is, on good biological grounds, quite properly regarded as the equivalent of a zygote, and its subsequent stages as embryonic stages in development."[3]

The **National Academy of Sciences** noted the following:

> "**The method used to initiate the reproductive cloning procedure is called nuclear transplantation, or somatic cell nuclear transfer (SCNT)**. It involves replacing the chromosomes of a human egg with the nucleus of a body (somatic) cell from a developed human. In reproductive cloning, the egg is then stimulated to undergo the first few divisions to become an aggregate of 64 to 200 cells called a blastocyst. The blastocyst is a preimplantation embryo that contains some cells with the potential to give rise to a fetus and other cells that help to make the placenta. If the blastocyst is placed in a uterus, it can implant and form a fetus. If the blastocyst is instead maintained in the laboratory, cells can be extracted from it and grown on their own."[4]

Embryonic stem cells can be isolated from a blastocyst-stage embryo early in human development, whether produced by fertilization or by cloning (SCNT):

> "[A]n embryonic stem cell (ES cell) is defined by its origin. It is derived from the blastocyst stage of the embryo. The blastocyst is the stage of embryonic development prior to implantation in the uterine wall."[5]

The equivalence of the embryo, as zygote and blastocyst, was noted by the National Academy of Sciences.

To emphasize this point, we should note that this same technique of cloning, somatic cell nuclear transfer (SCNT), was the process used to create the cloned sheep Dolly.

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[3] "Human Cloning and Human Dignity: An Ethical Inquiry", Report of the President's Council on Bioethics, July 2002; p.50

[4] Scientific and Medical Aspects of Human Reproductive Cloning, Report of the National Academy of Sciences and the Institute of Medicine, National Academy Press, Washington, DC, Jan 2002; Preface page xii

[5] "Stem Cells: Scientific Progress and Future Research Directions", National Institutes of Health, June 2001; Pg. 5

We need to be clear on the terms. All human cloning is reproductive, in that it creates – reproduces – a new developing human organism intended to be virtually identical to the cloned subject. Both "reproductive" and "therapeutic" cloning use exactly the same techniques to create the clone, and the cloned embryos are indistinguishable. The process, as well as the product, is identical. The only distinction is the purpose for use of the embryo—either transfer to a uterus in the hopes of a live birth, or destruction in the hopes of a medical miracle.

The technique of cloning is finished once that first cell, the one-celled embryo (zygote) is formed. Anything beyond that step is simply growth and development. And despite the attempts to employ various euphemisms, scientifically, genetically, what is created is a human being; its species is *Homo sapiens*, it is neither fish nor fowl, monkey nor cow—it is human. The use of disingenuous euphemisms to describe the embryo as something other than an embryo likewise are not scientific, and diverge from the accepted definitions as put forth by the National Academy of Sciences, the National Institutes of Health, and others, including well-known proponents of human cloning.

> "Moreover, because therapeutic cloning requires the creation and disaggregation ex utero of blastocyst stage embryos, this technique raises complex ethical questions."
> "Unlike much stem cell research, which can use spare embryos remaining from infertility procedures, CRNT [cell replacement through nuclear transfer, aka therapeutic cloning] requires the deliberate creation and disaggregation of a human embryo."[6]

The theory that cloning (SCNT) will produce matching tissues for transplant that will not be rejected has already been shown incorrect. When tested in mice,[7] the ES cells from the cloned mouse embryo were rejected by the genetically-identical host:

> "Jaenisch addressed the possibility that ES clones derived by nuclear transfer technique could be used to correct genetic defects… However, the donor cells, although derived from the animals with the same genetic background, are rejected by the hosts."[8]

Dr. James Thomson, who originally isolated human embryonic stem cells, has stated in one of his published papers that cloning is unlikely to be clinically significant.

> "[T]he poor availability of human oocytes, the low efficiency of the nuclear transfer procedure, and the long population-doubling time of human ES cells make it difficult to envision this [therapeutic cloning by SCNT] becoming a routine clinical procedure…"[9]

Other leaders in the embryonic stem cell field have also published similar views, including Australia's Alan Trounson:[10]

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[6] Robert P. Lanza, Arthur L. Caplan, Lee M. Silver, Jose B. Cibelli, Michael D. West, Ronald M. Green; "The ethical validity of using nuclear transfer in human transplantation"; *The Journal of the American Medical Association* 284, 3175-3179; Dec 27, 2000.

[7] Rideout WM *et al*., "Correction of a genetic defect by nuclear transplantation and combined cell and gene therapy," *Cell* 109, 17-27; 5 April 2002 (published online 8 March 2002)

[8] Tsai RYL, Kittappa R, and McKay RDG; "Plasticity, niches, and the use of stem cells"; *Developmental Cell* 2, 707-712; June 2002.

[9] Odorico JS, Kaufman DS, Thomson JA, "Multilineage differentiation from human embryonic stem cell lines," *Stem Cells* 19, 193-204; 2001

> "However, it is unlikely that large numbers of mature human oocytes would be available for the production of ES cells, particularly if hundreds are required to produce each ES line… In addition, epigenetic remnants of the somatic cell used as the nuclear donor can cause major functional problems in development, which must remain a concern for ES cells derived by nuclear transfer. …it would appear unlikely that these strategies will be used extensively for producing ES cells compatible for transplantation."

Thomas Okarma, chief executive officer, Geron Corporation says: "The odds favoring success are vanishingly small, and the costs are daunting." "It would take thousands of [human] eggs on an assembly line to produce a custom therapy for a single person. **The process is a nonstarter, commercially**."[11]

The evidence from animal studies indicates that it will indeed require a tremendous number of human oocytes (eggs) to produce even one ES cell line from cloned embryos. Dr. Peter Mombaerts, who was one of the first mouse cloners, estimates that it will require a minimum of 100 eggs.[12] This would mean for example that to treat, theoretically, the 17 million diabetics in the U.S. by this technique would require at least 1.7 billion human eggs. The reported first cloning of a human embryo in South Korea this year actually required 242 eggs to obtain just one ES cell line.[13] Woo Suk Hwang, lead author of the South Korean human cloning study, admitted that the technique developed in his lab "cannot be separated from reproductive cloning…" This is because it is the same technique used to create the embryo, and in fact the same embryo, that is used for either subsequent procedure.

Moreover, **allowing "therapeutic" cloning while trying to ban reproductive cloning is unfeasible, and will simply hasten development of the process supposedly to be banned, reproductive cloning**. Again, honest proponents of cloning have noted this themselves:

> "It is true that the techniques developed in CRNT [cell replacement through nuclear transfer, aka therapeutic cloning] research can prepare the way scientifically and technically for efforts at reproductive cloning."[14]

The American Society for Reproductive Medicine (ASRM), the largest professional organization with expertise in reproductive technologies, says that SCNT is simply the procedure that clones embryos for WHATEVER purpose (whether for starting a pregnancy or destroying for research). And ASRM concedes that if cloning for research is allowed, that research will be used to refine the process and will make it easier for people to perform "reproductive" cloning:

[Footnote continued from previous page]

10 Trounson AO, "The derivation and potential use of human embryonic stem cells", *Reproduction, Fertility, and Development* 13, 523-532; 2001

11 (Denise Gellene, "Clone Profit? Unlikely", Los Angeles Times, May 10, 2002)

12 Mombaerts P, "Therapeutic cloning in the mouse", *Proceedings of the National Academy of Sciences USA* 100, 11924-11925; 30 Sept 2003 (published online 29 August 2003

13 Hwang WS *et al.*, "Evidence of a pluripotent human embryonic stem cell line derived from a cloned blastocyst", *Science* 303, 1669-1674; 12 March 2004 (published online 12 Feb 2004)

14 Robert P. Lanza, Arthur L. Caplan, Lee M. Silver, Jose B. Cibelli, Michael D. West, Ronald M. Green; "The ethical validity of using nuclear transfer in human transplantation"; *The Journal of the American Medical Association* 284, 3175-3179; Dec 27, 2000.

"If undertaken, the development of SCNT for such therapeutic purposes, in which embryos are not transferred for pregnancy, is likely to produce knowledge that could be used to achieve reproductive SCNT."[15]

There are in truth few actual positive published scientific reports regarding the claims put forth for cloning and embryonic stem cells, and a significant number of negative characteristics. The theoretical potential of SCNT cloning to treat diseases, and the theoretical ability to control their differentiation without tumor formation, is wishful thinking.

The published literature shows that the claims for embryonic stem cell advantages over adult stem cells are thus far unsubstantiated. Indeed, the National Institutes of Health has noted that: "Thus, at this stage, any therapies based on the use of human ES cells are still hypothetical and highly experimental."[16] And also "Whether embryonic stem cells will provide advantages over stem cells derived from cord blood or adult bone marrow hematopoietic stem cells remains to be determined."[17]

The lack of success of cloning and embryonic stem cells should be compared with the **real successes of adult stem cells**. A wealth of scientific papers published over the last few years document that adult stem cells are a much more promising source of stem cells for regenerative medicine. Adult stem cells actually do show pluripotent capacity in generation of tissues, meaning that they can generate many, if not all, of the different tissues of the body. In a paper published in May 2001, the researchers found that one adult bone marrow stem cell could regenerate not only marrow and blood, but also form liver, lung, digestive tract, skin, heart, muscle.[18] Other researchers have found pluripotent ability of adult stem cells various sources including from bone marrow,[19],[2021] peripheral blood,[22] inner ear,[23] and umbilical cord blood.[24]

A chart in the accompanying handout shows examples (not all-inclusive) of tissues from which adult stem cells have been isolated, as well as some of the derivatives from those stem cells. Bone marrow stem cells seem particularly "plastic", potentially with the ability to form all adult tissues. Cord blood stem cells also have shown remarkable abilities. Even liposuctioned fat has been found to contain stem cells which can be transformed into other tissues. In point of fact, any time someone has looked in a tissue for stem cells, they have found them.

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[15] The Ethics Committee of the American Society for Reproductive Medicine; "Human somatic cell nuclear transfer (cloning)"; *Fertility and Sterility* 74, 873-876; November 2000.

[16] National Institutes of Health, "Stem cells: Scientific progress and future directions", June 2001; p17

[17] National Institutes of Health, "Stem cells: Scientific progress and future directions", June 2001; p63

[18] Krause DS *et al.*; "Multi-Organ, Multi-Lineage Engraftment by a Single Bone Marrow-Derived Stem Cell"; Cell 105, 369-377; 4 May 2001

[19] Jiang Y *et al.*; "Pluripotency of mesenchymal stem cells derived from adult marrow"; *Nature* 418, 41-49; 4 July 2002

[20] D'Ippolito G *et al.*, "Marrow-isolated adult multilineage inducible (MIAMI) cells, a unique population of postnatal young and old human cells with extensive expansion and differentiation potential", *J. Cell Science* 117, 2971-2981, 15 July 2004 (published online 1 June 2004)

[21] Yoon Y-s *et al.*, "Clonally expanded novel multipotent stem cells from human bone marrow regenerate myocardium after myocardial infarction", *Journal of Clinical Investigation* 115, 326-338, February 2005

[22] Zhao Y *et al.*; "A human peripheral blood monocyte-derived subset acts as pluripotent stem cells"; *Proceedings of the National Academy of Sciences USA* 100, 2426-2431; 4 March 2003

[23] Li H *et al.*, "Pluripotent stem cells from the adult mouse inner ear", *Nature Medicine* 9, 1293-1299, October 2003

[24] Kögler G *et al.*, "A new human somatic stem cell from placental cord blood with intrinsic pluripotent differentiation potential", *J. Experimental Medicine* 200, 123-135, 19 July 2004

Many published references also show that adult stem cells can multiply in culture for extensive periods of time, retaining their ability to differentiate, and providing sufficient numbers of cells for clinical treatments. More importantly, adult stem cells have been shown to be effective in treating animal models of disease, including such diseases as diabetes,[25] stroke,[26] spinal cord injury,[27] Parkinson's disease,[28] and retinal degeneration.[29]

Moreover, **adult stem cells are already being used clinically to treat many diseases in human patients**. These include as reparative treatments with various cancers, autoimmune diseases such as multiple sclerosis, lupus, and arthritis, anemias including sickle cell anemia, and immunodeficiencies. Adult stem cells are also being used to treat patients by formation of cartilage, growing new corneas to restore sight to blind patients, treatments for stroke, and several groups are using adult stem cells with patients to repair damage after heart attacks. Early clinical trials have shown initial success in patient treatments for Parkinson's disease and spinal cord injury. And, the first FDA-approved trial to treat juvenile diabetes in human patients is ready to begin at Harvard Medical School, using adult cells. An advantage of using adult stem cells is that in most cases the patient's own stem cells can be used for the treatment, circumventing the problems of immune rejection, and without tumor formation.

The mechanism for these amazing regenerative treatments is still unclear. Adult stem cells in some cases appear capable of interconversion between different tissue types, known as transdifferentiation. In some tissues, adult stem cells appear to fuse with the host tissue and take on that tissue's characteristics, facilitating regeneration. And in some studies, the adult stem cells do not directly contribute to the regenerating tissue, but instead appear to stimulate the endogenous cells of the tissue to begin repair. Whatever the mechanism, the adult cells are successful at regenerating damaged tissue. As Robert Lanza, a proponent of embryonic stem cells and cloning has noted, "there is ample scientific evidence that adult stem cells can be used to repair damaged heart or brain tissue… if it works, it works, regardless of the

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[25] Oh S-H *et al.*, "Adult bone marrow-derived cells transdifferentiating into insulin-producing cells for the treatment of type I diabetes," *Laboratory Investigation* published online 22 March 2004; Kodama S *et al.*, "Islet regeneration during the reversal of autoimmune diabetes in NOD mice", *Science* 302, 1223-1227; 14 Nov 2003; Hess D *et al.*, "Bone marrow-derived stem cells initiate pancreatic regeneration", *Nature Biotechnology* 21, 763-770; July 2003

[26] Willing AE *et al.*, "Mobilized peripheral blood stem cells administered intravenously produce functional recovery in stroke", *Cell Transplantation* 12, 449-454; 2003; Arvidsson A *et al.*; "Neuronal replacement from endogenous precursors in the adult brain after stroke"; *Nature Medicine* 8, 963-970; Sept 2002; Riess P *et al.*; "Transplanted neural stem cells survive, differentiate, and improve neurological motor function after experimental traumatic brain injury"; *Neurosurgery* 51, 1043-1052; Oct 2002

[27] Hofstetter CP *et al.*, "Marrow stromal cells form guiding strands in the injured spinal cord and promote recovery", *Proc Natl Acad Sci USA* 99, 2199-2204; 19 February 2002; Sasaki M *et al.*, "Transplantation of an acutely isolated bone marrow fraction repairs demyelinated adult rat spinal cord axons," *Glia* 35, 26-34; July 2001; Ramón-Cueto A *et al.*, "Functional recovery of paraplegic rats and motor axon regeneration in their spinal cords by olfactory ensheathing glia," *Neuron* 25, 425-435; February 2000

[28] Liker MA *et al.*; "Human neural stem cell transplantation in the MPTP-lesioned mouse"; *Brain Research* 971, 168-177; May 2003; Åkerud P *et al.*; "Persephin-overexpressing neural stem cells regulate the function of nigral dopaminergic neurons and prevent their degeneration in a model of Parkinson's disease"; *Molecular and Cellular Neuroscience* 21, 205-222; Nov 2002; Ourednik J *et al.*; "Neural stem cells display an inherent mechanism for rescuing dysfunctional neurons"; *Nature Biotechnology* 20, 1103-1110; Nov 2002

[29] Otani A *et al.*, "Rescue of retinal degeneration by intravitreally injected adult bone marrow-derived lineage-negative hematopoietic stem cells", *J. Clinical Investigation* 114, 765-774, September 2004; Otani A *et al.*, "Bone marrow derived stem cells target retinal astrocytes and can promotes or inhibit retinal angiogenesis"; *Nature Medicine* 8, 1004-1010; Sept 2002; Tomita M *et al.*, "Bone marrow derived stem cells can differentiate into retinal cells in injured rat retina"; *Stem Cells* 20, 279-283; 2002

mechanism."[30] The citations given above for adult stem cells are only a sampling, including some more recent references. A representative list of diseases currently in patient trials with adult stem cells is given as Appendix A.

In summary, adult stem cells have been shown by the published evidence to be a more promising alternative for patient treatments, with a vast biomedical potential. Adult stem cells have proven success in the laboratory dish, in animal models of disease, and in current clinical treatments. Adult stem cells also avoid problems with tumor formation, transplant rejection, and provide realistic excitement for patient treatments. There are no valid or compelling grounds—scientific, medical, or ethical—to proceed with any human cloning. A comprehensive ban on all human cloning is the only sufficient answer. I urge you to defeat this Bill.

Thank you once again for allowing me to present testimony on this issue.

[30] Steve Mitchell, "Study casts doubt on adult stem cells", UPI; 12 October 2003

Appendix A

ADULT STEM CELL BENEFITS TO HUMAN PATIENTS

CANCERS:	AUTO-IMMUNE DISEASES:
• Brain tumors—medulloblastoma and glioma	• Systemic lupus (auto-immune condition that can affect skin, heart, lungs, kidneys, joints, and nervous system)
• Retinoblastoma (cancer)	• Sjogren's syndrome(autoimmune disease w/ symptoms similar to arthritis)
• Ovarian cancer	• Myasthenia (An autoimmune neuromuscular disorder)
• Skin cancer: Merkel cell carcinoma	• Autoimmune cytopenia
• Testicular cancer	• Scleromyxedema (skin condition)
• Tumors abdominal organs, Lymphoma	• Scleroderma (skin disorder)
• Non-Hodgkin's lymphoma	• Crohn's disease (chronic inflammatory disease of the intestines)
• Hodgkin's lymphoma	• Behcet's disease
• Acute lymphoblastic leukemia	• Rheumatoid arthritis
• Acute myelogenous leukemia	• Juvenile arthritis
• Chronic myelogenous leukemia	• Multiple sclerosis
• Juvenile myelomonocytic leukemia	• Polychondritis (chronic disorder of the cartilage)
• Cancer of the lymph nodes: Angioimmunoblastic lymphadenopathy	• Systemic vasculitis (inflammation of the blood vessels)
• Multiple myeloma (cancer affecting white blood cells of the immune system)	**CARDIOVASCULAR:**
• Myelodysplasia (bone marrow disorder)	• Heart damage
• Breast cancer	**IMMUNODEFICIENCIES**
• Neuroblastoma (childhood cancer of the nervous system)	• Severe combined immunodeficiency syndrome
• Renal cell carcinoma (cancer of the kidney)	**ANEMIAS AND OTHER BLOOD CONDITIONS:**
• Soft tissue sarcoma (malignant tumor that begins in the muscle, fat, fibrous tissue, blood vessels)	• Sickle cell anemia
• Various solid tumors	• Sideroblastic anemia
• Waldenstrom's macroglobulinemia (type of lymphoma)	• Aplastic anemia
• Hemophagocytic lymphohistiocytosis	• Red cell aplasia (failure of red blood cell development)
NEURAL DEGENERATIVE DISEASES and INJURIES:	• Amegakaryocytic thrombocytopenia
• Parkinson's disease	• Thalassemia (genetic (inherited) disorders all of which involve underproduction of hemoglobin)
• Spinal cord injury	• Primary amyloidosis (A disorder of plasma cells)
• Stroke damage	• Diamond blackfan anemia
OCULAR:	• Fanconi's anemia
• Corneal regeneration	• Chronic Epstein-Barr infection (condition similar to Mono)
WOUNDS and INJURIES:	**OTHER METABOLIC DISORDERS:**
• Limb gangrene	• Sandhoff disease (hereditary genetic disorder)
• Surface wound healing	• Hurler's syndrome (hereditary genetic disorder)
	• Osteogenesis imperfecta (bone/cartilage disorder)
	• Krabbe Leukodystrophy (hereditary genetic disorder)